This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PTO/SB/06 (09-11)
Approved for use through 1/31/2014. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 15/997,091	Filing Date 06/04/2018	☐ To be Mailed

ENTITY: ☑ LARGE ☐ SMALL ☐ MICRO

APPLICATION AS FILED - PART I

	(Column 1)	(Column 2)			
FOR	NUMBER FILED	NUMBER EXTRA		RATE ($)	FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A		N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A		N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A		N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*		x $100 =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*		x $460 =	
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).				
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))					
* If the difference in column 1 is less than zero, enter "0" in column 2.				TOTAL	

APPLICATION AS AMENDED - PART II

		(Column 1)		(Column 2)	(Column 3)			
AMENDMENT	07/10/2019	CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	* 30	Minus	** 20	= 10		x $100 =	1000
	Independent (37 CFR 1.16(h))	* 3	Minus	*** 3	= 0		x $460 =	0
	☐ Application Size Fee (37 CFR 1.16(s))							
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							
							TOTAL ADD'L FEE	1000

		(Column 1)		(Column 2)	(Column 3)			
AMENDMENT		CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	*	Minus	**	=		x $0 =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=		x $0 =	
	☐ Application Size Fee (37 CFR 1.16(s))							
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							
							TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.	LIE
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".	/ROLITA M WIMBUSH/
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".	
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.	

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

REQUEST FOR CONTINUED EXAMINATION (RCE) TRANSMITTAL		
	Application Number	15/997,091
	Filing Date	June 4, 2018
	First Named Inventor	Edwin S. Olson
	Confirmation Number	5161
	Group Art Unit	1776
	Examiner Name	Amber Orlando
	Attorney Docket Number	4820.001U10
	Customer No.	21186

This is a Request for Continued Examination (RCE) under 37 C.F.R § 1.114 of the above-identified application entitled SORBENTS FOR THE OXIDATION AND REMOVAL OF MERCURY

1. Submission required under 37 C.F.R. § 1.114:
   - X Amendment and Response Under 37 C.F.R § 1.116 (80 pages) is enclosed.
   - X Certification and Request for Prioritized Examination (Track 1) (1 pg)
   - X Information Disclosure Statement (2 pages), Form 1449 (1 page), and copies of cited documents (6).
   - X Petition for Extension of Time (1 pg).
   - X DECLARATION UNDER 37 C.F.R. § 1.132 (A) (11 pgs), (B) (12 pgs), (C) (16 pgs), and (D) (6 pgs)

2. Fees
   - X Authorization to charge deposit account 19-0743 in the amount of $1300.00 to pay the RCE filing fee required under 37 C.F.R. § 1.17(e).
   - X Authorization to charge Deposit Account 19-0743 in the amount of $4000.00 for the Prioritized Examination (Track 1) filing fee as set forth in 37 C.F.R. § 1.17(c); and Authorization to charge Deposit Account 19-0743 for the Processing Fee (Track 1) set forth in 37 C.F.R. § 1.17(i) in the amount of $140.00.
   - X Authorization to charge deposit account 19-0743 in the amount of $1400.00 to pay the extension of time fee.
   - X Authorization to charge deposit account 19-0743 in the amount of $1000.00 to cover the fee for additional claims.

The fee for additional claims has been calculated as follows:

CLAIMS AS AMENDED						
	Claims Remaining After Amendment		**Highest Number Previously Paid For**	**Present Extra**	Rate	**Fee**
TOTAL CLAIMS	**30**	-	**20**	**10**	**x 100.00 =**	**1000.00**
INDEPENDENT CLAIMS	**3**	-	**3**	**0**	**x 460.00 =**	**0.00**
[] MULTIPLE DEPENDENT CLAIMS PRESENTED						**0.00**
TOTAL						**1000.00**

The Commissioner is hereby authorized to charge any additional fees or credit overpayment to Deposit Account No. 19-0743.

SCHWEGMAN LUNDBERG & WOESSNER, P.A.

By: /Nicholas P. Lanzatella/
Nicholas P. Lanzatella
Reg. No. 63,803

Electronic Patent Application Fee Transmittal

Application Number:	15997091
Filing Date:	04-Jun-2018
Title of Invention:	SORBENTS FOR THE OXIDATION AND REMOVAL OF MERCURY
First Named Inventor/Applicant Name:	Edwin S. Olson
Filer:	Janal M. Kalis/Megan Reed
Attorney Docket Number:	4820.001US10

Filed as Large Entity

Filing Fees for Utility under 35 USC 111(a)

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
REQUEST FOR PRIORITIZED EXAMINATION	1817	1	4000	4000
Pages:				
Claims:				
CLAIMS IN EXCESS OF 20	1202	10	100	1000
Miscellaneous-Filing:				
PROCESSING FEE, EXCEPT PROV. APPLS.	1830	1	140	140
Petition:				
Patent-Appeals-and-Interference:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				
Extension - 3 months with $0 paid	1253	1	1400	1400
Miscellaneous:				
RCE- 1ST REQUEST	1801	1	1300	1300
		Total in USD ($)		**7840**

Electronic Acknowledgement Receipt	
EFS ID:	36547902
Application Number:	15997091
International Application Number:	
Confirmation Number:	5161
Title of Invention:	SORBENTS FOR THE OXIDATION AND REMOVAL OF MERCURY
First Named Inventor/Applicant Name:	Edwin S. Olson
Customer Number:	21186
Filer:	Janal M. Kalis/Megan Reed
Filer Authorized By:	Janal M. Kalis
Attorney Docket Number:	4820.001US10
Receipt Date:	10-JUL-2019
Filing Date:	04-JUN-2018
Time Stamp:	17:00:27
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	DA
Payment was successfully received in RAM	$7840
RAM confirmation Number	071119INTEFSW00004067190743
Deposit Account	190743
Authorized User	Megan Reed
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows: 37 CFR 1.16 (National application filing, search, and examination fees) 37 CFR 1.17 (Patent application and reexamination processing fees)	

37 CFR 1.19 (Document supply fees)

37 CFR 1.20 (Post Issuance fees)

37 CFR 1.21 (Miscellaneous fees and charges)

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		SIGNED_4820_001U10_RCE_Resp_Ext_IDS_Dec_Tr12.pdf	7044486 57e39af4c9bf15046b2121f53577f53324282939	yes	131

Multipart Description/PDF files in .zip description

Document Description	Start	End
Affidavit-traversing rejectns or objectns rule 132	126	131
Affidavit-traversing rejectns or objectns rule 132	110	125
Affidavit-traversing rejectns or objectns rule 132	98	109
Affidavit-traversing rejectns or objectns rule 132	87	97
Extension of Time	86	86
Information Disclosure Statement (IDS) Form (SB08)	85	85
Transmittal Letter	83	84
TrackOne Request	82	82
Applicant Arguments/Remarks Made in an Amendment	9	81
Claims	3	8
Amendment Submitted/Entered with Filing of CPA/RCE	2	2
Request for Continued Examination (RCE)	1	1

Warnings:

Information:

2	Non Patent Literature	4820003US2_ADAR_05222019.pdf	385392 7d69afab34c3f12b945a35d7c984bcceca9cdbed	no	3

Warnings:					
Information:					
3	Non Patent Literature	4820003US2_OARN_06212019.pdf	725411 e5cd411e36653e4663d76a883ea76ba917ef8147	no	7
Warnings:					
Information:					
4	Non Patent Literature	4820004US1_FOAR_06212019.pdf	3420798 4df6d6cc027a421318e268b85e3a594de4ac0eba	no	31
Warnings:					
Information:					
5	Non Patent Literature	4820007US4_NALL_05302019.pdf	405171 037a81efdb7cea4f080e1f3bdcb29430be815c0c	no	3
Warnings:					
Information:					
6	Non Patent Literature	4820007US4_NOAR_05082019.pdf	396732 58359b85ebd004efa827f412f8f5f4e1a2a5dda6	no	7
Warnings:					
Information:					
7	Foreign Reference	WO_2012030560_A1.pdf	956404 f3ba9bc976639c9f0ceaec2c4a975837f58c936b	no	19
Warnings:					
Information:					
8	Fee Worksheet (SB06)	fee-info.pdf	39391 f6432a898ef1708fc674029c369ffeafbe9c7189	no	2
Warnings:					
Information:					
			Total Files Size (in bytes):	13373785	

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New International Application Filed with the USPTO as a Receiving Office

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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Inventor(s): Edwin S. Olson et al.	Examiner: AMBER ROSE ORLANDO
Application No.: 15/978,760	Group Art Unit: 1776
Filed: May 14, 2018	Docket No.: 4820.007US4
Confirmation No.: 6432	
Title: SORBENTS FOR THE OXIDATION AND REMOVAL OF MERCURY	

DECLARATION UNDER 37 C.F.R. § 1.132

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

DECLARATION D

I, John Pavlish, declare and say as follows:

1. I have been the Chief Technology Officer and Senior Vice President of Midwest Energy Emissions Corporation since November 16, 2014. Prior to this, I served as an Executive Consultant Advisor to Midwest Energy Emissions Corporation. Prior to joining Midwest Energy Emissions Corporation, I was a Senior Research Advisor and the Director of the Center for Air Toxic Metals Program at the Energy & Environmental Research Center in Grand Forks, North Dakota. I have over 25 years of mercury-related experience and am regarded as an international expert on the topic of mercury. My primary areas of interest and expertise include research, technical consultation and development of mercury control technologies, in particular, for coal combustion and gasification systems. I am an inventor of a number of patented mercury control technologies and have years of experience in development and testing of these technologies for commercial applications. Over the last 15 years, I have spent much time evaluating the efficacy of a number of different mercury control technologies/approaches and their cost competitiveness in the commercial market. I also have years of power plant experience and have worked for an engineering/consulting company, Black & Veatch, where I served as Unit Leader/System Engineer. I am a professional engineer, a member of the American Society of Mechanical Engineers, and a member of the Air & Waste Management Association (A&WMA). I serve on numerous professional and

technical committees and am a U.S. Representative on the Mercury Emissions from Coal International Experts Working Group on Reducing Emissions from Coal and a member of the United Nations Environment Programme Global Mercury Partnership, Reduction of Mercury Releases from Coal Combustion. I have published over 2●● papers, articles, and reports on various mercury-related topics and issues.

2. Declaration B at item 8 describes that a pilot-scale 55●,●●●-Btu/hr pulverized coal (pc)-fired test unit was used to combust subbituminous coal and test mercury control using various sorbents. The coal combustion flue gas exiting the pilot unit was cooled down to a nominal temperature of 149°C (3●●°F) and then was introduced into a single wire tubular ESP unit. Activated carbon sorbents were fed with a K-Tron dual-screw feeder upstream of the ESP. The feeder was calibrated prior to the start of each carbon injection test. No scrubber was used. Before Hg control testing began, a baseline condition was established with the pilot-scale unit, and flue gas mercury content was measured before each test as about 6-1● $\mu g/m^3$. The flue gas HCl concentration, with no additives on the coal, as calculated by the chlorine measured in the coal, was 2-5 ppm.

3. U.S. patent publication no. 2●●4/●●●3716 ("Nelson") describes treatment of activated carbon outside the flue gas with hydrogen bromide (HBr), and describes testing to measure the percent mercury removal when the treated activated carbon was injected into either simulated or actual flue gas at various injection rates. Specifically, Nelson performed experiments in Example 5 (paragraphs [●●82]-[●●85]) and 7 (paragraphs [●●89]-[●●92]), and provides the data in FIG. 14 and FIG. 15.

4. In Example 5, Nelson treated Norit DARCO® FGD with gaseous HBr, and tested its use by injecting the HBr-treated sorbent into a simulated coal-fired flue-gas stream in a pilot-scale test system. Nelson's FIG. 14 shows data for one activated carbon sample treated with HBr. The activated carbon had 1● wt% HBr, and at a sorbent injection rate of about 3.7 lb/MMacf gave a mercury removal of about 82%. As reported in paragraph [●●82] of Nelson, duct-injection runs were performed with a simulated coal-fired flue-gas

stream on a 50-acfm pilot-scale test system. As described, the mercury mass transfer to fluidized sorbent and adsorption kinetics in this system were similar to that in a full-scale utility application. The fully-instrumented duct-injection test system that was used included a propane burner unit to generate the hot flue gas; a humidification drum to add an appropriate degree of moisture to the gas; an elemental mercury spiking subsystem with elemental mercury permeation tubes; a flue gas spiking subsystem with mass flow controllers for SO_2, NO_x, and HCl; a small sorbent feeder and fluidizing injection subsystem to lessen sorbent pulsing; 10 meters of insulated, 10-cm-diameter ducting circling the ceiling; thermocouples; an electrostatic filter with an effective specific collection area (SCA) of about 500 ft^2/Kacf; a back-up fabric filter; a safety filter; an orifice plate to measure flow; and a variable-speed I.D. fan. The gas temperature at injection was about 175 °C and at the electrostatic precipitator (ESP) was about 145 °C and the spiked flue gas concentrations were about 24 μg/Nm^3 Hg(0), 1400 ppm SO_2 , 600 ppm NO_x, and 5 ppm HCl, typical values for coal-fired power plants.

5. In Example 7, Nelson treated Norit DARCO® FGD with gaseous HBr, and tested its use in a coal-fired power plant by injecting the treated sorbent into the flue gas prior to the electrostatic precipitator (ESP). Nelson's FIG. 15 shows data for two activated carbon samples treated with HBr. The two activated carbon samples contained 9 wt% HBr. The data in FIG. 15 for the two HBr-treated sorbents show that at a sorbent injection rate of about 2.2 lb/MMacf, 45% of the mercury was removed, and at a sobent injection rate of about 4.2 lb/MMacf, 62% of the mercury was removed. As reported in paragraphs [0089]-[0091] of Nelson, a large-scale duct-injection trial was performed at the 18-MW scale, with about 60,000 acfm of flue gas at 160 °C (320 °F). The plant had stoker-fed boilers, burned a high-sulfur bituminous coal, and had just a cold-side ESP for emission control. Baseline sampling according to the Ontario Hydro Method indicated no intrinsic mercury removal of mercury across the ESP. Without sorbent injection, the plant emitted about 10 μg/Nm^3 of mercury from the stack, with 80 to 90% of this in oxidized forms. In these trials, the mercury was measured using a speciating PS Analytical Sir Galahad continuous mercury monitor. Inlet mercury values were obtained

by sampling upstream of the sorbent injection point and outlet mercury was measured at the stack. The sorbents were injected into ductwork through a lance to mix with the flue gases about 40 feet from the entrance to the ESP. The flue gas contained about 1000 ppm of SO_2, 20 ppm of SO_3, 250 ppm of NO_x, and 25 ppm of HCl. The ESP had an SCA of 370 ft^2/Kacfm.

6. Nelson's Examples 5 and 7 do not describe the use of a scrubber. Example 7 of Nelson uses only a cold-side ESP for emission control, with injection of the activated carbon upstream of the ESP. Example 5 of Nelson describes an ESP that occurs after the point of injection and that has a temperature of 145 °C (293 °F) at the inlet, also corresponding to a cold-side ESP. Similarly, in the pilot-scale setup described at item 8 of Declaration B no scrubber was used, and activated carbon was injected upstream of the ESP. These similarities between Nelson's Example 5 and 7 and the pilot-scale setup described at item 8 of Declaration B allow for good comparison with the Nelson data.

7. Nelson's Example 5 describes a flue gas HCl concentration of 5 ppm, which is similar to the flue gas HCl concentration in the pilot-scale setup described at item 8 of Declaration B, allowing for good comparison between Nelson's Example 5 and the pilot-scale setup described at item 8 of Declaration B. However, Nelson's Example 7 describes a flue gas HCl concentration of 25 ppm. The higher HCl concentration in Nelson's Example 7 flue gas allows for easier mercury removal, due to HCl acting as a promotor of the activated carbon, as compared to the pilot-scale setup described at item 8 of Declaration B.

8. The mercury concentration of the flue gas from the pilot-scale setup described at item 8 of Declaration B was in the range of 6-10 $\mu g/m^3$, as compared to Nelson's Example 5 data for which the mercury concentration of the flue gas is about 24 $\mu g/m^3$. The higher mercury concentration in Nelson's Example 5 allows for easier mercury removal as the mercury concentration at the point of activated carbon injection is much higher. To illustrate this, to remove 70% of the mercury from Nelson's Example 5 setup,

the mercury concentration leaving the ESP after the mercury is captured by the treated activated carbon would be: 24 - (24*70/100) = 7.2 $\mu g/m^3$. To remove 70% of the mercury from the pilot-scale setup described at item 8 of Declaration B, the mercury concentration leaving the ESP after the mercury is captured by the activated carbon would be: 8 - (8*70/100) = 2.4 $\mu g/m^3$. When mercury concentration is lower, the probability of activated carbon sorbent particles contacting mercury in the flue gas is lower, and the overall number of encounters between activated carbon particles and mercury atoms or compounds per time is lower; therefore, the activated carbon sorbent particles must be more adsorptive (e.g., reactive) toward mercury in order to remove mercury at low concentrations as compared to the same activated carbon sorbent placed in a higher concentration of mercury. As the calculation shows, it is more difficult to remove the same percentage of mercury from the flue gas starting with a lower concentration of 8 $\mu g/m^3$ than starting at a higher concentration of 24 $\mu g/m^3$.

9. As explained at item 6, Nelson's experimental setup in Examples 5 and 7 and the experimental setup described at item 8 of Declaration B inject activated carbon sorbent into a flue gas upstream of an ESP and use no scrubber, making the procedures comparable. However, as explained at item 7, the higher HCl concentration in Nelson's Example 7 flue gas allows for easier mercury removal, due to HCl acting as a promotor of the activated carbon, as compared to the pilot-scale setup described at item 8 of Declaration B. Further, as explained at item 8, the higher mercury concentration in Nelson's Example 5 makes it easier for Nelson's sorbents to remove the same overall percentage of mercury from the flue gas, as compared to the pilot-scale setup described at item 8 of Declaration B. Therefore, if Nelson's Example 5 and 7 HCl and mercury concentrations were changed to match those of the pilot-scale setup described at item 8 of Declaration B, Nelson's sorbents would remove a lower percentage of mercury than found in Nelson's Examples 5 and 7.

10. I further declare that all statements made herein of my own knowledge are true, and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by a fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application and/or any patent issued thereon.

Dated: March 20, 2019 By: / John Pavlish /

John Pavlish

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Inventor(s): Edwin S. Olson et al. Examiner: AMBER ROSE ORLANDO
Application No.: 15/978,760 Group Art Unit: 1776
Filed: May 14, 2018 Docket No.: 4820.007US4
Confirmation No.: 6432
Title: SORBENTS FOR THE OXIDATION AND REMOVAL OF MERCURY

DECLARATION UNDER 37 C.F.R. § 1.132

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

DECLARATION C

We, John Pavlish and Nicholas Lentz, declare and say as follows:

1. I, John Pavlish, have been the Chief Technology Officer and Senior Vice President of Midwest Energy Emissions Corporation since November 16, 2014. Prior to this, I served as an Executive Consultant Advisor to Midwest Energy Emissions Corporation. Prior to joining Midwest Energy Emissions Corporation, I was a Senior Research Advisor and the Director of the Center for Air Toxic Metals Program at the Energy & Environmental Research Center in Grand Forks, North Dakota. I have over 25 years of mercury-related experience and am regarded as an international expert on the topic of mercury. My primary areas of interest and expertise include research, technical consultation and development of mercury control technologies, in particular, for coal combustion and gasification systems. I am an inventor of a number of patented mercury control technologies and have years of experience in development and testing of these technologies for commercial applications. Over the last 15 years, I have spent much time evaluating the efficacy of a number of different mercury control technologies/approaches and their cost competitiveness in the commercial market. I also have years of power plant experience and have worked for an engineering/consulting company, Black & Veatch, where I served as Unit Leader/System Engineer. I am a professional engineer, a member of the American Society of Mechanical Engineers, and a member of the Air & Waste Management Association (A&WMA). I serve on numerous professional and

technical committees and am a U.S. Representative on the Mercury Emissions from Coal International Experts Working Group on Reducing Emissions from Coal and a member of the United Nations Environment Programme Global Mercury Partnership, Reduction of Mercury Releases from Coal Combustion. I have published over 200 papers, articles, and reports on various mercury-related topics and issues.

2. I, Dr. Nicholas Lentz, Field Technical Manager for Midwest Energy Emissions Corporation, have more than 10 years of experience conducting mercury research and tests, both in the lab and in the field with over 30 full-scale mercury test programs and also numerous bench- and pilot-test projects. I am also an expert in the identification and development of new analytical methods for the advancement of elemental and small molecule analysis in a wide range of matrices including coal and coal by-products, CO_2 capture solutions, oil and gas fuels; analysis for combustion flue gas, syngas, fuel oil, and biowaste. Prior to my current position, I was an Associate Director for Energy Technology Applications in the Institute for Energy Studies at the University of North Dakota. I also previously was a Center for Air Toxic Metals (CATM) Program Area Manager and Research Scientist at the Energy & Environmental Research Center where I was responsible for managing a portfolio of measurement-based research projects in the Analytical Measurement Area of CATM as well as experimental design and analysis related control technologies to remove mercury, trace metals, and halogens from combustion and gasification systems. I have a B.S. in Chemistry from Bemidji State University and Ph.D. in Analytical Chemistry from Iowa State University. I have authored and co-authored numerous publications.

3. All websites referenced in this document were accessed 3/15/2019.

4. Merriam-Webster dictionary defines "bromine" as "a nonmetallic halogen element that is isolated as a deep red corrosive toxic volatile liquid of disagreeable odor. See, https://www.merriam-webster.com/dictionary/bromine. Wikipedia defines "bromine" as "...a chemical element with symbol Br and atomic number 35. It is the

third-lightest halogen, and is a fuming red-brown liquid at room temperature that evaporates readily to form a similarly coloured gas." See, https://en.wikipedia.org/wiki/Bromine. Dictionary.com defines "bromine" as "an element that is a dark-reddish, fuming, toxic liquid and a member of the halogen family: obtained from natural brines and ocean water, and used chiefly in the manufacture of gasoline antiknock compounds, pharmaceuticals, and dyes. Symbol: Br; atomic weight: 79.909; atomic number: 35 ...." See, https://www.dictionary.com/browse/bromine.

5. Merriam-Webster dictionary defines "chlorine" as "a halogen element that is isolated as a heavy greenish-yellow diatomic gas of pungent odor and is used especially as a bleach, oxidizing agent, and disinfectant in water purification." See, https://www.merriam-webster.com/dictionary/chlorine. Wikipedia defines "chlorine" as "...a chemical element with symbol Cl and atomic number 17. The second-lightest of the halogens, it appears between fluorine and bromine in the periodic table and its properties are mostly intermediate between them. Chlorine is a yellow-green gas at room temperature." See, https://en.wikipedia.org/wiki/Chlorine. Dictionary.com defines "chlorine" as "a halogen element, a heavy, greenish-yellow, incombustible, water-soluble, poisonous gas that is highly irritating to the respiratory organs, obtained chiefly by electrolysis of sodium chloride brine: used for water purification, in the making of bleaching powder, and in the manufacture both of chemicals that do not contain chlorine, as ethylene glycol, and of those that do. Symbol: Cl; atomic weight: 35.453; atomic number: 17." See, https://www.dictionary.com/browse/chlorine.

6. Encyclopedia Britannica online states that "[a]t room temperature and atmospheric pressure the halogen elements in their free states exist as diatomic molecules." https://www.britannica.com/science/halogen-element. The Chemistry LibreTexts Library states that "[h]alogens form diatomic molecules (of the form X_2, where X denotes a halogen atom) in their elemental states. The bonds in these diatomic molecules are non-polar covalent single bonds" See, https://chem.libretexts.org/Bookshelves/Inorganic_Chemistry/Supplemental_Modules_(I

norganic_Chemistry)/Descriptive_Chemistry/Elements_Organized_by_Block/2_p-Block_Elements/Group_17%3A_The_Halogens/0Group_17%3A_Physical_Properties_of_the_Halogens/Group_17%3A_General_Properties_of_Halogens. ThoughtCo.com states that "[h]alogens range from solid (I_2) to liquid (Br_2) to gaseous (F_2 and Cl_2) at room temperature. As pure elements, they form diatomic molecules with atoms joined by nonpolar covalent bonds." See, https://www.thoughtco.com/halogen-elements-and-properties-606650.

7. Sigma-Aldrich gives the properties of elemental bromine, Br_2 as including a molecular weight of 159.81 g/mol, a boiling point of 58.8 °C, and a melting point of -7.2 °C. See, https://www.sigmaaldrich.com/catalog/product/sigald/207888?lang=en&region=US.

8. Sigma-Aldrich gives the properties of Cl_2 as including a molecular weight of 70.91 g/mol, a boiling point of -34 °C, and a melting point of -101 °C. See, https://www.sigmaaldrich.com/catalog/product/aldrich/295132?lang=en&region=US.

9. Merriam-Webster dictionary defines "bromide" as "1: a binary compound of bromine with another element or a radical including some (such as potassium bromide) used as sedatives." See, https://www.merriam-webster.com/dictionary/bromide. Wikipedia defines "bromide" as "...a chemical compound containing a bromide ion or ligand. This is a bromine atom with an ionic charge of -1 (Br^-); for example, in caesium bromide, caesium cations (Cs^+) are electrically attracted to bromide anions (Br^-) to form the electrically neutral ionic compound CsBr. The term "bromide" can also refer to a bromine atom with an oxidation number of -1 in covalent compounds such as sulfur dibromide (SBr_2).." See, https://en.wikipedia.org/wiki/Bromide. Dictionary.com defines "bromide" as "1. A salt of hydrobromic acid consisting of two elements, one of which is bromine, as sodium bromide, NaBr; 2. A compound containing bromine, as methyl bromide." See, https://www.dictionary.com/browse/bromide.

10. Merriam-Webster dictionary defines "chloride" as "1: a compound of chlorine with another element or group especially:a salt or ester of hydrochloric acid; 2: a monovalent anion consisting of one atom of chlorine." See, https://www.merriam-webster.com/dictionary/chloride. Wikipedia defines "chloride" as "...a compound of chlorine with a salt or ester of hydrochloric acid" and as "...the anion (negatively charged ion) Cl^-." See, https://en.wikipedia.org/wiki/Chloride_(disambiguation) and https://en.wikipedia.org/wiki/Chloride. Dictionary.com defines "chloride" as "1. A salt of hydrochloric acid consisting of two elements, one of which is chlorine, as sodium chloride, NaCl; 2. A compound containing chlorine, as methyl chloride, CH_3Cl." See, https://www.dictionary.com/browse/chloride.

11. Wikipedia defines "hydrogen halides" as "... diatomic inorganic compounds with the formula HX where X is one of the halogens: fluorine, chlorine, bromine, iodine, or astatine. ... Hydrogen halides are gases that dissolve in water to give acids which are commonly known as hydrohalic acids. The direct reaction of hydrogen with fluorine and chlorine gives hydrogen fluoride and hydrogen chloride, respectively. Industrially these gases are, however, produced by treatment of halide salts with sulfuric acid. Hydrogen bromide arises when hydrogen and bromine are combined at high temperatures in the presence of a platinum catalyst. The least stable hydrogen halide, HI, is produced less directly, by the reaction of iodine with hydrogen sulfide or with hydrazine." See, https://en.wikipedia.org/wiki/Hydrogen_halide.

12. Merriam-Webster defines "hydrogen bromide" "a colorless irritating gas HBr that fumes in moist air and yields hydrobromic acid when dissolved in water." See, https://www.merriam-webster.com/dictionary/hydrogen%20bromide. Dictionary.com defines "hydrogen bromide" as "a colorless gas, HBr, having a pungent odor: the anhydride of hydrobromic acid." See, https://www.dictionary.com/browse/hydrogen-bromide. Wikipedia defines "hydrogen bromide" as "...the diatomic molecule with the formula HBr. It is a colorless compound and a hydrogen halide. Hydrobromic acid is a solution of HBr in water. Both the anhydrous and aqueous solutions of HBr are common

reagents in the preparation of bromide compounds. ...Hydrogen bromide (along with hydrobromic acid) is produced by combining hydrogen and bromine at temperatures between 200 and 400 °C. The reaction is typically catalyzed by platinum or asbestos."

13. Merriam-Webster defines "hydrogen chloride" as "a colorless pungent poisonous gas HCl that fumes in moist air and yields hydrochloric acid when dissolved in water." See, https://www.merriam-webster.com/dictionary/hydrogen%20chloride. Dictionary.com "hydrogen chloride" "a colorless gas, HCl, having a pungent odor: the anhydride of hydrochloric acid." Wikipedia defines "hydrogen chloride" as "[t]he compound hydrogen chloride has the chemical formula HCl and as such is a hydrogen halide. At room temperature, it is a colorless gas, which forms white fumes of hydrochloric acid upon contact with atmospheric water vapor. Hydrogen chloride gas and hydrochloric acid are important in technology and industry. Hydrochloric acid, the aqueous solution of hydrogen chloride, is also commonly given the formula HCl. ...pure chlorine gas can be combined with hydrogen to produce hydrogen chloride in the presence of UV light: $Cl_2(g) + H_2(g) \rightarrow 2\ HCl(g)$."

14. Sigma-Aldrich gives the properties of HBr as including a molecular weight of 80.91 g/mol, a boiling point of -67 °C, and a melting point of -87 °C. See, https://www.sigmaaldrich.com/catalog/product/aldrich/295418?lang=en&region=US.

15. Sigma-Aldrich gives the properties of HCl as including a molecular weight of 36.46 g/mol, a boiling point of -85 °C, and melting point of -114 °C. See, https://www.sigmaaldrich.com/catalog/product/aldrich/295426?lang=en&region=US.

16. Wikipedia defines the "octet rule" as "... a chemical rule of thumb that reflects observation that atoms of main-group elements tend to combine in such a way that each atom has eight electrons in its valence shell, giving it the same electron configuration as a noble gas. The rule is especially applicable to carbon, nitrogen, oxygen, and the

halogens, but also to metals such as sodium or magnesium." See, https://en.wikipedia.org/wiki/Octet_rule.

17. As shown by items 3-16 herein, hydrogen halides are diatomic molecules including a halogen atom and a hydrogen atom; in contrast, elemental halogens are diatomic molecules including two of the same halogen atom. HBr and HCl each include a hydrogen atom and one halogen atom, while Br_2 and Cl_2 each include two halogen atoms. Hydrogen halides have different properties than elemental halogens and are therefore different compounds. HBr has a molecular weight of 80.91 g/mol, while Br_2 has a molecular weight of 159.81 g/mol; HBr has a boiling point of -67 °C, while Br_2 has a boiling point of 58.8 °C; HBr has a melting point of -87 °C, while Br_2 has a melting point of -7.2 °C. HCl has a molecular weight of 36.46 g/mol, while Cl_2 has a molecular weight of 70.91 g/mol; HCl has a boiling point of -85 °C, while Cl_2 has a boiling point of 70.91 g/mol; HCl has a melting point of -114 °C, while Cl_2 has a melting point of -101 °C. Hydrogen halides are not part of and cannot be extracted or isolated from elemental halides; rather, only via a chemical reaction that results in a chemical and structural change can hydrogen halides be formed from elemental halides. Hydrogen bromide is produced by reacting hydrogen and Br_2 at about 200-400 °C, a reaction that is typically catalyzed by platinum or asbestos. Hydrogen chloride is produced by reacting hydrogen and chlorine with one another. Therefore, elemental halogens are not hydrogen halides, and do not include hydrogen halides—Br_2 is not HBr and does not include HBr, and Cl_2 is not HCl and does not include HCl.

18. As shown by items 3-16 herein, chlorine has an atomic number of 17, meaning it has 17 protons and 17 electrons, giving it an electron configuration of $1s^2 2s^2 2p^6 3s^2 3p^5$, having 7 electrons in its outer shell. Bromine has an atomic number of 35, meaning it has 35 protons and 35 electrons, giving it an electron configuration of $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^5$, also having 7 electrons in its outer shell. According to the octet rule, a halogen atom desires to fill its outer shell with 8 electrons total by gaining one electron. A halide ion is a halogen atom that has accepted an electron from an

electron doner, in the case of chloride giving it 18 total electrons to give a total charge of -1, and in the case of bromide giving it 36 total electrons to give a total charge of -1. Halogen atoms do not donate electrons to other atoms, because this would result in a halogen atom losing an electron to have 6 electrons in its outer shell, an unstable configuration according to the octet rule. In the case of an elemental halogen, which exists as a diatomic molecule, instead of donating electrons to one another, each halogen atom shares one of its electrons in the outer shell with the other halogen atom via overlapping electron orbitals in a covalent bond, allowing each halogen atom to have a filled octet while the diatomic molecule remains neutrally charged. Therefore, a halogen atom does not donate electrons to another halogen atom to form a halide, and a diatomic halogen molecule never includes a halide; Br_2 is not and does not include Br^-, and Cl_2 is not and does not include Cl^-.

19. As described in the paper "Effect of HBr formation on mercury oxidation via $CaBr_2$ addition to coal during combustion", Y. Yang et al., RSC Adv., 2016, 6, 59009-59015 ("Yang"), in a bench-scale simulated coal-fired power plant, $CaBr_2$ was added in various concentrations to three different types of coal that were combusted and the concentration of HBr and Br_2 in the released combustion gases were analyzed by quantitative gas analysis mass spectrometry. See, Yang at Sections 2.1-2.2. Section 3.4 states at page 59012 bridging to page 59013 that "[t]he results confirmed the generation of HBr in coal-fired flue gas due to the $CaBr_2$ additive in coal, but Br_2 was not detected." Near the end of Section 3.4 at page 59013 Yang states that "[t]he HBr concentration in flue gas increased with increasing amounts of $CaBr_2$ additive...." At the top of the right column on page 59013, Yang proposes the following formula for the generation of HBr from $CaBr_2$: $CaBr_2 + H_2O \rightarrow CaO + HBr$, stating at page 59013 from the left column bridging to the right column that the water is generated by hydrogen-containing organisms in coal during combustion via $C_nH_mOH + O_2 \rightarrow H_2O + CO_2$.

20. As described in the paper "Mercury control evaluation of calcium bromide injection into a PRB-fired furnace with an SCR", M. Berry, Proceedings of the Air

Quality VI Conference, Arlington, VA, 2007 ("Berry"), a $CaBr_2$ was injected at various concentrations into the furnace of a full-scale coal-fired power plant and the concentration of HBr in the released combustion gases were analyzed at the ESP inlet and at the ESP outlet. Berry found that HBr content increased with increasing calcium bromide injection. See, Berry at page 5, top two paragraphs and Figure 3.

21. As described in the book "Coal Combustion Products (CCPs) Characteristics, Utilization, and Beneficiation", T. Robl et al., Woodhead Publishing, 2017, ("Robl"), at page 91, last full paragraph and last partial paragraph:

> As described previously, eastern coals with a higher chlorine content produce mostly oxidized mercury in their flue gases, while western coals, such as PRB coals, that have a low chlorine content tend to produce mostly elemental mercury. ...
>
> Halogen salts such as calcium chloride ($CaCl_2$), calcium bromide ($CaBr_2$), or potassium iodide (KI) can be added to the coal as a means of supplementing the coal chlorine content. Salts added with the coal or injected into the furnace decompose at furnace temperatures to form vapor-phase acids (HCl, hydrogen bromide (HBr), or hydrogen iodide (HI)) in the flue gas.

22. Typical temperatures in a coal-combustion furnace range from 2,400-4,200 °F, with internal flame temperatures reaching 4,000-4,200 °F or higher. Table 1 lists select halide salt boiling points. Coal-combustion furnace temperatures are higher than the boiling points of halide salts such as NaBr and $CaBr_2$. Thus, the conditions and environment inside the furnace/boiler are adequate for boiling of halide salts (whether in a solid state, in a liquid solution, or as part of the coal) to form gaseous molecules.

Table 1. Common Halide Salt Boiling Points.[1]

Compound	Boiling point, °F
NaBr	2,534
NaCl	2,669
NaI	2,379
$CaCl_2$	3,516
$CaBr_2$	3,299
CaI	2,012
NH_4Br	745
NH_4Cl	640
NH_4I	761

23. The FactSage program (see, http://www.factsage.com/) is one of the largest fully integrated database computing systems for chemical thermodynamics calculations. The FactSage program is a series of information, database, calculation, and manipulation modules that access databases containing properties of materials. The FactSage program can calculate the conditions for multiphase, multicomponent equilibria, with a wide variety of tabular and graphical output modes, under a large range of constraints. Equilibrium calculations performed by the FactSage program can be used to determine equilibrium molecular decomposition states as a function of temperature. These thermodynamic models can be used to predict the chemical species that will be present to react with other molecules present in the flue gas at the same time, such as radicals, ionic compounds, elemental forms of chemical elements, and the like. FactSage was used to calculate equilibrium concentrations of materials present for a 100 g solid NaBr sample in a coal-combustion furnace as a function of temperature, shown in Figure 1. Figure 1 clearly shows the rapid emergence of gaseous NaBr molecules once the NaBr boiling point of 2,530 °F is reached. At temperatures of around 3,000 °F, nearly all the solid NaBr has been converted to gas phase NaBr molecules. As the gas phase NaBr molecules are brought to temperatures beyond 3,000 °F, dissociation into gaseous sodium atoms and bromine atoms occurs.

[1] Lide, D.R., 1995, CRC handbook of chemistry and physics: a ready-reference book of chemical and physical data, CRC press.

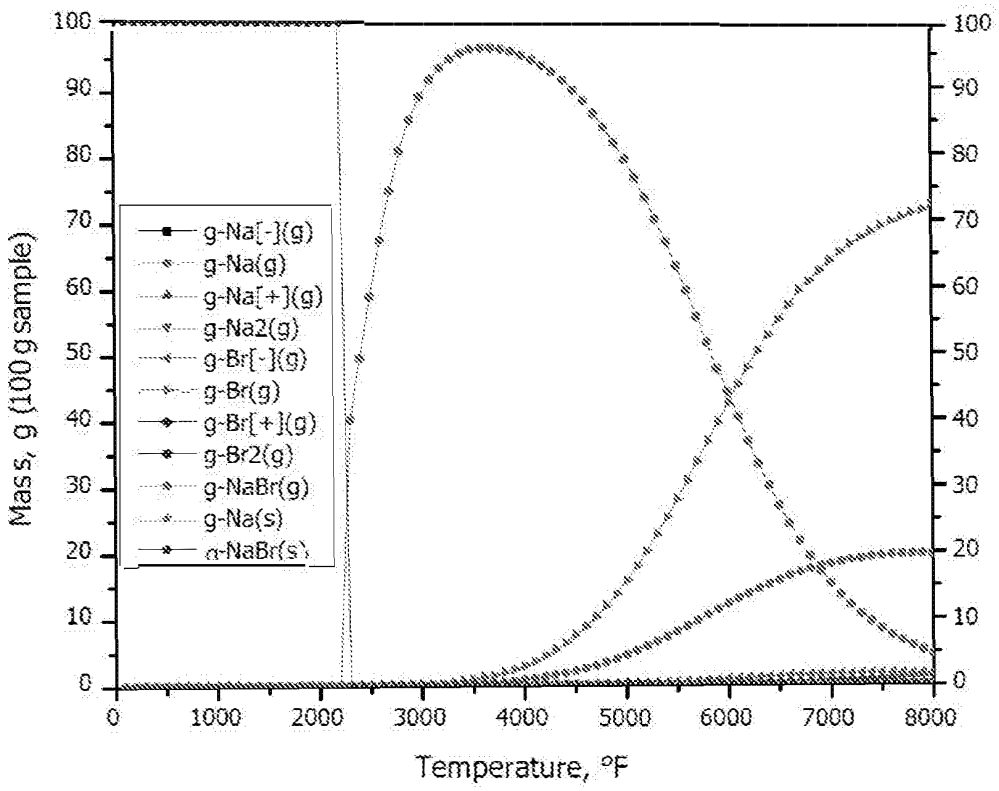


Figure 1. NaBr FactSage equilibrium calculation.

24. Not shown in Figure 1, the gaseous NaBr reacts with water molecules in the flue gas to form HBr, via $NaBr + H_2O \rightarrow NaOH + HBr$, see, Yang and discussion thereof at item 19 herein. The HBr is then available to react with Hg^0 released by the coal and with activated carbon sorbent that has been introduced further downstream into the flue gas.

25. The effect of chlorides in coal on flue gas HCl content has been studied much more than the effect of bromides on coal on flue gas HBr content, due in part to federal HCl emission regulations. Chlorides, like bromides, also exhibit a similar transformation to hydrogen chloride in coal combustion flue gas, see, Robl and discussion thereof at item 21 herein. Hydrogen chloride, as an acid gas, is one of the emission categories that the EPA regulates through the Mercury Air Toxics Standards (MATS)[2]. The MATS includes specific HCl limits that power plants must comply with by performing quarterly EPA

[2] https://www.epa.gov/mats

Method 26(A)[3] stack sampling to verify compliance. Inorganic and organically bound chlorides in the coal are volatilized and decomposed in the furnace and form HCl in the flue gas.

26. As shown in the report "Pilot- and full-scale demonstration of advanced mercury control technologies for lignite-fired power plants", S. Benson et al., Energy & Environmental Research Center, Final report, U.S. Department of Energy, National Energy Technology Laboratory, February 2005 ("Benson 1"), at figure 31 on page 37, addition of NaCl to lignite coal in a pilot-scale coal combustion system caused an increased HCl concentration in the flue gas. The HCl concentration in the flue gas increased with increased amounts of NaCl on the coal. Benson 1 shows at figure 36 on page 41 that addition of $CaCl_2$ to the coal caused increased HCl concentration in the flue gas. The HCl concentration in the flue gas increased with increasing amounts of $CaCl_2$ on the coal. Figures 31 and 36 of Benson 1 are reproduced below.

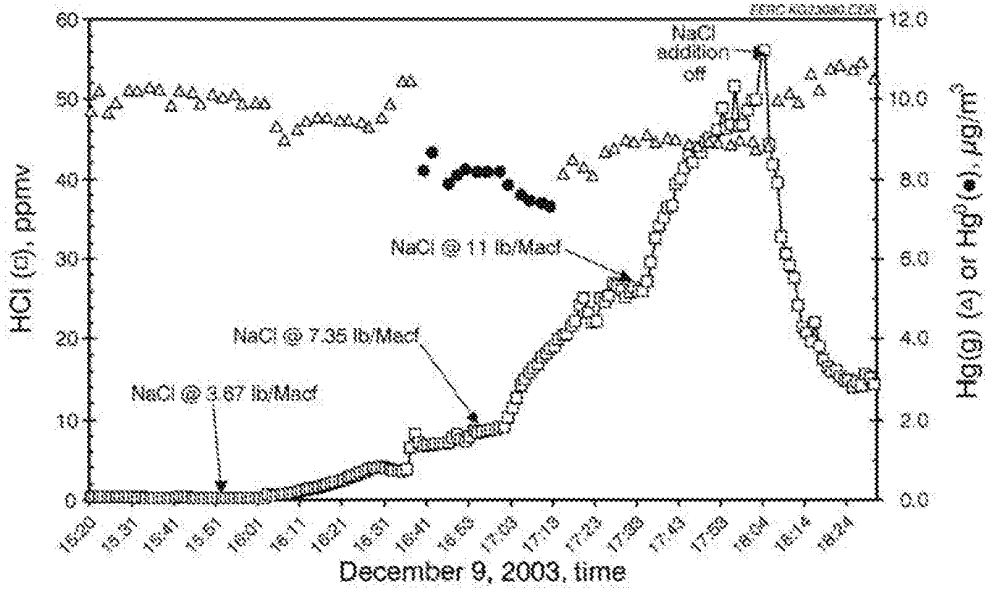


Figure 31. Temporal variations in SDA inlet HCl and FF outlet Hg(g) and Hg^0 concentrations as NaCl was added to the Center lignite coal.

[3] https://www.epa.gov/emc/method-26a-hydrogen-halide-and-halogen-isokinetic-method

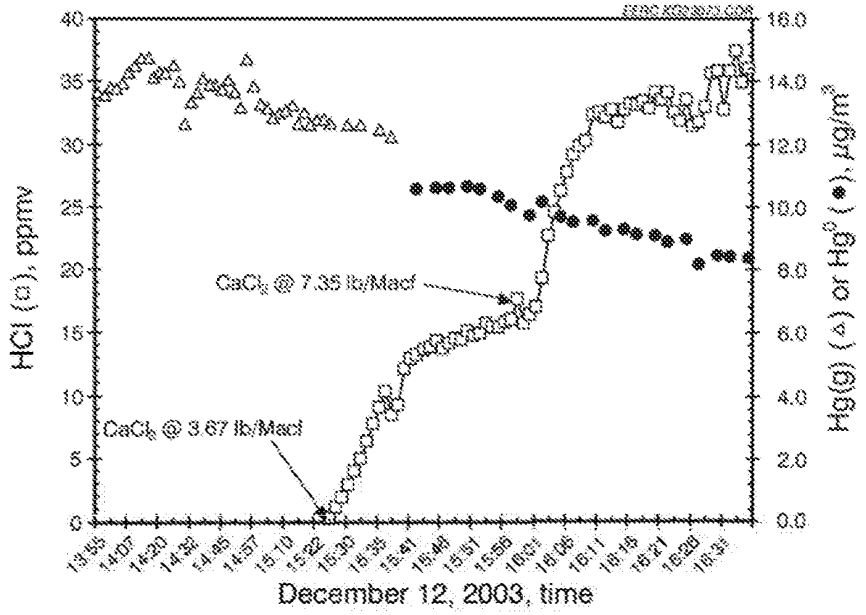


Figure 36. Temporal variations in SDA inlet HCl and FF outlet Hg(g) and Hg^0 concentrations during $CaCl_2$ additions to the Center lignite coal.

27. As shown in the report "JV Task 73----Mercury control technologies for electric utilities burning subbituminous coals", S. Benson et al., Energy and Environmental Research Center, Draft final report, June 2005 ("Benson 2"), at figure 11-11 at page 48, addition of $CaCl_2$ to subbituminous coal in a pilot-scale coal combustion system caused an increased HCl concentration in the flue gas. The HCl concentration in the flue gas increased with increased amounts of $CaCl_2$ on the coal. Figure 11-11 of Benson 2 is reproduced below.

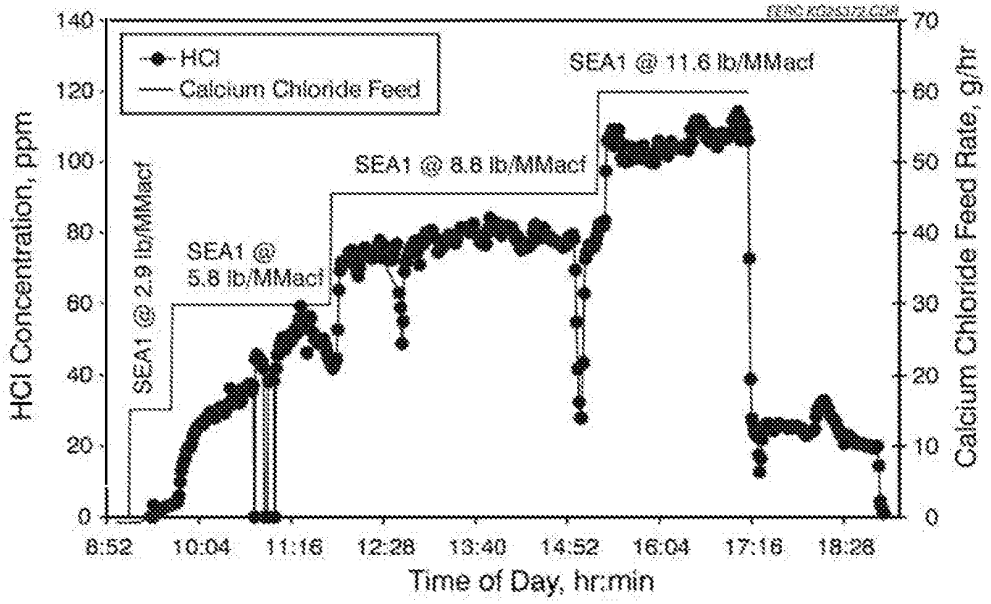


Figure 11-11. Temporal variations in ESP outlet HCl concentrations and SEA1 ($CaCl_2$) addition rates.

28. As shown by items 19-27 herein, in a coal-fired power plant, placing halide salts on the coal or in the combustion chamber results in formation of gaseous halide salt in the flue gas and formation of the respective hydrogen halide in the flue gas. Placing bromide salts such as NaBr or $CaBr_2$ on the coal or in the combustion chamber results in formation of gaseous NaBr or $CaBr_2$ in the flue gas, as well as formation of HBr in the flue gas. Likewise, placing chloride salts such as NaCl or $CaCl_2$ on coal or in the combustion chamber results in formation gasoues NaCl or $CaCl_2$ in the flue gas, as well as the formation of HCl in the flue gas.

29. Wikipedia defines "salt" as "...an ionic compound that can be formed by the neutralization reaction of an acid and a base. Salts are composed of related numbers of cations (positively charged ions) and anions (negative ions) so that the product is electrically neutral (without a net charge). These component ions can be inorganic, such as chloride (Cl^-), or organic, such as acetate ($CH_3CO_2^{-1}$); and can be monatomic, such as

fluoride (F^-), or polyatomic, such as sulfate (SO_4^{-2})." See, https://en.wikipedia.org/wiki/Salt_(chemistry).

30. Dictionary.com defines "bromide" as "Wikipedia defines "NaBr" as "a salt of hydrobromic acid consisting of two elements, one of which is bromine, as sodium bromide, NaBr." See, https://www.dictionary.com/browse/bromide.

31. Dictionary.com defines "salt" as "a Wikipedia defines "NaCl" as "a crystalline compound, sodium chloride, NaCl, occurring as a mineral, a constituent of seawater, etc., and used for seasoning food, as a preservative, etc." See, https://www.dictionary.com/browse/salt?s=t.

32. Sigma-Aldrich has an online products page entitled "Sodium Salts" that includes sodium bromide and sodium chloride. See, https://www.sigmaaldrich.com/materials-science/material-science-products.html?TablePage=19295381.

33. As shown by items 29-32 herein, NaBr is a salt that includes Na^+ ions and Br^- ions. NaCl is a salt that includes Na^+ ions and Cl^- ions. $CaBr_2$ is a salt that includes Ca^+ ions and Br^- ions. $CaCl_2$ is a salt that includes Ca^+ ions and Cl^- ions.

34. We further declare that all statements made herein of my own knowledge are true, and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by a fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application and/or any patent issued thereon.

Dated: March 20, 2019 By: / John Pavlish /

John Pavlish

Dated: March 15, 2019 By: / Nicholas Lentz /

Nicholas Lentz

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Inventor(s): Edwin S. Olson et al.	Examiner: AMBER ROSE ORLANDO
Application No.: 15/978,760	Group Art Unit: 1776
Filed: May 14, 2018	Docket No.: 4820.007US4
Confirmation No.: 6432	
Title: SORBENTS FOR THE OXIDATION AND REMOVAL OF MERCURY	

DECLARATION UNDER 37 C.F.R. § 1.132

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

DECLARATION B

I, John Pavlish, declare and say as follows:

1. I have been the Chief Technology Officer and Senior Vice President of Midwest Energy Emissions Corporation since November 16, 2014. Prior to this, I served as an Executive Consultant Advisor to Midwest Energy Emissions Corporation. Prior to joining Midwest Energy Emissions Corporation, I was a Senior Research Advisor and the Director of the Center for Air Toxic Metals Program at the Energy & Environmental Research Center in Grand Forks, North Dakota. I have over 25 years of mercury-related experience and am regarded as an international expert on the topic of mercury. My primary areas of interest and expertise include research, technical consultation and development of mercury control technologies, in particular, for coal combustion and gasification systems. I am an inventor of a number of patented mercury control technologies and have years of experience in development and testing of these technologies for commercial applications. Over the last 15 years, I have spent much time evaluating the efficacy of a number of different mercury control technologies/approaches and their cost competitiveness in the commercial market. I also have years of power plant experience and have worked for an engineering/consulting company, Black & Veatch, where I served as Unit Leader/System Engineer. I am a professional engineer, a member of the American Society of Mechanical Engineers, and a member of the Air & Waste Management Association (A&WMA). I serve on numerous professional and

technical committees and am a U.S. Representative on the Mercury Emissions from Coal International Experts Working Group on Reducing Emissions from Coal and a member of the United Nations Environment Programme Global Mercury Partnership, Reduction of Mercury Releases from Coal Combustion. I have published over 200 papers, articles, and reports on various mercury-related topics and issues.

2. U.S. patent publication no. 2004/0003716 ("Nelson") describes treatment of activated carbon outside the flue gas with hydrogen bromide (HBr), and describes testing to measure the percent mercury removal when the treated activated carbon was injected into either simulated or actual flue gas at various injection rates. Specifically, Nelson performed experiments in Example 5 (paragraphs [0082]-[0085]) and 7 (paragraphs [0089]-[0092]), and provides the data in FIG. 14 and FIG. 15.

3. In Example 5, Nelson treated Norit DARCO® FGD with gaseous HBr, and tested its use by injecting the HBr-treated sorbent into a simulated coal-fired flue-gas stream in a pilot-scale test system. Nelson's FIG. 14 shows data for one activated carbon sample treated with HBr. The activated carbon had 10 wt% HBr, and at a sorbent injection rate of about 3.7 lb/MMacf gave a mercury removal of about 82%.

4. In Example 7, Nelson treated Norit DARCO® FGD with gaseous HBr, and tested its use in a coal-fired power plant by injecting the treated sorbent into the flue gas prior to the electrostatic precipitator (ESP). Nelson's FIG. 15 shows data for two activated carbon samples treated with HBr. The two activated carbon samples contained 9 wt% HBr. The data in FIG. 15 for the two HBr-treated sorbents show that at a sorbent injection rate of about 2.2 lb/MMacf, 45% of the mercury was removed, and at a sobent injection rate of about 4.2 lb/MMacf, 62% of the mercury was removed.

5. The percent mercury removal, and the percent mercury removal per 1 wt% HBr additive on the sorbent, versus the sorbent injection rate for Nelson's HBr-treated activated carbon formed in Nelson's Examples 5 and 7 is given in the table below. The

percent mercury removal per 1 wt% HBr was calculated as the percent mercury removal divided by the HBr wt% on the sorbent. The units "lb/MMacf" are pounds of sorbent per 1 million actual cubic feet of flue gas.

Sample	Additive	Sorbent Description	Sorbent Injection Rate (lb/MMacf)	HBr wt% on Sorbent	%Hg Removal	%Hg Removal per 1 wt% HBr on Sorbent
N1	HBr outside flue gas	Norit DARCO® FGD	3.7	10	82	8.2
N2	HBr outside flue gas	Norit DARCO® FGD	2.2	9	45	5.0
N3	HBr outside flue gas	Norit DARCO® FGD	4.2	9	62	6.8

6. A bromine-treated activated carbon was prepared by exposing activated carbon (Norit DARCO® Hg, an activated carbon that a Norit Americas technical representative told me was rebranded for mercury control applications and was previously referred to as Norit DARCO® FGD) to gaseous bromine. A cement mixer was used to expose the activated carbon to the bromine gas. Tumbling vanes produced a dispersion of the activated carbon within the barrel. A cover was fit over the opening to keep the activated carbon dispersion inside the barrel. In the center of the lid, a small hole was drilled, and a tube extended to the center of the barrel. The tube was attached to a source of bromine vapor (Br_2) in dry nitrogen via a swivel so that the tube in the barrel would rotate and the tube to the source would be stationary. A charge of 1 to 5 kg of the activated carbon was weighed and transferred to the barrel. The weight of bromine transferred to the barrel was equal to 5 weight % of the amount of activated carbon.

7. An HCl-treated activated carbon was prepared by exposing activated carbon (Norit DARCO® Hg) to gaseous HCl. The carbon was weighed and added to a flask which was attached to a rotary apparatus. A hard-plastic tube was inserted into the

condenser end of the apparatus for introduction of the HCl/nitrogen gas mix. This extended to the center of the flask. HCl from a cylinder was run through a flow meter and mixed with a low flow of nitrogen in a T-tube attached to the inlet tube. The flow rate was set to provide 5 wt % HCl over 15 minutes exposure. The flask was slowly rotated in the apparatus at room temperature so that the carbon turned over but did not exit the flask. After the exposure period, the HCl flow was stopped and the HCl-treated activated carbon was removed.

8. A pilot-scale 550,000-Btu/hr pulverized coal (pc)-fired test unit was used to combust subbituminous coal and test mercury control using various sorbents. The coal combustion flue gas exiting the pilot unit was cooled down to a nominal temperature of 149°C (300°F) and then was introduced into a single wire tubular ESP unit. Activated carbon sorbents were fed with a K-Tron dual-screw feeder upstream of the ESP. The feeder was calibrated prior to the start of each carbon injection test. No scrubber was used. Before Hg control testing began, a baseline condition was established with the pilot-scale unit, and flue gas mercury content was measured before each test as about 6-10 $\mu g/m^3$. The flue gas HCl concentration, with no additives on the coal, as calculated by the chlorine measured in the coal, was 2-5 ppm. Percent mercury removal was then measured for the activated carbon alone (untreated), the activated carbon treated with Br_2 outside the flue gas described herein at item 6 as per the Nelson procedure, and with sodium bromide (NaBr) or sodium chloride (NaCl) added to coal prior to introduction to the furnace with injection of untreated activated carbon into the flue gas.

9. The results of the pilot-scale test with untreated activated carbon and with the activated carbon treated with Br_2 outside the flue gas described herein at item 6 are given in the table below.

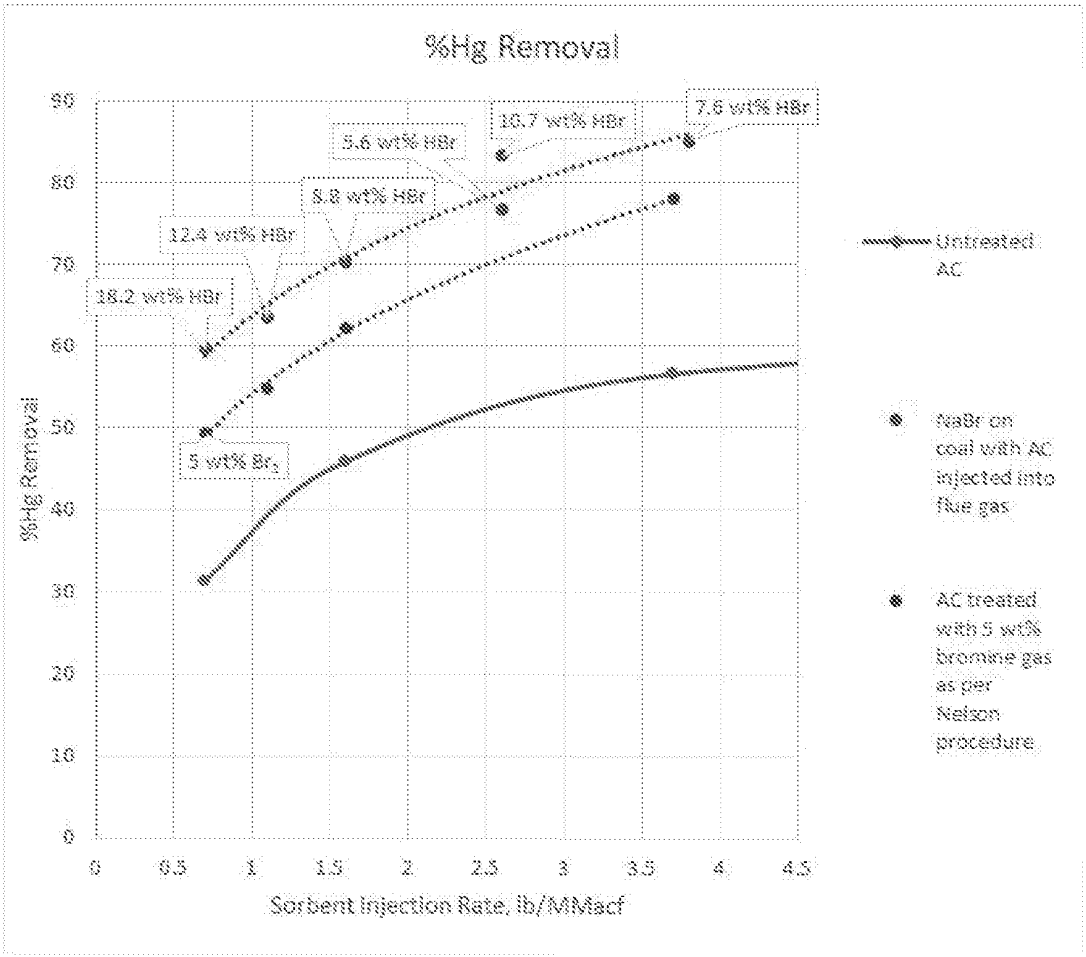
Sample	Additive	Sorbent Description	Sorbent Injection Rate (lb/MMacf)	Br_2 wt% on Sorbent	%Hg Removal
1	None	Norit DARCO® Hg	0.7	0	31.4
2	None	Norit DARCO® Hg	1.6	0	45.9
3	None	Norit DARCO® Hg	3.7	0	56.6
4	None	Norit DARCO® Hg	9.2	0	61.2
5	None	Norit DARCO® Hg	25.7	0	62.5
6	Br_2 outside flue gas	Norit DARCO® Hg	0.7	5	49.5
7	Br_2 outside flue gas	Norit DARCO® Hg	1.1	5	54.9
8	Br_2 outside flue gas	Norit DARCO® Hg	1.6	5	62.2
9	Br_2 outside flue gas	Norit DARCO® Hg	3.7	5	78.1

10. The results from the pilot-scale test with sorbent enhancement additives (SEAs) NaBr or NaCl added to coal along with injection of untreated activated carbon into the flue gas, and with the activated carbon treated with HCl outside the flue gas described at item 7, are given in the table below. The bromide (Br^-) or chloride (Cl^-) injection rate was calculated as the SEA injection rate times the fraction of the additive (based on molecular weight) that is Br^- or Cl^-; for Br^-, Br^-/NaBr = 79.904/(79.904+22.9898) = 0.7766; for Cl^-, Cl^-/NaCl = 35.453/(35.453+22.9898) = 0.6066. The HBr or hydrogen chloride (HCl) equivalent injection rate was calculated as the Br^- or Cl^- injection rate times the molecular weight ratio of HBr/Br^- or of HCl/Cl^-; for HBr/Br^-, this is (1.00794+79.904)/79.904 = 1.013; for HCl/Cl^-, this is (1.00794+35.453)/35.453 = 1.028. The equivalent HBr or HCl wt% on sorbent was calculated as the HBr or HCl injection rate divided by the sum of the sorbent injection rate and the HBr or HCl injection rate (e.g., 100% of the HBr or HCl was assumed to react with the sorbent). The percent mercury removal per 1 wt% HBr or HCl was calculated as the percent mercury removal divided by the HBr wt% or HCl wt% on sorbent.

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Sample	Additive	Additive injection rate (lb/MMacf)	Sorbent description	Sorbent injection rate (lb/MMacf)	Br or Cl injection rate (lb/MMacf)	HBr or HCl equivalent injection rate (lb/MMacf)	Equivalent HBr or HCl wt% on sorbent	%Hg removal	%Hg removal per 1 wt% HCl or HBr on sorbent	Milligrams HBr or HCl/MMacf per 1% Hg Removal
13	NaBr on coal	0.2	Norit DARCO® Hg	0.7	0.16	0.16	18.2	59.8	3.3	1211
14	NaBr on coal	0.2	Norit DARCO® Hg	1.1	0.16	0.16	12.4	63.6	5.1	1139
15	NaBr on coal	0.2	Norit DARCO® Hg	1.6	0.16	0.16	8.8	70.4	18.0	1029
16	NaBr on coal	0.2	Norit DARCO® Hg	2.6	0.16	0.16	5.6	76.7	13.6	944
17	NaBr on coal	0.4	Norit DARCO® Hg	2.6	0.31	0.31	10.7	83.3	7.8	1739
18	NaBr on coal	0.4	Norit DARCO® Hg	3.8	0.31	0.31	7.6	85.1	11.3	1702
19	NaCl on coal	2.4	Norit DARCO® Hg	0.7	1.46	1.50	67.5	60.6	0.9	11202
20	NaCl on coal	3.4	Norit DARCO® Hg	0.7	2.06	2.12	74.7	61.2	0.8	15714
21	NaCl on coal	4.9	Norit DARCO® Hg	0.7	2.97	3.06	80.9	57.8	0.7	23979
22	NaCl on coal	4.9	Norit DARCO® Hg	1.1	2.97	3.06	73.0	67.4	0.9	20564
23	NaCl on coal	4.9	Norit DARCO® Hg	1.6	2.97	3.06	65.0	69.6	1.1	19914
24	NaCl on coal	6.9	Norit DARCO® Hg	1.6	4.19	4.30	72.3	71.2	1.0	27412
25	HCl outside flue gas	0	Norit DARCO® Hg	0.7	0.04	0.04	5.0	27.9	5.6	569
26	HCl outside flue gas	0	Norit DARCO® Hg	1.6	0.08	0.08	5.0	34.2	6.8	1061
27	HCl outside flue gas	0	Norit DARCO® Hg	2.6	0.13	0.13	5.0	35.1	7.0	1680
28	HCl outside flue gas	0	Norit DARCO® Hg	4.9	0.24	0.25	5.0	40.3	8.1	2757
29	HCl outside flue gas	0	Norit DARCO® Hg	7.7	0.37	0.39	5.0	43.9	8.8	3978
30	HCl outside flue gas	0	Norit DARCO® Hg	15.5	0.75	0.78	5.0	52.9	10.6	6645

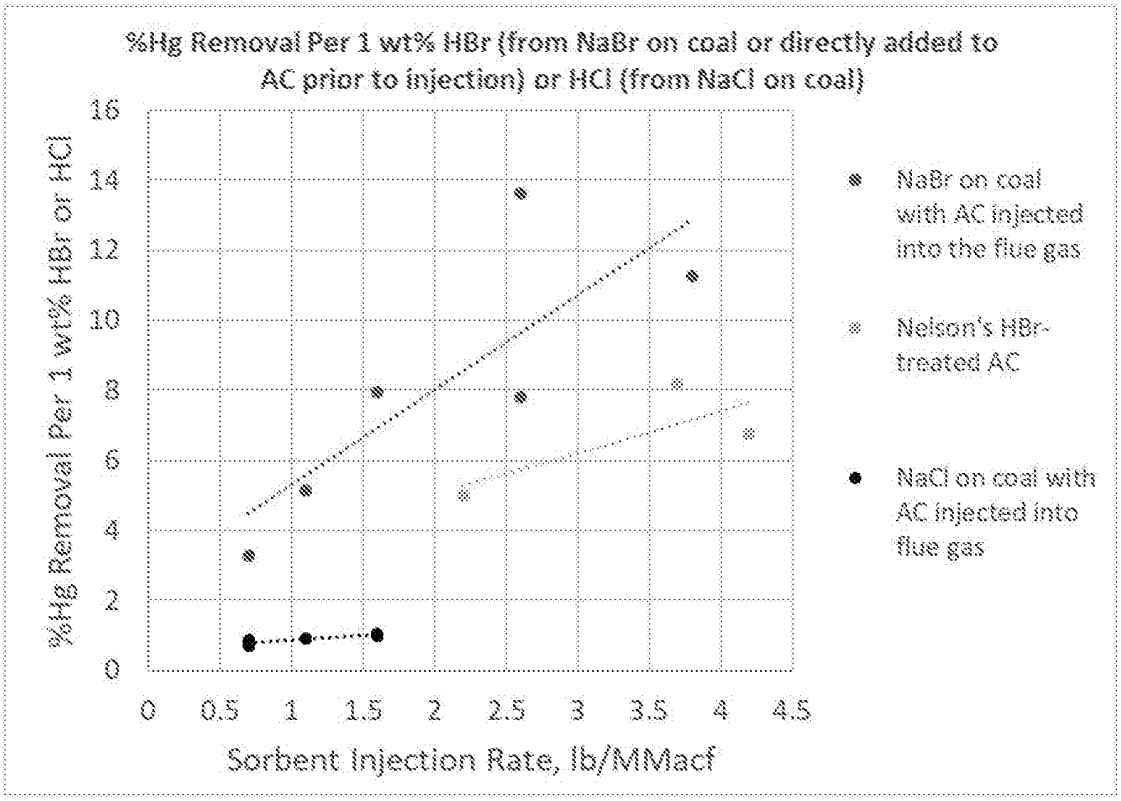
11. The following plot shows the percent mercury removal versus the sorbent injection rate for the activated carbon alone (untreated), the activated carbon treated with Br_2 outside the flue gas described herein at item 6 as per the Nelson procedure, and for NaBr added to coal prior to introduction to the furnace with injection of untreated activated carbon into the flue gas. All of the data in the following plot is taken from the data in the tables at item 9 and 10, which was produced using the same pilot-scale setup described at item 8.

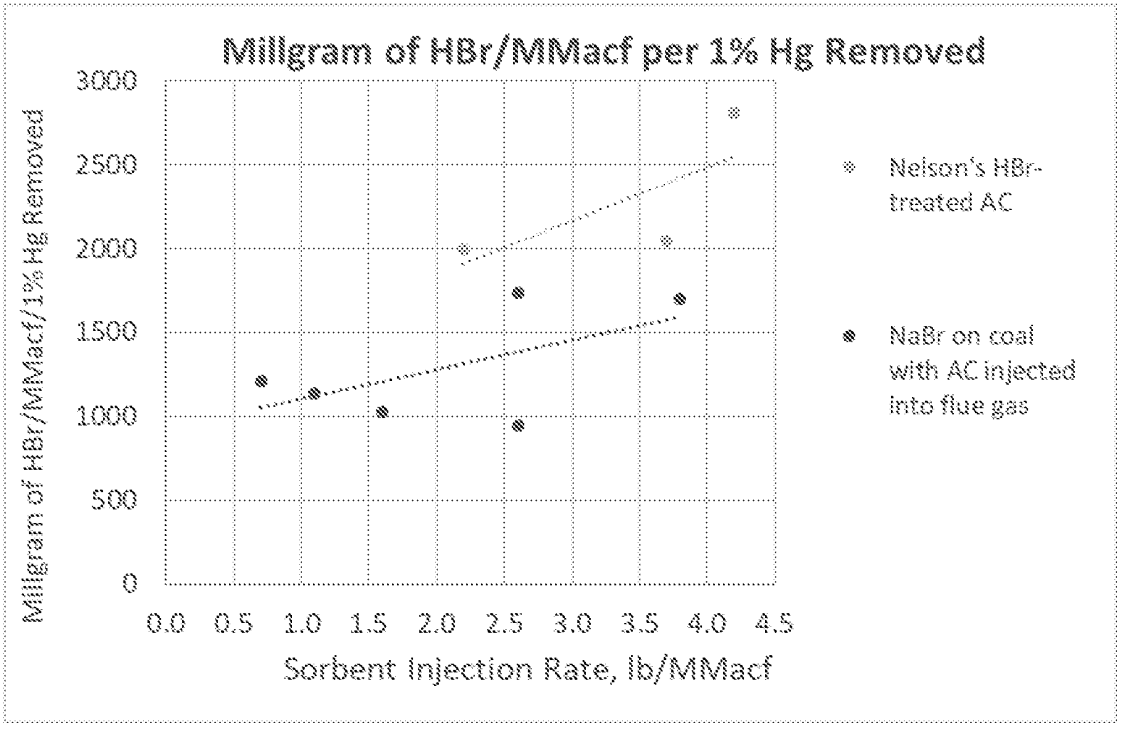


12. The data in the plot above show that the NaBr added to coal prior to introduction to the furnace with injection of untreated activated carbon into the flue gas (in-flight promotion with Br^-) provided a higher percent of mercury removal at all tested sorbent

injection rates as compared to the activated carbon alone (untreated) and compared to the activated carbon treated with Br_2 outside the flue gas described herein at item 6 as per the Nelson procedure. With NaBr added to the coal and activated carbon injected into the flue gas, there was a significant reduction in the amount of sorbent required to acheive similar mercury removal compared to the activated carbon treated with Br_2 outside the flue gas. For example, to acheive 70% mercury removal, 2.5 lb/MMacf of Br_2-treated carbon was required, as compared to 1.6 lb/MMacf with NaBr added to the coal and activated carbon injected into the flue gas; an additional (2.5-1.6/1.6)*100% or 56% treated sorbent was required to achieve the same leval of mercury removal.

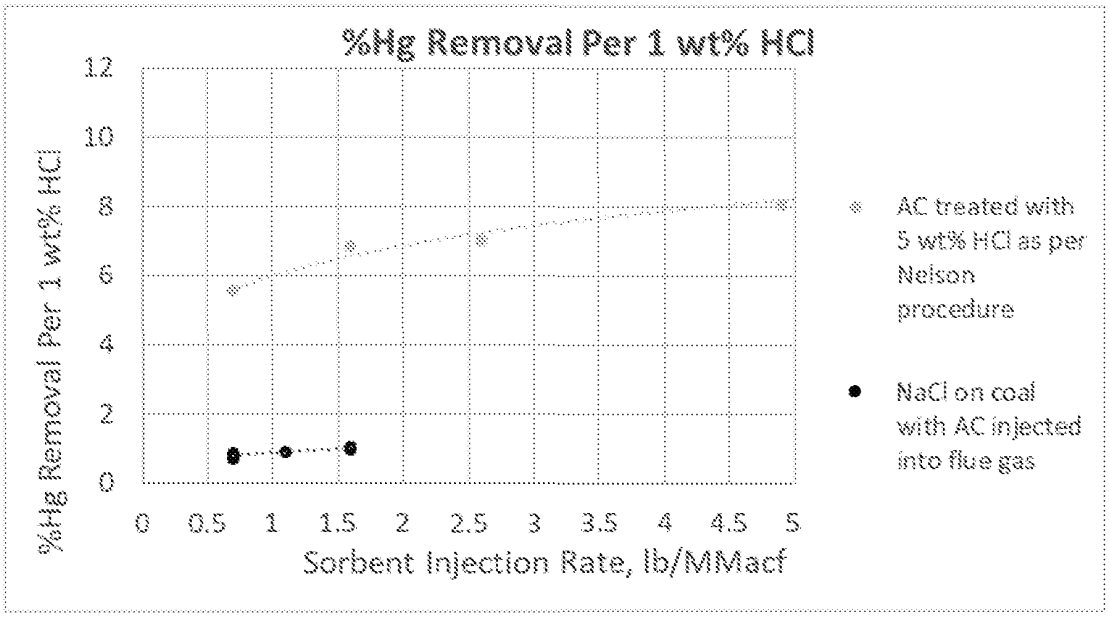
13. The following first plot shows the percent mercury removal per 1 wt% HBr or HCl versus the sorbent injection rate with NaBr or NaCl added to coal prior to introduction to the furnace with injection of untreated activated carbon into the flue gas, and for Nelson's activated carbon treated with HBr outside the flue gas. The following second plot shows the milligrams of HBr/MMacf per 1% mercury removal versus the sorbent injection rate with NaBr added to coal prior to introduction to the furnace with injection of untreated activated carbon into the flue gas, and for Nelson's activated carbon treated with HBr outside the flue gas; NaCl added to coal prior to introduction to the furnace with injection of untreated activated carbon into the flue gas was omitted from this plot because the values for the milligrams of HCl/MMacf per 1% mercury removal were so high (about 10,000 to 30,000). The data sets in the following first and second plots "NaBr on coal with AC injected into the flue gas" and "NaCl on coal with AC injected into flue gas" are taken from the data in table at item 10, which was produced using the same pilot-scale setup described at item 8. The data set in the following first and second plots "Nelson's HBr-treated AC" is taken from the table at item 5, which is from Nelson's experimental setup.

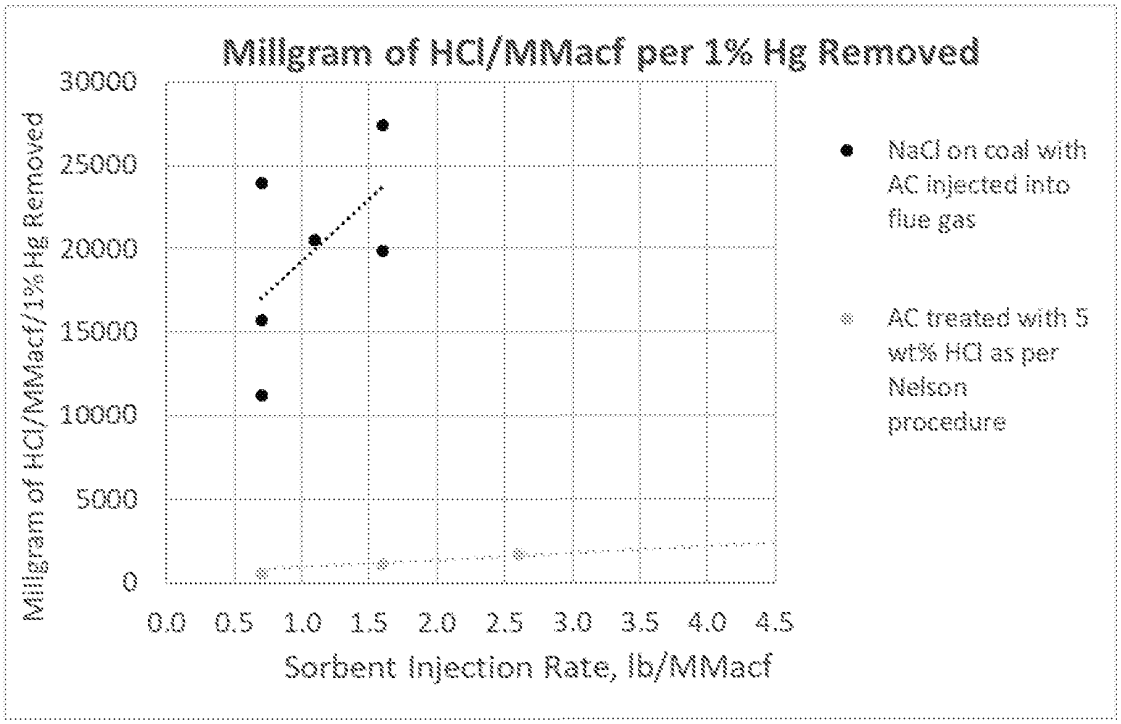

%Hg Removal Per 1 wt% HBr (from NaBr on coal or directly added to AC prior to injection) or HCl (from NaCl on coal)
%Hg Removal Per 1 wt% HBr or HCl
16
14
12
10
8
6
4
2
0
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
Sorbent Injection Rate, lb/MMacf
NaBr on coal with AC injected into the flue gas
Nelson's HBr-treated AC
NaCl on coal with AC injected into flue gas


Millgram of HBr/MMacf per 1% Hg Removed
Millgram of HBr/MMacf/1% Hg Removed
3000
2500
2000
1500
1000
500
0
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
Sorbent Injection Rate, lb/MMacf
Nelson's HBr-treated AC
NaBr on coal with AC injected into flue gas

14. The data in the first plot above show that the NaBr added to coal prior to introduction to the furnace with injection of untreated activated carbon into the flue gas provided a significantly higher (about 2x) percent mercury removal per 1 wt% HBr at all tested sorbent injection rates as compared to Nelson's activated carbon treated with HBr outside the flue gas. Further, the data show that NaBr added to coal prior to introduction to the furnace with injection of untreated activated carbon into the flue gas provided a significantly higher (about 6-8x) percent mercruy removal per 1 wt% HBr or HCl at all tested sorbent injection rates compared to the NaCl added to coal prior to introduction to the furnace with injection of untreated activated carbon into the flue gas. The data in the second plot above shows that NaBr added to coal prior to introduction to the furnace with injection of untreated activated carbon into the flue gas provided a significantly lower milligrams of HBr/MMacf per 1% mercury removal at all tested sorbent injection rates as compared to Nelson's activated carbon treated with HBr outside the flue gas, indicating more efficient (approximately 2x) use of HBr for mercury removal during in-flight promotion of activated carbon than treatment of activated carbon outside the flue gas.

15. The following first plot shows the percent mercury removal per 1 wt% HCl versus the sorbent injection rate for NaCl added to coal prior to introduction to the furnace with injection of untreated activated carbon into the flue gas, and for the activated carbon treated with HCl outside the flue gas described herein at item 7 as per the Nelson procedure. The following second plot shows the milligrams of HCl/MMacf per 1% mercury removal versus the sorbent injection rate with NaCl added to coal prior to introduction to the furnace with injection of untreated activated carbon into the flue gas, and for the activated carbon treated with HCl outside the flue gas described herein at item 7 as per the Nelson procedure. The data sets in the following first and second plots are taken from the data in table at item 10, which was produced using the same pilot-scale setup described at item 8.





16. The data in the first plot above show that activated carbon treated with HCl outside the flue gas as per the Nelson procedure provided a much higher percent of mercury removal per 1 wt% HCl at all tested sorbent injection rates as compared to NaCl

added to coal prior to introduction to the furnace with injection of untreated activated carbon into the flue gas. The data in the second plot above show that the milligrams of HCl/MMacf per 1% mercury removal versus the sorbent injection rate with NaCl added to coal prior to introduction to the furnace with injection of untreated activated carbon into the flue gas was significantly higher as compared to the activated carbon treated with HCl outside the flue gas described herein at item 7 as per the Nelson procedure, indicating more efficient use of HCl for mercury removal by treatment of activated carbon outside the flue gas than by promotion in-flight.

17. I further declare that all statements made herein of my own knowledge are true, and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by a fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application and/or any patent issued thereon.

Dated: March 20, 2019 By: / John Pavlish /

John Pavlish

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Inventor(s): Edwin S. Olson et al.	Examiner: AMBER ROSE ORLANDO
Application No.: 15/978,760	Group Art Unit: 1776
Filed: May 14, 2018	Docket No.: 4820.007US4
Confirmation No.: 6432	
Title: SORBENTS FOR THE OXIDATION AND REMOVAL OF MERCURY	

DECLARATION UNDER 37 C.F.R. § 1.132

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

DECLARATION A

I, John Pavlish, declare and say as follows:

1. I have been the Chief Technology Officer and Senior Vice President of Midwest Energy Emissions Corporation since November 16, 2014. Prior to this, I served as an Executive Consultant Advisor to Midwest Energy Emissions Corporation. Prior to joining Midwest Energy Emissions Corporation, I was a Senior Research Advisor and the Director of the Center for Air Toxic Metals Program at the Energy & Environmental Research Center in Grand Forks, North Dakota. I have over 25 years of mercury-related experience and am regarded as an international expert on the topic of mercury. My primary areas of interest and expertise include research, technical consultation and development of mercury control technologies, in particular, for coal combustion and gasification systems. I am an inventor of a number of patented mercury control technologies and have years of experience in development and testing of these technologies for commercial applications. Over the last 15 years, I have spent much time evaluating the efficacy of a number of different mercury control technologies/approaches and their cost competitiveness in the commercial market. I also have years of power plant experience and have worked for an engineering/consulting company, Black & Veatch, where I served as Unit Leader/System Engineer. I am a professional engineer, a member of the American Society of Mechanical Engineers, and a member of the Air & Waste Management Association (A&WMA). I serve on numerous professional and

technical committees and am a U.S. Representative on the Mercury Emissions from Coal International Experts Working Group on Reducing Emissions from Coal and a member of the United Nations Environment Programme Global Mercury Partnership, Reduction of Mercury Releases from Coal Combustion. I have published over 200 papers, articles, and reports on various mercury-related topics and issues.

2. Herein, when I refer to the invention I am referring to a method of separating mercury from a mercury-containing gas as described in independent claim 2 of U.S. patent application serial no. 15/978,760. All websites referenced in this document were accessed March 20, 2019.

The EPA Calls For New Mercury Removal Technology in the 1990s

3. The background story for this technology begins with the Clean Air Act Amendments of 1990. That law required the U.S. Environmental Protection Agency (EPA) to study the impact of various air pollutants, including mercury.[1] To assist in the research, in 1992, the EPA established a National Center for Excellence at the Energy & Environmental Research Center (EERC) referred to as the Center for Air Toxic Metals (CATM). It is through the EERC that my fellow co-inventors and I would eventually discover the invention claimed in U.S. patent application serial no. 15/978,760. Our research focused heavily on developing new methods for detecting, measuring, and ultimately, removing mercury from coal-fired power plant exhaust gas.

4. In 1997 and 1998, the EPA issued two reports to Congress: *Mercury Study Report to Congress* (issued December 1997)[2] and *Study of Hazardous Air Pollutant Emissions*

[1] Website: https://www.epa.gov/clean-air-act-overview/1990-clean-air-act-amendment-summary-title-iii
[2] United States Environmental Protection Agency, "Mercury Study Report to Congress, Volume I: Executive Summary", EPA-452/R-97-003, December 1997, https://www.epa.gov/mercury/mercury-study-report-congress

from Electric Utility Steam (issued February 1998)[3]. As an outcome of these studies, the EPA found a pressing need for regulation of mercury pollution from power plants.[4] Unfortunately, it also found that no existing technologies were up to the task of significantly reducing the mercury pollution from those plants.[5]

5. With that said, the EPA did provide some indications as to promising areas for future research. For example, similar to cited reference U.S. patent no. 5,435,980 ("Felsvang"), the EPA noted a connection between the chlorine content in coal and potential ways to remove mercury.[6] It also identified activated carbon injection as a potential control technology for mercury removal.[7] Nonetheless, it acknowledged that much more research was needed:

> Research continues on the chemistry and interactions of flue gas, fly ash, and mercury species. This fundamental research is needed at various flue gas conditions encountered across the utility industry in order to develop low cost mercury strategies for full-scale utility operation. Thus, while AC injection shows promise as a mercury control technology, more data and research are needed to understand the factors that affect mercury removal.[8]

6. In the wake of these reports, various governmental and industry organizations injected millions of dollars into basic scientific research and experimental studies in the

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[3] United States Environmental Protection Agency, "Study of Hazardous Air Pollutant Emissions from Electric Utility Steam Generating Units -- Final Report to Congress", United States Office of Air Quality EPA-453/R-98-004a, Environmental Protection Planning and Standards, February 1998, https://www.epa.gov/mats/study-hazardous-air-pollutant-emissions-electric-utility-steam-generating-units-final-report

[4] On March 15, 2005, the EPA issued the Clean Air Mercury Rule to significantly reduce mercury emissions from coal-fired power plants, with a goal of reducing utility emissions of mercury from 48 tons/year to 15 tons/year, a reduction of nearly 70 percent. See, https://en.wikipedia.org/wiki/Mercury_regulation_in_the_United_States.

[5] Footnote 3 reference at ES-19, "Regarding potential methods for reducing mercury emissions, the EPA has not identified any demonstrated add-on control technologies currently in use in the U.S. that effectively remove mercury from utility emissions."

[6] Footnote 3 reference at section 13, pages 37-38.

[7] Footnote 3 reference at section 13, pages 40-41.

[8] Footnote 3 reference at section 13, page 43, second full paragraph.

search for new mercury removal technologies.[9] Because increased regulation of mercury emissions was expected to require significant upgrades to the country's fleet of coal-fired plants, much of the research focused on retrofit technologies that could be adopted at relatively low cost, including sorbent injection systems[10].

The EPA Espouses the Conventional Wisdom in Favor of Pre-Treated Sorbents, Not In-Flight Sorbent Enhancement in the Flue Gas

7. In 2002, the EPA surveyed the state of research in this field and produced a follow-up report.[11] It noted that the complex chemistry of the coal combustion process was still not fully understood, but that progress had been made. It described how coals with higher halogen content (specifically, chlorine) were better able to oxidize mercury and promote its capture.[12] However, it also noted that this oxidation reaction could be inhibited by other chemicals present during combustion in the boiler.[13] The EPA also described promising experiments being performed with halogen-treated sorbents.[14]

8. Notably, the EPA did not recommend in-flight sorbent enhancement in the flue gas by spraying additives on coal or injecting halogens into the boiler. Rather, it described research into methods for *pre-treating* sorbents with various additives, including chlorine, and then injecting those pre-treated sorbents downstream from the

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[9] T. D. Brown, D. N. Smith, R. A. Hargis Jr., W. J. O'Dowd, 1999, Mercury Measurement and Its Control: What We Know, Have Learned, and Need to Further Investigate, Journal of the Air & Waste Management Association, 49:6, 1-97, DOI: 10.1080/10473289.1999.10463841

[10] Footnote 9 reference at page 80, first column.

[11] J. D. Kilgroe, C. B. Sedman, R. K. Srivastava, J. V. Ryan, C. W. Lee, S. A. Thorneloe, Control of Mercury Emissions from Coal-Fired Electric Utility Boilers: Interim Report, U.S. Environmental Protection Agency, Office of Research and Development, EPA-600/R-01-109, December 2001

[12] Footnote 11 reference at section 6, page 7, first full paragraph.

[13] Footnote 11 reference at section 5, page 7, second full paragraph "It is speculated that SO_2 and water vapor may inhibit gas-phase oxidation of Hg^0 by scavenging the chlorinating agent."

[14] Footnote 11 reference at ES-8, second-to-last full paragraph, "Impregnation of carbons with sulfur, iodine, or chlorine can increase the reactivity and capacity of sorbents."

boiler.[15] This approach ensured that, e.g., chlorinating agents could react with the sorbent material without being "scavenged" by other chemicals present in the boiler. This approach also ensured that the sorbent additive would have plenty of time to react with the sorbent—the EPA explained that, for many plants, injected sorbents would have only a few seconds to find and react with mercury present in the flue gas, with high and costly carbon-to-Hg ratios needed to achieve adequate mercury removal.[16] This is consistent with the general understanding in the industry that sorbent additives such as halogens or halides should be mixed with sorbents *before* coming in contact with mercury-containing flue gas.

Sidney Nelson Touts Brominated Sorbent, Not In-Flight Sorbent Enhancement in the Flue Gas

9. The same year the EPA published its follow-up report,[17] on April 24, 2002, Sidney Nelson filed the provisional application for the cited reference U.S. patent publication no. 2004/0003716 ("Nelson"), U.S. provisional application no. 60/377,790 ("Nelson provisional"). His application reported experiments that he had conducted using sorbents pre-treated with Br_2 and HBr. His application demonstrated that those pre-treated sorbents could outperform some commercially available sorbents, explaining exposing the activated carbon to concentrated forms of Br_2 or HBr outside the flue gas allows a relatively large quantity of the concentrated Br_2 or HBr to react with the activated carbon.[18]

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[15] Footnote 11 reference at section 5, paragraph bridging pages 33-34.
[16] Footnote 11 reference at 5-33, "Activated carbon duct injection seems to be the most promising Hg control technology for coal-fired electric utility boilers equipped with ESPs. In this technology, the injected activated carbon removes Hg only while contacting the flue gas during very limited sorbent/gas contact time (<3 seconds)." Note that this section of the report refers to the reaction between pre-treated chlorinated sorbent and mercury as occurring "in-flight." To be clear, this portion of the report describes only the use of a pre-treated sorbent, not the claimed invention.
[17] Footnote 11 reference.
[18] Nelson at paragraph [0043], "...it appears that in exposing PAC to concentrated bromine gas, a relatively large quantity of the bromine reacts with the carbon, forming surface compounds on the large surface-area of the carbon."

10. Consistent with EPA teachings, Nelson did not recommend or teach adding chemicals to the flue gas or in-flight mixing of Br_2 and HBr with sorbents. Quite the contrary, he recommended that the bromine be contacted with the sorbent outside the presence of boiler gases "...for a sufficient time..." to ensure that enough bromine reacted with the sorbent.[19] Treatment times for HBr- and Br_2-treatment of activated carbon described by Nelson were on the order of several minutes (1.5-100 minutes)[20]; in contrast, only a few seconds are available for in-flight sorbent enhancement in the flue gas (e.g., generally less than 10 seconds)[16]. He also identified an even further reason to avoid in-flight sorbent enhancement in the flue gas: he noted that bromine compounds are "...quite corrosive."[21] As a result, he recommended mixing bromine and sorbent in equipment "...preferably lined with corrosion-resistant material..."[21] such as Teflon[22]—an approach that is not possible when bromine is added to coal or injected upstream from or into the boiler.

11. Despite the development of brominated sorbents and other advancements in the field, by 2003, the EPA recognized that there was still no "single best technology that can be broadly applied" for mercury capture.[23]

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[19] Nelson at paragraphs [0023], [0028], and claim 1.
[20] Nelson at page 8, paragraph [0087] and the table at the top of the second column. For HBr-treated activated carbon, the adsorption rate was 1 gram of HBr absorbed per 1 kg of activated carbon per minute, or 0.1 wt% HBr absorbed per minute, meaning that to reach the 9 wt% HBr reported in the table required about 90 minutes. Note that Figure 14 reports results for 10 wt% HBr, and Figure 15 reports results for 9 wt% HBr. For Br_2-treated activated carbon, the adsorption rate was 10 grams of Br_2 absorbed per 1 kg of activated carbon per minute, or 1 wt% Br_2 absorbed per minute, meaning that to reach the 15 wt% Br_2 reported in the table required about 15 minutes. Note that Figures 14 and 15 report results for 1.5 wt%, 5 wt%, and 15 wt% Br_2, according to the table requiring about 1.5 to 15 minutes to form.
[21] Nelson at paragraph [0044].
[22] Nelson provisional at page 4, last paragraph.
[23] J. H. Pavlish, E. A. Sondreal, M. D. Mann, E. S. Olson, K. C. Galbreath, D. L. Laudal, S. A. Benson, "Status Review of Mercury Control Options for Coal-Fired Power Plants", Fuel Processing Technology 82 (2003) 89–165, at page 89, first paragraph.

The EPA Continues to Teach Away from In-Flight Sorbent Enhancement in the Flue Gas

12. In 2005, the EPA issued another follow-on report.[24] In this report, the EPA again noted the connection between chlorine content in coal and mercury capture.[25] It also recognized the advantages of brominated carbon sorbents.[26] The report also notes that halogen-containing sorbent enhancement additives have been added to coal along with injection of activated carbon sorbents into the flue gas to remove mercury.[27] However, despite being aware of these facts—facts that the examiner has relied on to demonstrate obviousness of the claims at issue—in the final summary the EPA does not recommend, or even mention, in-flight sorbent enhancement in the flue gas.[28] Although the EPA's "key observations" for retrofitting the country's coal plant fleet mention the use of fuel additives and the injection of activated carbon into the flue gas, the use of these technologies together is not mentioned, and in-flight enhancement of the sorbent in the flue gas is not mentioned; rather, injection of pre-treated halogenated activated carbon is emphasized.[29]

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[24] U.S. Environmental Protection Agency, "Control of Mercury Emissions from Coal Fired Electric Utility Boilers: An Update", Air Pollution Prevention and Control Division, National Risk Management Research Laboratory, Office of Research and Development, February 18, 2005

[25] Footnote 24 reference at page 25, third-to-last bullet point. See also, page 10, second paragraph, with regard to chloride salts on coal, noting that "Long term effects, such as corrosion, plugging, impacts on combustion equipment could not be assessed during the short-term parametric tests. Therefore, the use of coal additives offer some promise at improving mercury capture; however, they may have other impacts that need to be evaluated."

[26] Footnote 24 reference at pages 18-21.

[27] Footnote 24 reference at page 22, second paragraph. See also, page 24, second-to-last full paragraph, "Additives used to enhance PAC performance or other sorbents that may be used, however, might cause adverse effects on plant components. The potential for such impacts would have to be evaluated through long-term field testing conducted over time periods of several months or more."

[28] Footnote 24 reference at pages 30-32.

[29] Footnote 24 reference at pages 31-32, items 6 and 9, discussing injection of activated carbon and halogenated activated carbon, are the only items to highlight specific mercury removal levels, and fail to mention halogenated fuel additives or in-flight sorbent enhancement in the flue gas.

13. The EPA's failure to recommend the use of halogenated fuel additives in combination with injection of activated carbon into the flue gas to cause in-flight enhancement of the sorbent in the flue gas is particularly striking because my coinventors and I had already begun publishing results from initial testing of in-flight sorbent enhancement in the flue gas. The EPA acknowledged those results in their report, noting that 63% mercury removal was achieved, and specifically found that this approach is different from merely using pre-treated sorbent.[27] Nonetheless, despite having this initial data as a roadmap to arrive at the claimed invention, the EPA continued to espouse the conventional view in favor of pre-treated sorbents.

The Department of Energy Funds Research into In-Flight Sorbent Enhancement in the Flue Gas

14. Despite the EPA's optimism for injection of pre-treated halogenated carbon sorbents into the flue gas in the early 2000s, various research groups were pursuing alternative technologies during this time period. The EERC was one of those groups. After extensive research into methods for detecting and measuring mercury species, and some research into various sorbents, my co-inventors and I theorized that in-flight sorbent enhancement in the flue gas could provide an improvement over pre-treated sorbent.

15. The EERC obtained funding to test this theory in 2003 from the U.S. Department of Energy's National Energy Technology Laboratory (DOE/NETL) under the Office of Fossil Energy's Innovations for Existing Plants (IEP) Program.[30] The goal of Phases I and II of the program was development of Hg control technologies that could achieve 50 to 70% Hg capture at costs 25 to 50% less than the baseline 1999 estimate.[31] Our initial pilot-scale tests suggested that our approach could achieve mercury removal efficiencies

[30] T.J. Feeley III, J. Murphy, J. Hoffmann, S. A. Renninger, A Review of DOE/NETL's Mercury Control Technology R&D Program for Coal-Fired Power Plants, April 2003.
[31] Footnote 30 reference, page 3, second paragraph.

ranging from 50-90%. As a result, the EERC successfully obtained several multi-million-dollar awards under the program.[32]

In-Flight Sorbent Enhancement in the Flue Gas Is Finally Recognized as a Critical Advancement

16. It is estimated that over $60 million dollars was spent by the EERC on the research, development, testing, and demonstration of mercury removal from flue gas.[33] In 2008, DOE published a document highlighting the successful development and demonstration of the technology.[34] Some of the key advantages of the technology are highlighted as follows[34, 35]:

- Improves mercury oxidation and enhances activated carbon reactivity, which can improve capture in downstream equipment.
- Allows use of more abundantly available supplies of activated carbon (treated activated carbons have limited supply).
- Improves mercury capture while using far less activated carbon.
- Improves mercury capture efficiencies in some instances to greater than 90% (standard ACs can be limited to around 60%).
- Allows for performance and cost optimization of SEA and activated carbon at each site.
- Minimizes ESP particulate and opacity problems by using lower amounts of activated carbon.
- Minimizes fabric filter particulate emissions and pressure drop while allowing the unit to operate at maximum load by using lower amounts of activated carbon.

[32] Footnote 30 reference, page 2, second paragraph; page 5 at Table 1; page 6 at Table 2; page 7 at Table 3; page 9, first full paragraph; page 13, last paragraph; page 17, last full paragraph; paragraph bridging pages 17-18; page 18, first full paragraph; and page 19, last partial paragraph.
[33] https://www.midwestemissions.com/
[34] U.S. Department of Energy, Office of Fossil Energy, National Energy Technology Laboratory, Cooperative Research and Development, "Successes: Sorbent Enhancement Additive Technology for Mercury Control", 2008
[35] A. P. Jones, J. W. Hoffmann, D. N. Smith, T. J. Feeley, J. T. Murphy, "DOE/NETL's Phase II Mercury Control Technology Field Testing Program: Preliminary Economic Analysis of Activated Carbon Injection," Environ. Sci. Technol., 2007, 41 (4), pp 1365–1371. DOI: 10.1021/es0617340, January 17, 2007.

In-Flight Sorbent Enhancement in the Flue Gas Experiences Commercial Success and Is Copied by Sidney Nelson and Other Competitors

17. One of the most straightforward indications of the success of the invention comes from chemical giant Albemarle, one of the largest suppliers of bromine worldwide. In 2008, Albemarle acquired Sidney Nelson's brominated sorbent company Sorbent Technologies Corp. and the Nelson patent.[36] Albermarle continued to market and sell brominated carbon sorbents. Nonetheless, today, even Albemarle now sells chemicals and systems for in-flight sorbent enhancement in the flue gas.[37]

18. In fact, even Mr. Nelson himself ultimately accepted the benefits of in-flight sorbent enhancement in the flue gas. In a post-Albemarle acquisition presentation entitled "How China Can Leapfrog the World in Mercury Emission Reduction", he noted that pre-treated sorbents were accepted in the U.S., but he recommended that Chinese operators should instead use in-flight sorbent enhancement in the flue gas.[38] As his basis for proposing that new approach he did not cite his own research or some commonly understood reference or theory from the 1990s or early 2000s. Rather, he relied on data collected by myself and my colleagues at the EERC and published in 2006.[39]

19. Despite the initial success of pre-treated sorbents, in-flight sorbent enhancement in the flue gas has more recently experienced important growth in the U.S. EPA data indicates that in-flight sorbent enhancement in the flue gas is currently used by more than

[36] See, U.S. assignment database for U.S. patent no. 6,953,494, assigned to Sorbent Technologies Corporation on 9/18/2006, and assigned to Albemarle Corporation on 9/30/2010. See also, http://www.chemeurope.com/en/news/85387/albemarle-corporation-acquires-sorbent-technologies-corporation.html.
[37] https://www.albemarle.com/businesses/bromine-specialties/bromine-&-derivatives/mercury-control, at the "ADDITIVES" tab.
[38] https://www.dri.edu/images/stories/editors/leapfrog/techprog/IId_3_NelsonJr.pdf at slide 24.
[39] Footnote 38 reference at slide 20.

one-third of all plants in the U.S.,[40] and it has been recognized as one of the key technologies enabling cost effective mercury removal from coal plant exhaust.

20. I further declare that all statements made herein of my own knowledge are true, and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by a fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application and/or any patent issued thereon.

Dated: March 20, 2019 By: / John Pavlish /

John Pavlish

[40] EPA Air Markets Program Data: https://ampd.epa.gov/ampd/. From this webpage, the "Query" tab was clicked. For programs and data sets, the program "mercury and air toxics standards (MATS)" and the data set "facility attributes" were selected, and then "next step" was clicked. For time frame, "select a range" was selected from 2019 to 2019, and then "next step" was clicked. For criteria, nothing was selected, and then "next step" was clicked. For variables, only the variables "owner", "fuel type (primary)", and "mercury controls" were selected, and then "next step" was clicked. The CSV file was downloaded, and then the "facility" file was opened as an Excel spreadsheet. The data was sorted to include only coal plants, column G, which totaled 606. Column H was then sorted to include only additives to enhance PAC; the total number was 70. Column H was then sorted to include only the units that had actually filled out what mercury control technology they are using, which totaled 228. Assuming that the 228 units are a random sampling of the 606 total, that number statistically represents all of the units and the distribution of different mercury control approaches. Thus, if 70 units are using coal additives with PAC and 228 units are representative of the 606, about 1/3 (e.g., 70/228 = 0.31) of the units are using coal additives with PAC.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Inventor(s):	Edwin S. Olson et al.	Examiner:	Amber Orlando
Serial No.:	15/997,091	Group Art Unit:	1776
Filed:	June 4, 2018	Docket:	4820.001U10
Customer No.:	21186	Confirmation No.:	5161
Title:	SORBENTS FOR THE OXIDATION AND REMOVAL OF MERCURY		

PETITION FOR A THREE-MONTH EXTENSION OF TIME

Mail Stop RCE
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

In accordance with the provision of 37 C.F.R § 1.136(a), it is respectfully requested that a three-month extension of time be granted in which to respond to the Final Office Action mailed January 11, 2019, said period of response being extended from April 11, 2019 to July 11, 2019.

Please charge Deposit Account No. 19-0743 in the amount of $1,400.00 to cover the required extension fee. Please charge any additional fees or credit overpayment to deposit Account No. 19-0743.

Respectfully submitted,

SCHWEGMAN LUNDBERG & WOESSNER, P.A.
P.O. Box 2938
Minneapolis, MN 55402
(612) 349-9580

Date July 10, 2019

By /Nicholas P. Lanzatella/
Nicholas P. Lanzatella
Reg. No. 63,803

Modified form PTO/SB/08A(04-07) OMB 651-0031
US Patent & Trademark Office: U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Substitute for form 1449A/PTO

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Use as many sheets as necessary)

Complete if Known	
Application Number	15/997,091
Filing Date	June 4, 2018
First Named Inventor	Edwin S. Olson
Group Art Unit	1776
Examiner Name	Amber Orlando

Sheet 1 of 1

Attorney Docket No: 4820.001U10

US PATENT DOCUMENTS

Examiner Initial *	USP Document Number	Publication Date	Name of Patentee or Applicant of cited Document
	US-10,343,114	7/9/2019	Olson, Edwin S, et al.
	US-20120100053A1	4/26/2012	Durham, Michael D, et al.
	US-20130157845A1	6/20/2013	Nalepa, Christopher J, et al.

FOREIGN PATENT DOCUMENTS

Examiner Initial *	Foreign Document Number	Publication Date	Name of Patentee or Applicant of cited Document	T 1
	WO-2012030560A1	3/8/2012	Nalepa, Christopher J, et al.	

OTHER DOCUMENTS – NON PATENT LITERATURE DOCUMENTS

Examiner Initial *	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T 1
	"Application Serial No. 15/382,114, Final Office Action mailed 06-21-19", 31 pgs	
	"Application Serial No. 15/589,359, Advisory Action mailed 05-22-19", 3 pgs	
	"Application Serial No. 15/589,359, Non Final Office Action mailed 06-21-19", 7 pgs	
	"Application Serial No. 15/978,760, Notice of Allowability mailed 05-30-19", 3 pgs	
	"Application Serial No. 15/978,760, Notice of Allowance mailed 05-08-19", 7 pgs	

EXAMINER DATE CONSIDERED

* EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. 1 Applicant is to place a check mark here if English language Translation is attached

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Inventor(s): Edwin S. Olson et al.	Examiner: Amber Orlando
Serial No.: 15/997,091	Group Art Unit: 1776
Filed: June 4, 2018	Docket: 4820.001U10
Customer No.: 21186	Confirmation No.: 5161

Title: SORBENTS FOR THE OXIDATION AND REMOVAL OF MERCURY

INFORMATION DISCLOSURE STATEMENT

MS Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

In compliance with the duty imposed by 37 C.F.R. § 1.56, and in accordance with 37 C.F.R. §§ 1.97 *et. seq.*, the enclosed materials are brought to the attention of the Examiner for consideration in connection with the above-identified patent application. Applicant respectfully requests that this Information Disclosure Statement be entered and the documents listed on the attached PTO 1449 Form be considered by the Examiner and made of record. Pursuant to the provisions of MPEP 609, Applicant requests that a copy of the PTO 1449 Form, initialed as being considered by the Examiner, be returned to the Applicant with the next official communication.

Pursuant to 37 C.F.R. § 1.97(b), it is believed that no fee or statement is required with the Information Disclosure Statement. However, if an Office Action on the merits has been mailed after filing of the application or after the filing of the most recent RCE, the Commissioner is hereby authorized to charge the required fees to Deposit Account No. 19-0743 in order to have this Information Disclosure Statement considered.

Pursuant to 37 C.F.R. § 1.98(a)(2), copies of cited U.S. Patents and Published Applications, and Non-Published Applications identifiable by USPTO Serial Number, are no longer required to be provided to the Office. Applicant acknowledges the requirement to submit copies of foreign patent documents and non-patent literature in accordance with 37 C.F.R § 1.98(a)(2).

The Examiner is invited to contact the undersigned at the telephone number indicated if there are any questions regarding this communication.

Respectfully submitted,

SCHWEGMAN LUNDBERG & WOESSNER, P.A.
P.O. Box 2938
Minneapolis, MN 55402
(612) 349-9580

Date July 10, 2019 By /Nicholas P. Lanzatella/
Nicholas P. Lanzatella
Reg. No. 63,803

NPL:mlr1

CERTIFICATION AND REQUEST FOR PRIORITIZED EXAMINATION UNDER 37 CFR 1.102(e)

(Page 1 of 1)

First Named Inventor:	Edwin S. Olson	Nonprovisional Application Number (if known):	15/997,091
Title of Invention:	SORBENTS FOR THE OXIDATION AND REMOVAL OF MERCURY	Docket No.:	4820.001U10

APPLICANT HEREBY CERTIFIES THE FOLLOWING AND REQUESTS PRIORITIZED EXAMINATION FOR THE ABOVE-IDENTIFIED APPLICATION.

1. The processing fee set forth in 37 CFR 1.17(i)(1) and the prioritized examination fee set forth in 37 CFR 1.17(c) have been filed with the request. The publication fee requirement is met because that fee, set forth in 37 CFR 1.18(d), is currently $0. The basic filing fee, search fee, and examination fee are filed with the request or have been already been paid. I understand that any required excess claims fees or application size fee must be paid for the application.

2. I understand that the application may not contain, or be amended to contain, more than four independent claims, more than thirty total claims, or any multiple dependent claims, and that any request for an extension of time will cause an outstanding Track I request to be dismissed.

3. **Request for Continued Examination – Prioritized Examination under § 1.102(e)(2)**

   i. A request for continued examination has been filed with, or prior to, this form.
   ii. If the application is a utility application, this certification and request is being filed via EFS-Web.
   iii. The application is an original nonprovisional utility application filed under 35 U.S.C. 111(a), or is a national stage entry under 35 U.S.C 371.
   iv. This certification and request is being filed prior to the mailing of a first Office action responsive to the request for continued examination.
   v. No prior request for continued examination has been granted prioritized examination status under 37 CFR 1.102(e)(2).

Signature /Nicholas P. Lanzatella/	Date July 10, 2019
Name (Print/Typed) Nicholas P. Lanzatella	Practitioner Registration Number: 63,803

Note: *This form must be signed in accordance with 37 CFR 1.33. See 37 CFR 1.4(d) for signature requirements and certifications. Submit multiple forms if more than one signature is required, see below*.*

*Total of 1 forms are submitted.

REMARKS

This responds to the Final Office Action dated January 11, 2019.

Claims 1, 16, and 19-20 are presently amended. Claims 4, 6-8, 11, 13-15, and 17 are presently canceled, and claims 2-3 and 5 were canceled previously. New claims 21-41 are presently added. As a result, claims 1, 9-10, 12, 16, and 18-42 are now pending in this application.

Support for the new claims is as follows.

New claim	Support in present published U.S. application
21	[0059]
22	[0090]
23	[0105]
24	[0123]
25	FIG. 11 and [0237]
26	FIG. 11 and [0237]
27	[0069] and Example 10 at [0122]
28	[0077]
29	[0069]
30	[0112]
31	[0146]
32	FIG. 2
33	[0012] and [0021]
34	[0015] and [0051]
35	[0047]
36	[0123]
37	[0058] and FIG. 11
38	[0109]
39	[0007], [0053], [0072], [0208], [0219]
40	[0007], [0053], [0072], [0208], [0219]
41	See, current claims 1 and 20
42	[0025], [0072], [0090], see also, current claims 1 and 20

New claims 21-42 are dependent on independent claim 1. As such, these dependent claims incorporate all the features of claim 1. Accordingly, claims 21-42 are patentable for at least the reasons given herein for patentability of claim 1.

New independent claims 41 and 42 include features that are similar to the features of independent claim 1. Claims 41 and 42 are therefore patentable for the reasons given herein for patentability of independent claim 1.

37 CFR § 1.132 Declarations

A 37 CFR § 1.132 declaration by John Pavlish filed with the Response of 3/20/2019 for U.S. patent application no. 15/978,760 is submitted herewith that describes objective evidence of nonobviousness ("Declaration A"). The 37 CFR § 1.132 declaration by John Pavlish submitted with the last response was revised and filed with the Response of 3/20/2019 for U.S. patent application no. 15/978,760 and is submitted herewith ("Declaration B"). A 37 CFR § 1.132 declaration by John Pavlish and Nicholas Lentz filed with the Response of 3/20/2019 for U.S. patent application no. 15/978,760 is submitted herewith that explains that Br_2 is not HBr and does not include HBr, and Cl_2 is not HCl and does not include HCl; that Br_2 is not and does not include Br^-, and Cl_2 is not and does not include Cl^-; NaBr is a salt that includes Na^+ ions and Br^- ions; and that NaCl is a salt that includes Na^+ ions and Cl^- ions ("Declaration C"). A 37 CFR § 1.132 declaration by John Pavlish filed with the Response of 3/20/2019 for U.S. patent application no. 15/978,760 is submitted herewith that explains that data from Nelson's experimental setup and from the pilot-scale unit of item 8 of Declaration B are validly comparable ("Declaration D").

Summary of Arguments

Response to Examiner's Rejection under 35 USC § 103

The Claims at issue stand rejected over Felsvang in view of Nelson based on the Examiner's assessment that Felsvang teaches in-flight sorbent promotion using a chlorine-based material and Nelson teaches that bromine-based materials are superior for promoting sorbents. This was, respectfully, in error. As explained below, the Examiner has not established a *prima facia* case of obviousness.

The Cited Refences Do Not Provide a Motivation to Attempt In-Flight Promotion With HBr or Br^- Over Pre-Treatment of Sorbents

As an initial matter, while Felsvang does mention supplying chloride to coal and providing activated carbon in flue gas, Felsvang does not teach that this process promotes the activated carbon. The Examiner fails to identify any teaching in the art that exposure of activated carbon to halogen- or halide-containing flue gas (as opposed to, e.g., concentrated halogen or halide gas) would generate a promoted sorbent, as opposed to, for example, the activated carbon and the halogen or halide in the flue gas providing independent, albeit complementary, mechanisms for mercury removal. For example, a person with a cold may expect aspirin and a decongestant to work well together at reducing symptoms, but that does not mean that taking the two compounds together will cause an additional beneficial chemical reaction.

To be sure, writing a decade later, Sidney Nelson acknowledges that chlorine and bromine can be used to promote carbon sorbents in-flight in the flue gas.[1] But, as the Examiner acknowledges, the Nelson reference does not teach in-flight promotion in the flue gas as a way to create a promoted sorbent, nor does Nelson teach adding any chemical to the flue gas would improve mercury removal. Quite the contrary, Nelson describes pre-treating sorbent (i.e., outside of flue gas) as an "essential element" of his invention.[2] He offers specific reasons as to why pre-treatment was viewed as essential. For example, he notes that bromine species can be "quite corrosive,"[3] the carbon should be "uniformly exposed to and reacted with the bromine,"[4] the carbon should be purged of H_2O which interferes with bromination,[5] and he describes a mixing time for HBr and activated carbon of 90 minutes or more[6]. As explained more fully below, a person of ordinary skill in the art would recognize that the combustor and flue gas ductwork are composed of

[1] Declaration A at item 18.
[2] Nelson at paragraph [0040].
[3] Nelson at paragraph [0044].
[4] Nelson at paragraph [0046].
[5] Nelson at paragraphs [0048] and [0051].
[6] Nelson at page 8, paragraph [0087] and the table at the top of the second column. For HBr-treated activated carbon, the adsorption rate was 1 gram of HBr absorbed per 1 kg of activated carbon per minute, or 0.1 wt% HBr absorbed per minute, meaning that to reach the 9 wt% HBr reported in the table required about 90 minutes. Note that Figure 14 reports results for 10 wt% HBr, and Figure 15 reports results for 9 wt% HBr. For Br_2-treated activated carbon, the adsorption rate was 10 grams of Br_2 absorbed per 1 kg of activated carbon per minute, or 1 wt% Br_2 absorbed per minute, meaning that to reach the 15 wt% Br_2 reported in the table required about 15 minutes. Note that Figures 14 and 15 report results for 1.5 wt%, 5 wt%, and 15 wt% Br_2, according to the table requiring about 1.5 to 15 minutes to form.

corrodible metal, the concentration of halogen in the flue gas would be low, the flue gas would contain significant H_2O (e.g., 7% as per Nelson)[7], and that in-flight mixing would allow for only several seconds of contact time between the activated carbon and the promoter rather than 90 minutes. Thus, Nelson would motivate a person of ordinary skill in the art to promote sorbents in a controlled setting outside of a flue gas, not to attempt in-flight promotion in a flue gas. At the very least, Examiner has not shown that a person of ordinary skill in the art would be motivated to modify Felsvang in view of Nelson.

Objective Evidence Confirms the Patentability of the Claims

The arguments above are reflected in the story of the claimed invention. Submitted herewith is Declaration A by inventor John Pavlish that describes objective evidence of nonobviousness. Mr. Pavlish explains—with support from extensive contemporaneous documentation—how the EPA kicked off a race for the development of new mercury removal technologies. From early on though, the conventional wisdom was that sorbents should be pre-treated before injection into the flue gas. While at the Energy & Environmental Research Center ("EERC"), Mr. Pavlish and his co-inventors fought against this conventional wisdom and eventually obtained millions of dollars in federal grant money to develop the claimed invention. Their efforts were so successful that the Department of Energy specifically highlighted their work as a significant achievement. Since then, this technology has been recognized as one of the most widely adopted technologies for mercury control in the U.S.

The claimed invention has had such a significant impact on the industry, that even Sidney Nelson himself (the author of the Nelson reference) eventually touted the benefits of in-flight promotion in the flue gas with bromine. In doing so, he acknowledged that this approach differed from the conventional approach of pre-treating sorbent, and he specifically cited the work of the EERC as demonstrating the benefits of in-flight promotion in the flue gas with bromine. This objective evidence of non-obviousness further establishes the patentability of these claims. *Crocs, Inc. v. Int'l Trade Comm'n*, 598 F.3d 1294, 1310 (Fed. Cir. 2010) (internal quotation marks omitted) (objective evidence "can be the most probative evidence of nonobviousness in the record, and enables the court to avert the trap of hindsight").

[7] Nelson at paragraph [0079].

What follows is a detailed description of support for the arguments above, rebuttal evidence showing that the presently claimed invention has properties that could not be predicted from any cited reference, and responses to the Examiner's arguments.

Table of contents.

I. The Office Action rejected claims 1, 4, and 6-20 under 35 U.S.C. § 103(a) over U.S. patent publication no. 2004/0003716 ("Nelson") in view of U.S. patent no. 5,435,980 ("Felsvang"). 13

I(A). A person of ordinary skill in the art would not combine Nelson and Felsvang as alleged. ... 14

I(A)(1). Br_2 is not HBr and does not include HBr, and Cl_2 is not HCl and does not include HCl; also, Br_2 is not and does not include Br^-, and Cl_2 is not and does not include Cl^-. 14

I(A)(2). There would be no motivation for a person of ordinary skill in the art to use Nelson's HBr in place of Felsvang's HCl or Cl^- in Felsvang's process. 15

I(A)(2)(a). Felsvang focuses on HCl or Cl^- concentration in the flue gas. 16

I(A)(2)(b). A person of ordinary skill in the art would not combine Nelson with Felsvang as alleged because they would not know or expect in-flight promotion of the activated carbon sorbent would occur. 17

I(A)(2)(b)(i). A person of ordinary skill in the art would not combine Nelson with Felsvang as alleged because Felsvang fails to describe or suggest in-flight promotion can occur. 17

I(A)(2)(b)(ii). Promoter concentration in flue gas is low compared to during treatment outside of flue gas. 19

I(A)(2)(b)(iii).Contact time between promotors in the flue gas and activated carbon is very short compared to treatment outside the flue gas. 19

I(A)(2)(b)(iv).Consumption of hydrogen halides in the flue gas via corrosion or scavenging. 20

I(A)(2)(c). A person of ordinary skill in the art would not be motivated to use Felsvang's process with activated carbon. 21

I(A)(2)(d). Nelson provides no motivation to replace Felsvang's HCl or Cl^- treatment with Nelson's HBr treatment. 23

I(A)(3). Reply to Examiner's response to arguments. 42

I(B). In-flight promotion versus treatment outside the flue gas. 54

I(B)(1). In-flight promotion with HBr or Br^- promoters is more effective for mercury removal than treating the sorbent with HBr, Br^-, or Br_2 outside the mercury-containing gas. 54

I(B)(2). There is no way a person of ordinary skill in the art could predict that in-flight promotion of a sorbent with HBr or Br^- promoters is more effective for mercury removal than use of a sorbent that is treated with the same promoters outside the flue gas. 58

I(B)(3). Reply to Examiner's response to arguments. 60

I(C). In-flight promotion with HBr or Br^- versus HCl or Cl^- 64

I(C)(1). In-flight promotion with HBr or Br^- promoters is more effective for mercury removal than in-flight promotion with HCl or Cl^- promoters. 64

I(C)(2). There would be no way for a person of ordinary skill in the art to predict this advantage from the from the cited references. 66

I(C)(3). Reply to Examiner's response to arguments. 66

I(D). A person of ordinary skill in the art would find that treatment of activated carbon outside the flue gas with HCl as per Nelson's process actually provides more effective mercury removal per wt% HCl than treatment of activated carbon with HCl or Cl^- in the flue gas. 67

I(D)(1). Even if a person of ordinary skill in the art compared the mercury removal of Felsvang to activated carbons treated with HCl outside of the flue gas, they would not determine that in-flight promotion provides the same or better mercury removal properties per wt% HCl. 68

I(D)(2). Reply to response to arguments. 70

I(E). Objective evidence of non-obviousness of the claimed invention. 72

II. Double patenting rejections. 73

The Rejection of Claims Under §103

I. The Office Action rejected claims 1, 4, and 6-20 under 35 U.S.C. § 103(a) over U.S. patent publication no. 2004/0003716 ("Nelson") in view of U.S. patent no. 5,435,980 ("Felsvang").

This rejection is respectfully traversed.

As explained herein at **I(A)**, a person of ordinary skill in the art would not combine Nelson and Felsvang as alleged. Part **I(B)** discusses in-flight promotion with HBr or Br^- in the flue gas versus treatment outside the flue gas. As explained herein at **I(B)(1)**, in-flight promotion with HBr or Br^- promoters is more effective for mercury removal than treating the sorbent with HBr, Br^-, or Br_2 outside the mercury-containing gas, and as explained herein at **I(B)(2)**, there would be no way for a person of ordinary skill in the art to predict this advantage from the cited references. Part **I(C)** discusses in-flight promotion in the flue gas with HBr or Br^- versus HCl or Cl^-. As explained herein at **I(C)(1)**, in-flight promotion with HBr or Br^- promoters is more effective for mercury removal than in-flight promotion with HCl or Cl^- promoters, and as explained herein at **I(C)(2)**, there would be no way for a person of ordinary skill in the art to predict this advantage from the cited references. Part **I(D)** explains that a person of ordinary skill in the art would find that treatment of activated

carbon outside the flue gas with HCl as per Nelson's process actually provides more effective mercury removal per wt% HCl than treatment of activated carbon with HCl or Cl^- in the flue gas. As explained herein at **I(D)(1)**, even if a person of ordinary skill in the art compared the mercury removal of activated carbons promoted with HCl or Cl^- in the flue gas to activated carbons treated with HCl outside of the flue gas, they would not determine that in-flight promotion provides the same or better mercury removal properties per wt% HCl. Section **I(E)** discusses objective evidence of non-obviousness of the claimed invention. Sections **I(A)(3)**, **I(B)(3)**, **I(C)(3)**, and **I(D)(2)** reply to the Examiner's responses to arguments made in the Response of 12/3/2018.

I(A). A person of ordinary skill in the art would not combine Nelson and Felsvang as alleged.

As explained herein at **I(A)(1)**, Br_2 is not HBr and does not include HBr, and Cl_2 is not HCl and does not include HCl; also, Br_2 is not and does not include Br^-, and Cl_2 is not and does not include Cl^-. As explained herein at **I(A)(2)**, there would be no motivation for a person of ordinary skill in the art to use Nelson's HBr in place of Felsvang's HCl or Cl^- in Felsvang's process. Section **I(A)(3)** includes replies to the Examiner's responses to arguments in the Response of 12/3/2018.

I(A)(1). Br_2 is not HBr and does not include HBr, and Cl_2 is not HCl and does not include HCl; also, Br_2 is not and does not include Br^-, and Cl_2 is not and does not include Cl^-.

As explained in Declaration C at item 17, hydrogen halides are diatomic molecules including a halogen atom and a hydrogen atom; in contrast, elemental halogens are diatomic molecules including two of the same halogen atom. HBr and HCl each include a hydrogen atom and one halogen atom, while Br_2 and Cl_2 each include two halogen atoms. Hydrogen halides have different properties than elemental halogens and are therefore different compounds. HBr has a molecular weight of 80.91 g/mol, while Br_2 has a molecular weight of 159.81 g/mol; HBr has a boiling point of -67 °C, while Br_2 has a boiling point of 58.8 °C; HBr has a melting point of -87 °C, while Br_2 has a melting point of -7.2 °C. HCl has a molecular weight of 36.46 g/mol, while Cl_2 has a molecular weight of 70.91 g/mol; HCl has a boiling point of -85 °C, while Cl_2 has a boiling point of 70.91 g/mol; HCl has a melting point of -114 °C, while Cl_2 has a melting point of -101 °C. Hydrogen halides are not part of and cannot be extracted or isolated from elemental halides; rather,

only via a chemical reaction that results in a chemical and structural change can hydrogen halides be formed from elemental halides. Hydrogen bromide is produced by reacting hydrogen and Br_2 at about 200-400 °C, a reaction that is typically catalyzed by platinum or asbestos. Hydrogen chloride is produced by reacting hydrogen and chlorine with one another. Therefore, elemental halogens are not hydrogen halides, and do not include hydrogen halides—Br_2 is not HBr and does not include HBr, and Cl_2 is not HCl and does not include HCl.

As explained in Declaration C at item 18, chlorine has an atomic number of 17, meaning it has 17 protons and 17 electrons, giving it an electron configuration of $1s^2 2s^2 2p^6 3s^2 3p^5$, having 7 electrons in its outer shell. Bromine has an atomic number of 35, meaning it has 35 protons and 35 electrons, giving it an electron configuration of $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^5$, also having 7 electrons in its outer shell. According to the octet rule, a halogen atom desires to fill its outer shell with 8 electrons total by gaining one electron. A halide ion is a halogen atom that has accepted an electron from an electron donor, in the case of chloride (Cl^-) giving it 18 total electrons to give a total charge of -1, and in the case of bromide (Br^-) giving it 36 total electrons to give a total charge of -1. Halogen atoms do not donate electrons to other atoms, because this would result in a halogen atom losing an electron to have 6 electrons in its outer shell, an unstable configuration according to the octet rule. In the case of an elemental halogen, which exists as a diatomic molecule, instead of donating electrons to one another, each halogen atom shares one of its electrons in the outer shell with the other halogen atom via overlapping electron orbitals in a covalent bond, allowing each halogen atom to have a filled octet while the diatomic molecule remains neutrally charged. Therefore, a halogen atom does not donate electrons to another halogen atom to form a halide, and a diatomic halogen molecule never includes a halide; Br_2 is not and does not include Br^-, and Cl_2 is not and does not include Cl^-.

I(A)(2). There would be no motivation for a person of ordinary skill in the art to use Nelson's HBr in place of Felsvang's HCl or Cl^- in Felsvang's process.

Independent claim 1 recites "…combusting coal in a combustion chamber, the coal[[that]] compris[[es]]ing an additive comprising Br_2, HBr, [[Br^-]]a bromide compound, or a combination thereof, to form the mercury-containing gas…."

The Office Action admits that Felsvang fails to describe or suggest a halogen or halide promoter that is Br_2, HBr, or Br^-. Nelson fails to describe or suggest in-flight promotion of activated carbon with a halide or hydrogen halide in the flue gas. The Office Action alleges that one of ordinary skill in the art would replace Felsvang's HCl or Cl^- with Nelson's HBr to accomplish the presently claimed method, stating that such a modification of Felsvang would be made "...to promote activated carbon (Nelson paragraphs [0017] and [0041]) so as to provide an effective carbon sorbent for mercury." (Office Action, page 4, last sentence of second full paragraph). Applicant respectfully disagrees. As explained below, a person of ordinary skill in the art would not be motivated to use Nelson's HBr in Felsvang's process, because Nelson fails to describe or suggest that HBr-treatment of activated carbon provides similar, let alone improved, mercury-removal ability as compared to HCl or Cl^--treatment of activated carbon.

As explained herein at **I(A)(2)(a)**, Felsvang focuses on HCl or Cl^- concentration in the flue gas. As explained herein at **I(A)(2)(b)**, a person of ordinary skill in the art would not combine Nelson with Felsvang as alleged because Felsvang fails to describe or suggest in-flight promotion can occur. As explained herein at **I(A)(2)(c)**, a person of ordinary skill in the art would not be motivated to use Felsvang's process with activated carbon. As explained herein at **I(A)(2)(d)**, Nelson provides no motivation to replace Felsvang's HCl or Cl^- treatment with Nelson's HBr treatment.

I(A)(2)(a). Felsvang focuses on HCl or Cl^- concentration in the flue gas.

Felsvang is directed to adding chlorine (Cl_2) or chloride (Cl^-) materials to the coal or combustion products. Felsvang makes clear that addition of chlorine or chloride material increases the amount of chloride supplied to the flue gas, or to the drying-absorption zone, see, Abstract and col. 3, lines 40-44. Felsvang states at col. 3, line 67 bridging to col. 4, line 4: "[i]t has been experienced that the increase of the Hg-removing effect of chloride addition to the drying-absorption zone in a process treating flue gases of low chloride content is especially remarkable when activated carbon is present...." Felsvang states at col. 4, lines 51-55: "...most chloride or chlorine containing compounds will release gaseous chlorides when introduced into the combustion zone of a coal fired boiler...." Felsvang states at col. 6, lines 3-11:

> **If the chloride content is found to be below a certain value as defined above and in the attached claims arrangements are taken according to the invention for increasing the gas chloride content. This may be done in connection with an introduction of activated carbon which in itself also has a Hg removing effect and together with chloride addition exihibts a synergistic effect enabling an extremely efficient Hg removal.**

At column 3, lines 53-55, Felsvang states that "[t]he term 'chloride' is intended to mean chloride ions as such or gaseous hydrogene chloride or compounds which by heating in the presence of coal forms Cl^- or HCl." Thus, Felsvang gives a definition of "chloride" that includes both HCl and Cl^-.

I(A)(2)(b). A person of ordinary skill in the art would not combine Nelson with Felsvang as alleged because they would not know or expect in-flight promotion of the activated carbon sorbent would occur.

As explained herein at **I(A)(2)(b)(i)**, a person of ordinary skill in the art would not combine Nelson with Felsvang as alleged because Felsvang fails to describe or suggest in-flight promotion can occur. As explained herein at **I(A)(2)(b)(ii)**, promoter concentration in flue gas is low compared to during treatment outside of flue gas. As explained herein at **I(A)(2)(b)(iii)**, contact time between promotors in the flue gas and activated carbon is very short compared to treatment outside the flue gas. As explained herein at **I(A)(2)(b)(iv)**, a person of ordinary skill in the art would believe that hydrogen halides in the flue gas would be consumed via corrosion or scavenging.

I(A)(2)(b)(i). A person of ordinary skill in the art would not combine Nelson with Felsvang as alleged because Felsvang fails to describe or suggest in-flight promotion can occur.

Felsvang fails to describe or suggest that any reaction occurs between activated carbon and HCl in the flue gas. Felsvang's primary focus is the enhancement of HCl or Cl^- concentration in the flue gas, with addition of activated carbon being optional and not required to experience the effect of the invention. At col. 6, lines 29-33, Felsvang states "...the chloride introduction may

alternatively be performed separately from the introduction of activated carbon or it may be performed without using activated carbon." At col. 6, lines 8-11, Felsvang explains that, in addition to increasing the chloride content, (emphasis added) "[t]his may be done in connection with an introduction of activated carbon which in itself also has a Hg removing effect and together with chloride addition exhibits a synergistic effect enabling an extremely efficient Hg removal." Felsvang therefore describes that activated carbon removes mercury, and that increasing HCl or Cl^- content removes mercury, and when the two are used together they operate side-by-side, failing to describe or suggest any reaction that occurs between the HCl or Cl^- and the activated carbon. Only a portion of Felsvang's Example 4 demonstrates the use of activated carbon with HCl or Cl^-, finding only a small increase in mercury-removal activity (discussed herein at **I(A)(2)(c)**), while the majority of Felsvang's Examples (1-3) are devoid of any mention of activated carbon.

In contrast, Nelson describes a chemical reaction that occurs between the halogens and the activated carbon, and disparages simple impregnation or physical adsorption of halogens onto the activated carbon, explaining at paragraphs [0017] and [0044] that physical adsorption leads to desorption from the activated carbon. Nelson explains at paragraphs [0044] and [0053] that elevated temperatures should be used during the treatment of the activated carbon with the bromine gas to minimize physical absorption and maximize chemical reaction between the bromine and the activated carbon which avoids desorption of the bromine during transport, storage, and upon injection into a hot gas stream.

A person of ordinary skill in the art would have to understand that a reaction can occur between Felsvang's HCl or Cl^- and the activated carbon in Felsvang's flue gas in order to understand that Nelson's bromine-treated sorbents have any similarity to the sorbents of Felsvang. With Felsvang's failure to describe or suggest any chemical reaction between the activated carbon and the HCl or Cl^- in the flue gas, a person of ordinary skill in the art would have no idea that Nelson's hydrogen bromide could be used in place of Felsvang's HCl or Cl^-. Therefore, a person of ordinary skill in the art would not replace Felsvang's HCl or Cl^- with HBr or Br^-. Independent claim 1 is patentable for at least this reason.

I(A)(2)(b)(ii). Promoter concentration in flue gas is low compared to during treatment outside of flue gas.

At paragraph [0051] Nelson gives a preference for the use of pure Br_2 or HBr to treat the activated carbon. Nelson's Examples do not mention the use of a carrier gas to dilute the halogen gases used to prepare the treated sorbents used therein.

Forming HBr or Br^- in the flue gas from bromide salts such as NaBr on coal gives a very low concentration of HBr/Br^- in the flue gas compared to pure HBr. A person of ordinary skill in the art would believe the concentration of HBr/Br^- in the flue gas would be too low to result in effective treatment of activated carbon injected into the flue gas, especially considering the short contact time between the HBr/Br^- and the activated carbon as discussed herein at **I(A)(2)(b)(iii)**.

I(A)(2)(b)(iii).Contact time between promotors in the flue gas and activated carbon is very short compared to treatment outside the flue gas.

As explained in Declaration A at item 10, Nelson states repeatedly that the bromine-containing gas is to be contacted with the activated sorbent "for a sufficient time" to increase the ability of the activated carbon to adsorb mercury. See, e.g., Abstract and paragraphs [0023] and [0028]. Nelson at page 8, paragraph [0087] and the table at the top of the second column describes contact times required to form HBr- and Br_2-treated activated carbons. For HBr-treated activated carbon, the adsorption rate was 1 gram of HBr absorbed per 1 kg of activated carbon per minute, or 0.1 wt% HBr absorbed per minute, meaning that to reach the 9 wt% HBr reported in the table required about 90 minutes. Note that Figure 14 reports results for 10 wt% HBr, and Figure 15 reports results for 9 wt% HBr. For Br_2-treated activated carbon, the adsorption rate was 10 grams of Br_2 absorbed per 1 kg of activated carbon per minute, or 1 wt% Br_2 absorbed per minute, meaning that to reach the 15 wt% Br_2 reported in the table required about 15 minutes. Note that Figures 14 and 15 report results for 1.5 wt%, 5 wt%, and 15 wt% Br_2, according to the table requiring about 1.5 to 15 minutes to form. In contrast, as explained in Declaration A at item 10, contact times between a promoter in the flue gas and activated carbon injected therein are generally less than 10 seconds.

As explained in Declaration A at item 8, before the priority date of the present claims, the EPA did not recommend in-flight sorbent enhancement in the flue gas by spraying additives on coal or injecting halogens into the boiler. Rather, it described research into methods for *pre-treating*

sorbents with various additives, including chlorine, and then injecting those pre-treated sorbents downstream from the boiler. This approach ensured that the sorbent additive would have plenty of time to react with the sorbent—the EPA explained that, for many plants, injected sorbents would have only a few seconds to find and react with mercury present in the flue gas, with high and costly carbon-to-Hg ratios needed to achieve adequate mercury removal.

A person of ordinary skill in the art would believe the contact time between HBr/Br^- in the flue gas would be too short to increase the ability of the activated carbon injected into the flue gas to adsorb mercury, especially considering the low concentration of HBr/Br^- in the flue gas as discussed herein at **I(A)(2)(b)(ii)**.

I(A)(2)(b)(iv).Consumption of hydrogen halides in the flue gas via corrosion or scavenging.

As explained in Declaration A at item 10, Nelson states at paragraph [0044] that a corrosion-resistant material should line the equipment used to mix the bromine gas and the activated carbon "...because the bromine species can be quite corrosive." Nelson states at paragraph [0051] that "[i]t it not a preferred embodiment of this invention to include water with the bromine gas vapor if this causes corrosion problems in the processing equipment that outweigh any advantages."

As explained in Declaration A at item 8, before the priority date of the presently claimed invention, the EPA did not recommend in-flight sorbent enhancement in the flue gas by spraying additives on coal or injecting halogens into the boiler. Rather, it described research into methods for *pre-treating* sorbents with various additives, including chlorine, and then injecting those pre-treated sorbents downstream from the boiler. This approach ensured that, e.g., chlorinating agents could react with the sorbent material without being "scavenged" by other chemicals present in the boiler.

A person of ordinary skill in the art would believe that HBr in the flue gas would be consumed via corrosion of the combustion chamber and other metallic areas of the coal-combustion plant in contact with the flue gas, or via scavenging by other species present in the flue gas. As a result, a person of ordinary skill in the art would believe that an inadequate concentration of HBr would be present for reaction with activated carbon injected into the flue gas, especially considering the low concentration of HBr/Br^- in the flue gas as discussed herein at **I(A)(2)(b)(ii)**, and the short contact time between the HBr/Br^- and the activated carbon as discussed herein at **I(A)(2)(b)(iii)**.

I(A)(2)(c). A person of ordinary skill in the art would not be motivated to use Felsvang's process with activated carbon.

Felsvang gives no data showing that the addition of HCl or Cl^- additives to coal can produce enhanced HCl or Cl^- concentrations in the activated carbon. Felsvang includes only a single Example showing the use of activated carbon for mercury removal, Example 4, the relevant portions of which are reproduced below (col. 9, lines 21-46):

> HCl concentration in the flue gas was 142 mg/Nm^3. Mercury was measured in and out of the system. The following results were achieved:

Inlet µgHg/Nm^3 at 5% O_2	Outlet µgHg/Nm^3 at 5% O_2	% Removal
5.4	0.14	97
5.2	0.18	97
5.0	0.20	96
4.7	0.18	96

> Average removal with this system is 96%.
> The above process was modified by adding activated carbon through conduit 14 to the stream of flue gas in duct 4 upstream of the drying chamber. Mercury was measured in and out of the system.
> The following results were achieved:

Amount of carbon mg/Nm^3	Inlet µgHg/Nm^3 at 5% O_2	Outlet µgHg/Nm^3 at 5% O_2	% Removal
8	4.0	0.10	98
8	4.4	<0.01	>99.8
36	6.2	0.01	99.8
36	5.6	<0.01	>99.7

Felsvang finds in Example 4 that HCl alone provided 96-97% mercury removal, while the addition of activated carbon provided 98-99.8% mercury removal, an improvement of only 1-3.8%. In contrast, Felsvang's Comparative Examples 1-3, performed with no added HCl or Cl^- in the flue

gas and no activated carbon, had a mercury removal of 1-37%. The activated carbon in Example 4 provided scarcely any improvement, with the vast majority of mercury removal improvement occurring in the presence of HCl alone without activated carbon. An improvement of 1-3.8% does not demonstrate a synergistic effect between HCl and activated carbon, especially in view of the 60-96% improvement in mercury removal achieved by HCl alone when Example 4 is compared to Comparative Examples 1-3. One of ordinary skill in the art would know that such a small improvement could have been caused by variability in combustion gas conditions and the accuracy of the measurements—evidence for any improvement from the use of activated carbon with the HCl in Felsvang is very weak and may not have occurred at all.

In addition, Felsvang fails to describe or suggest that in-flight promotion of activated carbon with HCl or Cl^- in the flue gas provides better mercury removal than treatment of activated carbon outside the flue gas with HCl. If one of ordinary skill in the art were hypothetically considering whether to use Felsvang's HCl or Cl^- treatment of activated carbon in the flue gas or Nelson's treatment of activated carbon outside the flue gas to remove mercury, that person would pick the process that results in the best mercury removal. As an initial matter, before considering modifying either one of the references, the person of ordinary skill would notice the extremely poor improvement (if any improvement actually occurred) caused by addition of activated carbon in Felsvang's sole Example showing the use of activated carbon (Example 4) and would question whether Felsvang's process is an efficient way to use activated carbon for mercury removal as compared to Nelson's process. If one of ordinary skill in the art were to investigate Felsvang's embodiments including activated carbon and compare the relative mercury-removal ability to that of activated carbon treated with HCl outside the flue gas, as shown herein at **I(D)**, they would find that treatment of activated carbon outside the flue gas with HCl as per Nelson's process actually provides more effective mercury removal per wt% HCl than treatment of activated carbon with HCl or Cl^- in the flue gas, which would lead one of ordinary skill in the art away from using Felsvang's process in the first place.

Therefore, a person of ordinary skill in the art hypothetically having Felsvang and Nelson in-hand would not select the Felsvang process to follow or modify and therefore would not be motivated to combine Felsvang and Nelson as alleged. Independent claim 1 is patentable over Felsvang and Nelson for this additional reason.

I(A)(2)(d). Nelson provides no motivation to replace Felsvang's HCl or Cl^- treatment with Nelson's HBr treatment.

For a person of ordinary skill in the art to be motivated to replace Felsvang's HCl- or Cl^--treatment with treatment by another material to provide an effective activated carbon sorbent for mercury removal, that person would need to think that the material they are using to replace the HCl or Cl^- would result in the same or better mercury-removal efficiency. However, as explained below, Nelson fails to describe or suggest that treatment of activated carbon with HBr provides the same, let alone better, mercury removal efficiency as activated carbon treated with HCl or Cl^-.

At paragraph [0017], Nelson states:

> **[0017]** The particular advantages of using bromine, rather than iodine or iodides, or chlorine or chlorides, with activated carbons for mercury control have not been previously appreciated. Gaseous bromine and hydrogen bromide have been combined with carbon substrates before, but not to sequester mercury from hot combustion-gas streams. For example, Greinke U.S. Pat. No. 5,372,619 found that bromine-treated carbon can make a superior natural-gas storage medium. In another example, SKC Inc. sells a small tube with hydrobromic acid-treated charcoal to sample air for ethylene oxide. However, with both of these uses it is

> important that the adsorption targets, natural gas and ethylene oxide, be easily desorbable from the carbon, the exact opposite of what is required in a mercury vapor sequestration application. In a similar vein, in U.S. Pat. No. 6,475,461 Ohsaki describes a process for treating carbon substrates with gaseous bromine or chlorine, but then explicitly desorbs them to achieve his desired product. Seki U.S. Pat. No. 3,961,020; Yoshida and Seki et al. U.S. Pat. No. 4,174,373; and Knoblauch et al. U.S. Pat. No. 5,179,058 impregnate activated carbon with bromine to produce a catalyst for reacting nitrogen oxide with ammonia to form nitrogen and water. In this application too, the bromine of the carbon does not act as a sequestration agent, permanently tying up its target. Rather, it serves as a catalyst, taking part in a repeated series of desired chemical reactions, but not becoming permanently consumed by any of them. Perhaps it is understandable that the tenacity of carbon-bromine-mercury complexes could be overlooked.

The first sentence of paragraph [0017] refers to the "…particular advantages of using bromine…" for treatment of activated carbons for mercury control, which must mean either elemental bromine (Br_2) or the element bromine generally, and is not a specific reference to bromides (Br^-). The "…particular advantages of using bromine…" is compared to iodine (I_2), iodides (I^-), chlorine (Cl_2), and chlorides (Cl^-), but no specific comparison is made between bromides (Br^-) and chlorides (Cl^-). However, it does not make sense for Nelson to refer to the element bromine generally while specifically distinguishing between chlorine (Cl_2) and chlorides (Cl^-), and iodine (I_2) and iodides (I^-) in the same sentence. If Nelson wanted to compare both elemental bromine (Br_2) and hydrogen bromide (HBr) to the other halides specifically disclosed in the first sentence, Nelson would have specifically distinguished between bromine (Br_2) and bromides (Br^-); therefore, "…bromine…" in the first sentence of paragraph [0017] would be interpreted as elemental bromine (Br_2), and not as the element bromine generally.

No "…particular advantages of using bromine…" are explicitly described in paragraph [0017], with the remainder of the paragraph focusing on the failure of the prior art to use bromine with activated carbon for mercury control, describing various disadvantages of other processes, such as the desorbability of Br_2, HBr, or Cl_2 from the activated carbon, or the failure of the Br_2 or HBr to act as a mercury sequestration agent. The paragraph concludes with a statement that it is

understandable that "…the tenacity of carbon-bromine-mercury complexes…" could be overlooked, which must refer to complexes including either elemental bromine (Br_2) or the element bromine generally, with no specific reference to bromide (Br^-) or complexes formed therefrom. The concluding statement of paragraph [0017] is directed toward the discussion in the bulk of paragraph [0017]—the prior art fails to use bromine with activated carbon for mercury control and therefore fails to generate carbon-bromine-mercury complexes—rather than as a statement of any relative advantage of bromine over other halogens or halides. The "…tenacity of carbon-bromine-mercury complexes…" is not specifically compared to the strength of any other complexes, such as carbon-chlorine-mercury complexes, carbon-chloride-mercury complexes, carbon-iodine-mercury complexes, or carbon-iodide-mercury complexes; therefore, at best, the "…tenacity…" of the complexes described in the last sentence of paragraph [0017] can be regarded as a general statement, rather than as a comparative one. Paragraph [0017] fails to attribute any advantage of Nelson's invention specifically to HBr or Br^-, and, moreover, fails to describe or suggest that HBr or Br^- treatment of activated carbon could provide equal, let alone better, mercury removal than HCl or Cl^- treatment of the activated carbon.

At paragraphs [0019]-[0022], Nelson states:

> **[0019]** Accordingly, it is an object of the present invention to provide a sorbent material that can be injected into a hot mercury-containing combustion gas, so that a significant portion of the mercury is adsorbed onto the sorbent and removed from the flue gas with the combustion fly ash.
>
> **[0020]** Further, it is an object of the present invention to provide a flexible, retrofitable mercury-control method that can be applied to a number of combustion gas streams and a wide range of exhaust system equipment configurations.
>
> **[0021]** In addition, it is an object of the present invention to provide a mercury sorbent material that is simple and inexpensive to manufacture and use.
>
> **[0022]** It is also an object of the present invention to provide a mercury sorbent material that causes the adsorbed gas-phase mercury to become essentially permanently-sequestered from future interactions with the environment.

Paragraphs [0019]-[0022] describe several general advantages of Nelson's activated carbon treatment, including the ability to remove mercury from a hot mercury-containing combustion gas, a flexible and retrofittable method that can be applied to a wide range of equipment configurations, simplicity and ease of use, and permanent sequestration of the mercury from environmental interactions. None of the advantages include equal or greater mercury-removal ability of HBr- or Br^--treated activated carbon as compared to HCl- or Cl^--treated activated carbon.

At paragraphs [0023]-[0024], similarly to what is stated in the Abstract and paragraphs [0028]-[0029], Nelson states:

> The mercury sorbent is prepared by treating a carbonaceous substrate with an effective amount of a bromine-containing gas for a sufficient time to increase the ability of the carbonaceous substrate to adsorb mercury and mercury-containing compounds.
>
> **[0024]** In some aspects of the invention, the bromine-containing gas comprises at least one of: elemental bromine and hydrogen bromide. In some aspects of the invention, the carbonaceous substrate comprises activated carbon.

Nelson therefore states that elemental bromine (Br_2) or hydrogen bromide (HBr) can be used to treat an activated carbon outside of a flue gas to increase the ability of the activated carbon to absorb mercury.

At paragraph [0041], Nelson states:

> **[0041]** I have discovered that the simple act of exposing a carbonaceous material, preferably powdered activated carbon (PAC), to gaseous bromine, $Br_2(g)$, or to gaseous hydrogen bromide, HBr(g), significantly increases the carbonaceous material's ability to remove mercury species when injected into high-temperature coal-fired flue-gas compositions. Surprisingly, gaseous bromine produces a much more effective and appropriate carbon sorbent for mercury in hot combustion gases than do iodine or iodide species, or chlorine or chloride species, in contrast to what has been taught in the prior art.

Paragraph [0041] begins by stating that gaseous bromine (defined as Br_2) or hydrogen bromide (HBr) increases the mercury absorption capacity of activated carbon. Then, paragraph

[0041] goes on to explicitly state that gaseous bromine, defined as Br_2 in the prior sentence, produces a more effective mercury-absorbing carbon sorbent than iodine (I_2), iodide (I^-), chlorine (Cl_2), or chloride (Cl^-). With the precise definitions given for gaseous bromine and hydrogen bromide, and then reference only to gaseous bromine in the next sentence, Nelson makes clear that the comparison of efficacy is only with respect to elemental bromine (Br_2) and not hydrogen bromide. Like paragraph [0017], paragraph [0041] also fails to describe or suggest that hydrogen bromide treatment of activated carbons is more effective for mercury removal than HCl or Cl^- treatment of activated carbons.

At paragraph [0042], Nelson states:

> **[0042]** The combination of carbon and gaseous bromine produces an inexpensive sorbent material that can be simply injected into the ductwork of a power plant ahead of an existing electrostatic precipitator, without the need for large volumes of sorbent, retrofitted flue-gas cooling, or extended sorption time on an additional fabric filter.

Paragraph [0042]'s reference to "gaseous bromine" refers only to elemental bromine (Br_2) due to the explicit definition given in the preceding paragraph [0041]. Paragraph [0042] expands on the advantage mentioned at paragraphs [0020]-[0021], stating that an advantage of the invention includes simple injection of the treated activated carbon sorbent into the ductwork ahead of an ESP, without the need for large volumes of sorbent, retrofitted flue-gas cooling, or extended sorption time on a filter.

At paragraph [0043], Nelson states:

> **[0043]** While not intending to be limited by hypothesized chemistry, it appears that in exposing PAC to concentrated bromine gas, a relatively large quantity of the bromine reacts with the carbon, forming surface compounds on the large surface-area of the carbon. When the PAC is then injected into the flue gas, the elemental mercury and oxidized mercury species there appear to react with at least one form of the bromine-carbon surface compounds that were created and are held fast. When the carbon particles are removed from the flue gas along with the fly ash by the electrostatic precipitator (ESP) or fabric filter, the mercury is removed

> with them. The mercury sorbents are then disposed of with the fly ash. Because the mercury has been chemically adsorbed, rather than just physically adsorbed, the captured mercury appears to be very stable and does not revolatilize or leach.

Paragraph [0043] expands on the general advantage described in paragraph [0022] of permanent sequestration of the mercury from environmental interactions. The advantage is not described or suggested to include equal or greater mercury-removal ability of HBr- or Br^--treated activated carbon as compared to HCl- or Cl^--treated activated carbon.

At paragraph [0044], Nelson states:

> [0044] Production of the new mercury sorbent materials is simple and inexpensive. The carbon material and the bromine gas need simply be contacted with each other for the advantageous mercury-reactive surface compounds to quickly form. Elemental bromine is a liquid at ambient temperature, but turns to a gas at only a modestly elevated temperature. Hydrogen bromide is a gas at even ambient temperature. Using a gas-phase carbon reactant considerably simplifies the production of the sorbent and leads to the low costs which are a requirement for a sorbent to be used as a once-through duct injectant. Any common mixing method and equipment can be use to contact the gaseous bromine species with the carbon-based substrates, although it is preferably lined with corrosion-resistant material, because the bromine species can be quite corrosive. It is also preferable that the mixing of bromine gas and carbon be done at an elevated temperature. This keeps the bromine gas in the gaseous form, but also minimizes the amount of any bromine physically-adsorbed into the pores of the carbon. Such physically adsorbed bromine is not chemically bound to the carbon lattice and can be emitted in handling, in storage, and especially, when the sorbent is injected into a hot flue gas.

Paragraph [0044] expands on the general advantage described in paragraph [0021] of simple and inexpensive generation and use of the treated activated carbon sorbent. Paragraph [0044] also describes that elevated temperature during treatment can provide an advantage of reduced physical-adsorption of the elemental bromine or the hydrogen bromide, which helps to avoid emission during

handling, storage, and during injection into a hot flue gas. The advantages are not described or suggested to include equal or greater mercury-removal ability of HBr- or Br^--treated activated carbon as compared to HCl- or Cl^--treated activated carbon.

At paragraph [0047], Nelson states:

> the process. An example would be a powdered activated carbon (PAC). Such a material would already have some gas-phase mercury adsorption capability which the treatment process of this invention will greatly amplify.

Nelson therefore states that the treatment process therein amplifies the mercury absorption capabilities of activated carbon. The advantage is not described or suggested to include equal or greater mercury-removal ability of HBr- or Br^--treated activated carbon as compared to HCl- or Cl^--treated activated carbon.

At paragraph [0049], Nelson states:

> **[0049]** A critical element in the process is that a bromine-containing gas **3** is used to treat the carbonaceous substrate. Preferably this gas comprises elemental bromine, $Br_2(g)$, although other bromine-containing gases, such as hydrogen bromide, HBr, will also have the advantageous effect of the invention.

Nelson therefore states that elemental bromine (Br_2) or hydrogen bromide (HBr) gas can be used to treat an activated carbon outside of a flue gas. Nelson also states that use HBr to treat the activated carbon "...will also have the advantageous effect of the invention." Nelson uses the singular "...effect..." and does not state that HBr can have all of the advantageous effects of Br_2 described therein; however, which particular advantageous effect does Nelson refer to? Further, Nelson refers generally to the advantageous effect of "...the advantageous effect of the invention..." but does not state that HBr can have all the advantageous effects of elemental bromine (Br_2); rather, Nelson states that HBr, like Br_2, can have "...the advantageous effect of the invention." By "...advantageous effect of the invention..." Nelson refers to general advantages of "...the invention..." and not specifically to advantages of Br_2; therefore, advantages specifically attributed to Br_2 in Nelson would not be imputed to HBr by the last sentence of paragraph [0049].

Nelson describes several general advantages at paragraph [0019]-[0022] that are not attributed specifically to Br_2 and that could be referred to by paragraph [0049]'s general reference to

"...the advantageous effect of the invention...", such as the ability to remove mercury from a hot mercury-containing combustion gas (expanded on at paragraph [0047]), a flexible and retrofittable method that can be applied to a wide range of equipment configurations (expanded on at paragraph [0042]), simplicity and ease of use (expanded on at paragraphs [0042] and [0044]), and permanent sequestration of the mercury from environmental interactions (expanded on at paragraph [0043]). Paragraphs [0044] and [0053] also describe that elevated temperature during treatment can provide an advantage of reduced physical-adsorption of the elemental bromine or the hydrogen bromide, which helps to avoid emission during handling, storage, and during injection into a hot flue gas. Paragraph [0062] states that mercury sorbents prepared according to Nelson's invention can capture mercury in at least the lower range of 300 °C to 400 °C. Paragraph [0065] states that injection of the treated activated carbon prior to a fabric filter can provide a longer residence time of the sorbent, higher utilization levels, as well as the possibility of recovering and reinjecting the sorbent at lower costs.

Paragraph [0017] refers to the "...particular advantages of using bromine, rather than iodine or iodides, or chlorine or chlorides, with activated carbon..." but, as explained herein, "...bromine..." would be interpreted as elemental bromine (Br_2); moreover, paragraph [0017] fails to describe or suggest any "...particular advantages of using bromine...." Paragraph [0017]'s concluding statement referring to the "...tenacity of carbon-bromine-mercury complexes..." fails to compare the strength of such complexes to the strength of any other complexes, such as carbon-chlorine-mercury complexes, carbon-chloride-mercury complexes, carbon-iodine-mercury complexes, or carbon-iodide-mercury complexes; therefore, at best, the "...tenacity..." of the complexes described in the last sentence of paragraph [0017] can be regarded as a general statement, rather than as a comparative one.

Paragraph [0041] begins by stating that gaseous bromine (defined as Br_2) or hydrogen bromide (defined as HBr) increases the mercury absorption capacity of activated carbon. Then, paragraph [0041] goes on to explicitly state that gaseous bromine, defined as Br_2 in the prior sentence, produces a more effective mercury-absorbing carbon sorbent than iodine (I_2), iodide (I^-), chlorine (Cl_2), or chloride (Cl^-). With the precise definitions given for gaseous bromine (Br_2) and hydrogen bromide, and then reference only to gaseous bromine (Br_2) in the next sentence, Nelson makes clear that the comparison of efficacy is only with respect to elemental bromine (Br_2) and not

hydrogen bromide. Paragraph [0041] fails to describe a general advantage of Nelson's invention; instead, paragraph [0041] specifically and particularly describes an advantage of elemental bromine (Br_2), which cannot be regarded as a general advantageous effect of "...the invention..." as it only applies to elemental bromine (Br_2). Accordingly, advantages explicitly attributed to Br_2 in paragraph [0041] of Nelson cannot be imputed to HBr by the last sentence of paragraph [0049].

Therefore, paragraph [0049] fails to describe or suggest that hydrogen bromide treatment of activated carbons is more effective for mercury removal than HCl or Cl^- treatment of activated carbons.

At paragraph [0050], Nelson states:

> **[0050]** In the liquid form at ambient temperatures, elemental bromine is dense and compact, with advantages in transport and storage. To be utilized in this invention, however, it must first be heated to at least about 60° C. and turned into a gaseous state. In such a state it can more uniformly treat the carbonaceous materials at low levels and provide the desired effect of increasing their mercury sequestration capabilities. A preferred method of converting the liquid bromine to a bromine-containing gas is to use a heated lance. Liquid bromine can be metered into such a heated-lance system at one end and be distributed as a gas to the substrate materials at the other end.

Nelson therefore states that an advantage of elemental bromine (Br_2) is that it is dense and compact which provides advantages in transport and storage.

At paragraph [0051], Nelson states:

> **[0051]** In some applications it may be beneficial to utilize a diluting carrier gas to better distribute the $Br_2(g)$ or HBr(g) among the carbonaceous substrate particles. However, if the process of this invention is practiced in a batch mode, it can be preferable to use pure $Br_2(g)$ or HBr(g). These can be

Nelson therefore states that elemental bromine (Br_2) or hydrogen bromide can be dispersed in a carrier gas during the treatment of the activated carbon.

At paragraph [0053], Nelson states:

> reactive towards mercury. By exposing the carbon to the bromine at an elevated temperature, less of the bromine species will volatilize off from the sorbents during their transport and storage or upon their injection into the hot combustion stream.

Paragraph [0053] describes that elevated temperature during treatment can provide an advantage of reduced volatilization during transport, storage, or during injection into the hot flue gas, expanding on the advantage described at paragraph [0044].

At paragraph [0054], Nelson states:

> **[0054]** Any level of bromination of carbonaceous substrates appears to increase their mercury-removal performance. While over 30 wt % of $Br_2(g)$ can be adsorbed into some powdered activated carbons, for example, significant increases in mercury reactivity will be observed with only about 1 wt % $Br_2(g)$ in the PAC. Greater degrees of bromination do correlate with greater maximum mercury capacities for a particular carbonaceous substrate. However, with the sorbent-injection application of this invention, only a fraction of a material's maximum possible mercury capacity is typically utilized, so the optimum level of bromine to combine with the carbon substrate may vary with the particular situation. If a PAC substrate is used, brominating to 1 wt % provides a highly-capable mercury sorbent, although a 5 wt % material performs better and may be preferable. Brominating to 15 wt % Br_2 generally produces an even more capable mercury sorbent, but as some of the bromine is held at less-energetic sites, there is a greater possibility that some degree of bromine may evolve off under some circumstances. Mercury sorbents with higher bromine concentrations will take longer to produce and cost more as well.

Paragraph [0054] refers to bromination of activated carbon, referring only to specific amounts of Br_2 used to treat the activated carbon and not giving any reference to, let alone specific amounts of, hydrogen bromide.

At paragraph [0062], Nelson states:

> **[0062]** **FIG. 4** describes the possible application of the sorbents to a plant which has a "hot-side" ESP, a particularly difficult situation for mercury control. In this equipment arrangement, the air preheater **22** follows the ESP **32**, so the temperature of the mercury-containing flue gas in the duct-work **64** before the particulate collection is very high, in the range of 300-to-400° C. Plain powdered activated carbons do not capture any mercury at these temperatures and PACs impregnated with iodine or sulfur lose their impregnates. Surprisingly, the mercury sorbents prepared according to the process of this invention appear to capture mercury in at least the lower end of this temperature range. Consequently, the sorbents from bin **71** can be useful even when injected at **72** into the very hot, low-oxygen, mercury-containing gases in ductwork **64**. The sorbents would be collected with the other gas stream particulates in the hot-side ESP **32** and the cleaned gas would proceed through ductwork **65** to the smokestack.

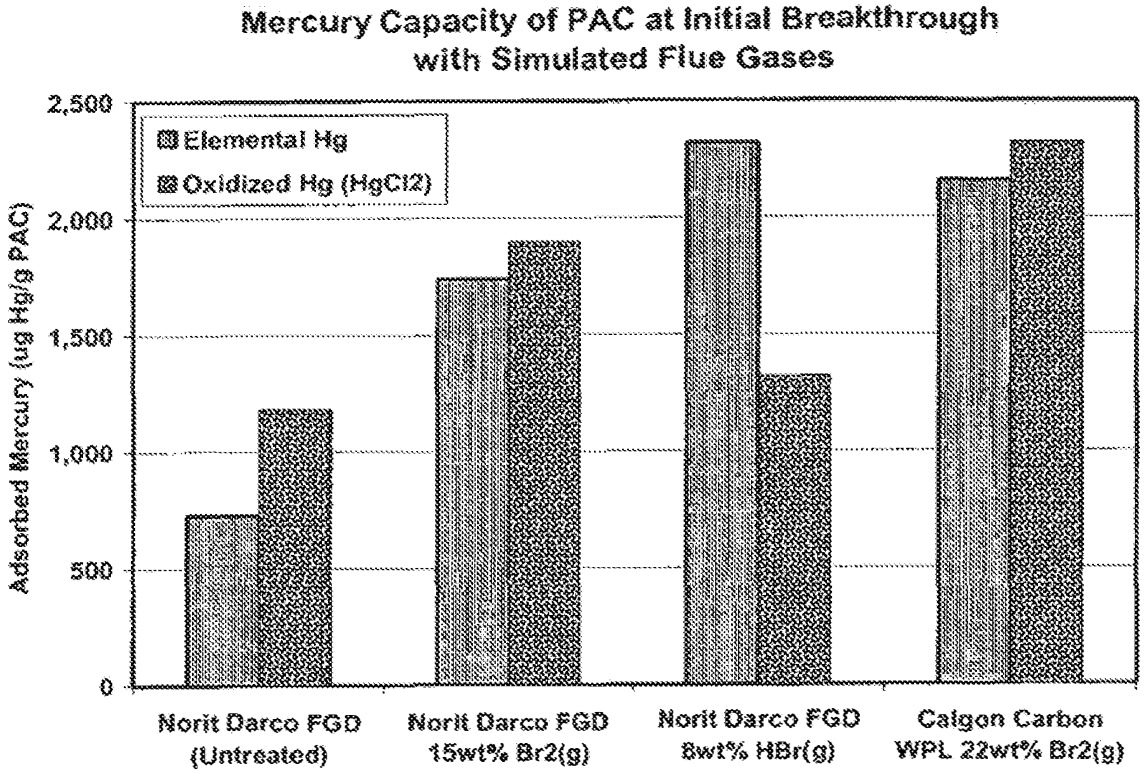
Paragraph [0062] states that mercury sorbents prepared according to Nelson's invention can capture mercury in at least the lower range of 300 °C to 400 °C, unlike activated carbons impregnated with iodine or sulfur.

At paragraph [0065], Nelson states:

> **[0065]** Two such arrangements bear particular mention. **FIG. 5** applies the sorbents in a "TOXECON®" arrange-ment. Here the mercury sorbents **71** are injected after an ESP **32** into the almost particulate-free ductwork **67** before a small, high-velocity fabric filter **33**. In this manner the fly ash **80** does not become mixed with the carbonaceous sorbents, allowing the fly ash to be sold for concrete use. Moreover, the filter cake of fabric filter **33** would predomi-nantly be mercury sorbent, allowing a longer residence time, higher utilization levels, and the possibility of recovering and reinjecting the sorbent to lower costs. The superior reactivity and capacities of the mercury sorbents of this invention make them prime candidates for use in such an arrangement.

Paragraph [0065] states that injection of the treated activated carbon prior to a fabric filter can provide a longer residence time of the sorbent, higher utilization levels, as well as the possibility of recovering and reinjecting the sorbent at lower costs.

Figure 12 of Nelson is reproduced below.



Paragraph [0080], discussing figure 12, states that:

> ...the brominated carbons adsorbed considerably more mercury species than the untreated version, with the improvements averaging about 100%. Importantly, the bromine-gas-treated sorbents removed about as much oxidized mercury-chloride from the test gases as elemental mercury, indicating performance improvements with both kinds of common flue-gas mercury species.

Both of the Br_2-treated activated carbons in figure 12 showed increased removal of both elemental mercury and oxidized mercury as compared to the untreated activated carbon. However, the HBr-treated activated carbon in figure 12 had hardly any improvement in removal of oxidized Hg compared to the untreated activated carbon, which paragraph [0080] describes as one of two common flue-gas mercury species, and that the removal of both of these species is "important."

The majority of Nelson's Examples (1-4 and 8) focus only on Br_2. Nelson's Examples 5-7 demonstrate the use of HBr-treated sorbent; however, none of these Examples or any other parts of Nelson compare the mercury-absorption performance of HBr-treated activated carbon to HCl-treated activated carbon. Although figures 14 and 15 illustrate HBr-treated activated carbon and Cl_2-treated activated carbon, Cl_2-treated activated carbon is not HCl-treated or Cl^--treated carbon and these figures fail to show any comparison to HCl- or Cl^--treated activated carbon.

At paragraph [0085], Nelson states:

> sorbents of this invention. See **FIG. 14**. About three times as much chlorine-gas treated PAC was required to achieve the same degree of mercury removal as with bromine. The

Figure 14 of Nelson is reproduced below:

Figure 14.

Duct-Injection Pilot Plant with ESP

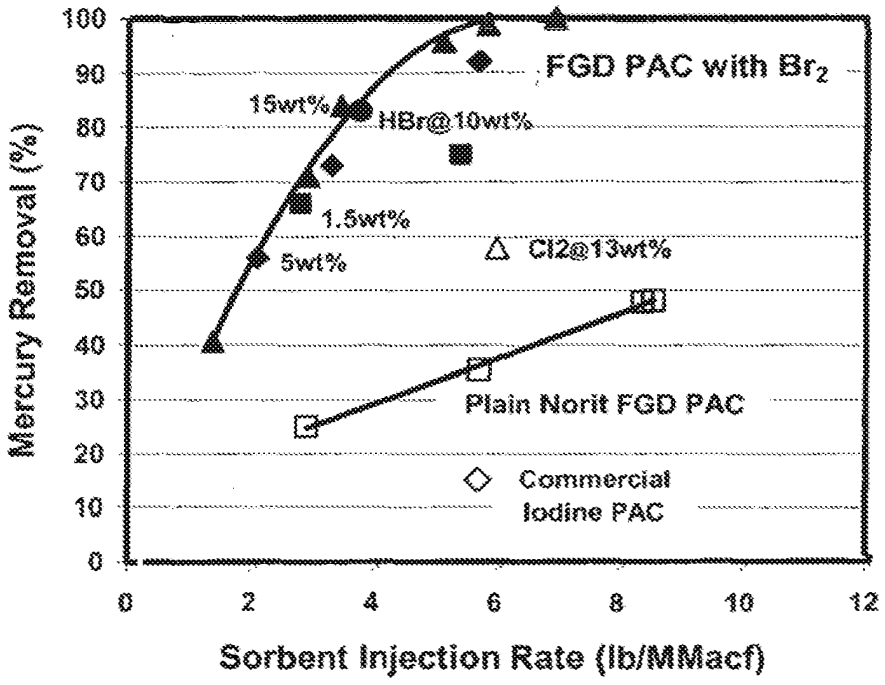


Figure 14 shows mercury removal percent from seven different types of activated carbons: commercial iodine activated carbon, plain Norit activated carbon, 13 wt% Cl_2-treated activated carbon, 10 wt% HBr-treated activated carbon, 1.5 wt% Br_2-treated activated carbon, 5 wt% Br_2-treated activated carbon, and 15 wt% Br_2-treated activated carbon. No HCl- or Cl^--treated activated

carbon is shown in Figure 14 or described in any of Examples 5-7 (the only Examples demonstrating the use of HBr-treated activated carbon). Paragraph [0085] states that about three times as much chlorine-gas treated activated carbon was required to achieve the same degree of mercury removal as with bromine, which can only be a comparison between the 13 wt% Cl_2-treated activated carbon and the 5 wt% Br_2-treated activated carbon which had a percent mercury removal that was about the same. Further, with regard to figure 14, Nelson states at paragraph [0084] that "[t]here was not much difference in performance between the various brominated samples, probably because in the duct-injection mode they only used a small fraction of their available mercury-adsorption capacity." Therefore, Nelson states that figure 14 does not provide an accurate comparison between the brominated samples, because the full mercury-adsorption capacity was not utilized.

At paragraph [0087], and the following table, Nelson states:

> **[0087]** Manufacture of the elemental bromine sorbents was much faster than for the others. The elemental bromine was adsorbed and reacted with the PACs much faster than was the elemental chlorine, for example—one-hundred-times faster. This allowed for quick and inexpensive manufacture of these sorbents. See the table below with rate data in terms of grams of gas adsorbed per kilogram of PAC per minute. The PAC adsorption of gaseous hydrogen bromide, HBr(g), was ten times faster than it was for chlorine.

Gaseous Halogen	Final Loading on FGD PAC (wt %)	Adsorption Rate (gm of gas) (kg PAC = min)	Concentration in Storage Vessel (ppm)
Br_2 (g)	5%	10	0
Br_2 (g)	15%	10	0.5
HBr (g)	9%	1	N.A.
Cl_2 (g)	13%	0.1	>40

Paragraph [0087] states that the activated carbon adsorbed elemental bromine (Br_2) and hydrogen bromide (HBr) faster than chlorine (explicitly shown as Cl_2 in the Table). The table shows the amount of treatment material (Br_2, HBr, or Cl_2) absorbed on the activated carbon and the rate of adsorption of the treatment material on the activated carbon. Paragraph [0087] and the table

that follows make no statements describing or suggesting mercury removal rates of the treated activated carbon.

Figure 15 of Nelson is reproduced below:

Figure 15.

Lausche Plant Duct-Injection ESP Trials

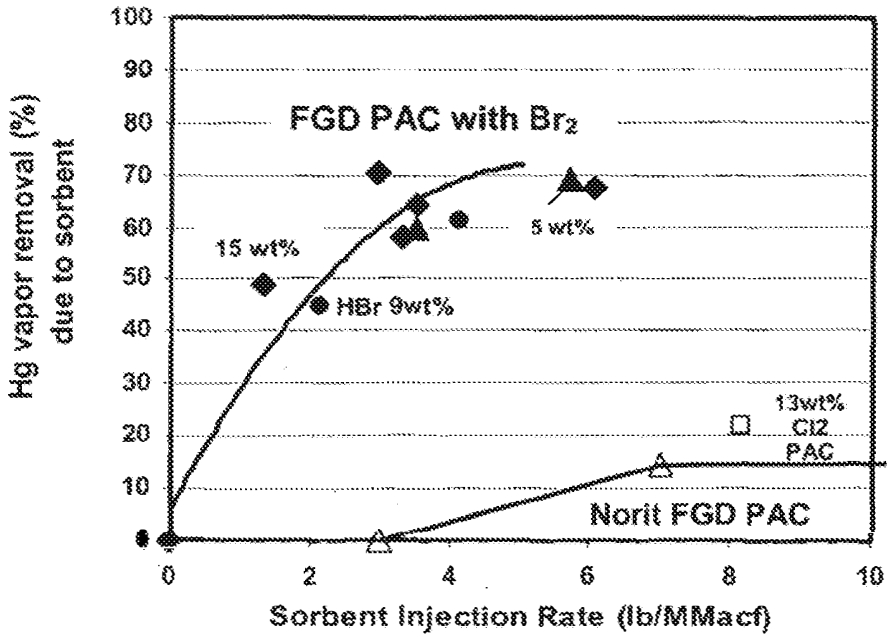


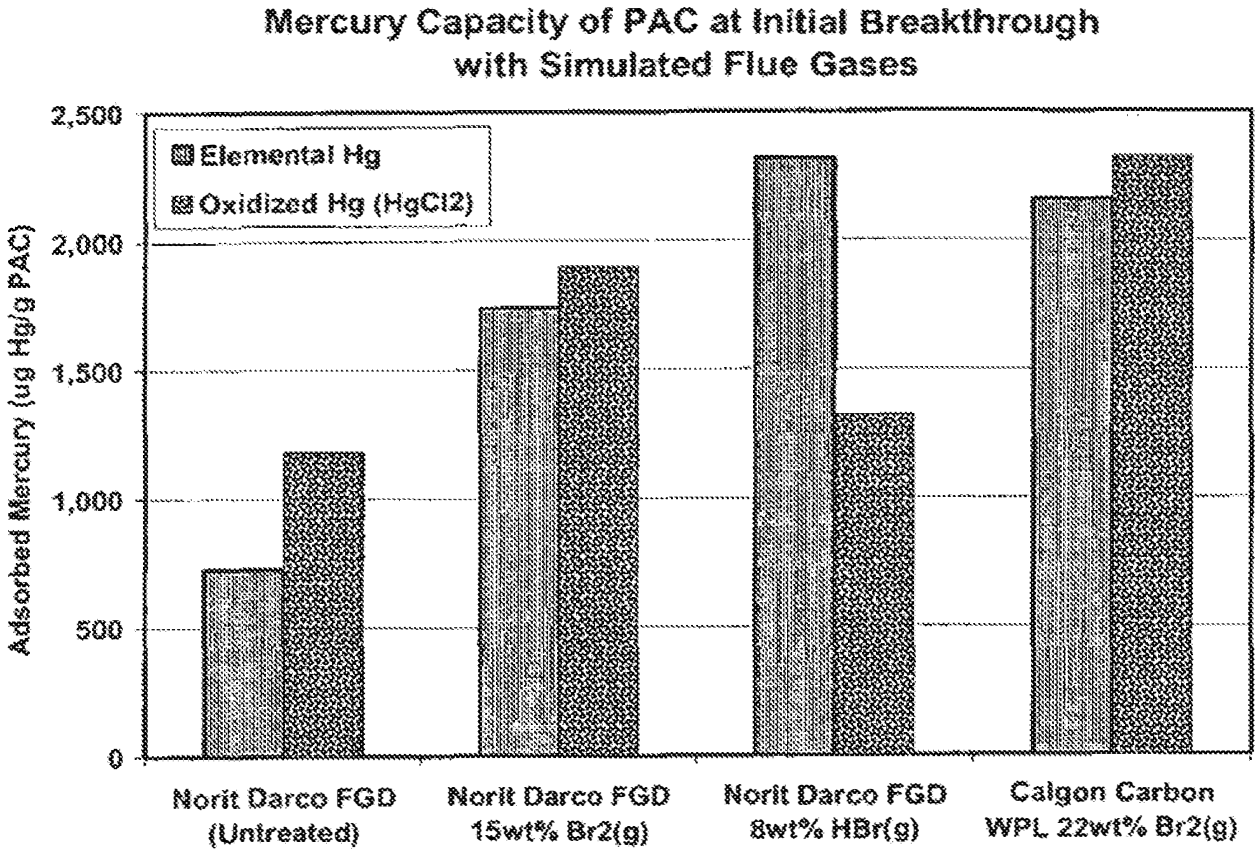
Figure 15 shows mercury removal percent from five different types of activated carbons: Norit activated carbon, 13 wt% Cl_2-treated activated carbon, 9 wt% HBr-treated activated carbon, 5 wt% Br_2-treated activated carbon, and 15 wt% Br_2-treated activated carbon. No HCl- or Cl^--treated activated carbon is shown in Figure 15 or described in any of Examples 5-7 (the only Examples demonstrating the use of HBr-treated activated carbon). For all data points showing HBr-treated activated carbon, a higher sorbent injection rate was needed to achieve equivalent mercury-removal performance as the Br_2-treated activated carbons (i.e., the HBr data points for a given mercury-removal percentage are always to the right of the Br_2 data points for that mercury-removal percentage), indicating HBr-treated activated carbon to have less mercury-removal ability than Br_2-treated activated carbons.

At paragraph [0092], Nelson states:

> **[0092]** The brominated sorbents of this invention, on the other hand, performed very well with this difficult flue gas, achieving about 50% mercury removal with only 2 lb/MMacf of sorbent consumption and almost 70% removal at an injection rate of 4 lb/MMacf. PACs brominated with Br_2 to 5 wt % and 15 wt %, and with HBr to 9 wt % all performed similarly.

Paragraph [0092] refers to the data shown in Figure 15. However, Figure 15 shows mercury removal percent from five different types of activated carbons: Norit activated carbon, 13 wt% Cl_2-treated activated carbon, 9 wt% HBr-treated activated carbon, 5 wt% Br_2-treated activated carbon, and 15 wt% Br_2-treated activated carbon. No HCl- or Cl^--treated activated carbon is shown in Figure 15 or described in any of Examples 5-7 (the only Examples demonstrating the use of HBr-treated activated carbon).

Taken in the context of the entire document, figures 14-15 and paragraph [0092] fails to describe or suggest equivalent mercury-removal performance of HBr-treated activated carbon and Br_2-treated activated carbon. With regard to figure 14, Nelson states at paragraph [0084] that "[t]here was not much difference in performance between the various brominated samples, probably because in the duct-injection mode they only used a small fraction of their available mercury-adsorption capacity." Therefore, Nelson states that figure 14 does not provide an accurate comparison between the brominated samples, because the full mercury-adsorption capacity was not utilized. In figure 15, for all data points showing HBr-treated activated carbon, a higher sorbent injection rate was needed to achieve equivalent mercury-removal performance as the Br_2-treated activated carbons (i.e., the HBr data points for a given mercury-removal percentage are always to the right of the Br_2 data points for that mercury-removal percentage), indicating HBr-treated activated carbon to have less mercury-removal ability than Br_2-treated activated carbons. In figure 12, reproduced below, Nelson compares the mercury capacity of untreated activated carbon, 15 wt% Br_2-treated activated carbon, 8 wt% HBr-treated activated carbon, and 22 wt%Br_2-treated activated carbon.



Paragraph [0080], discussing figure 12, states that:

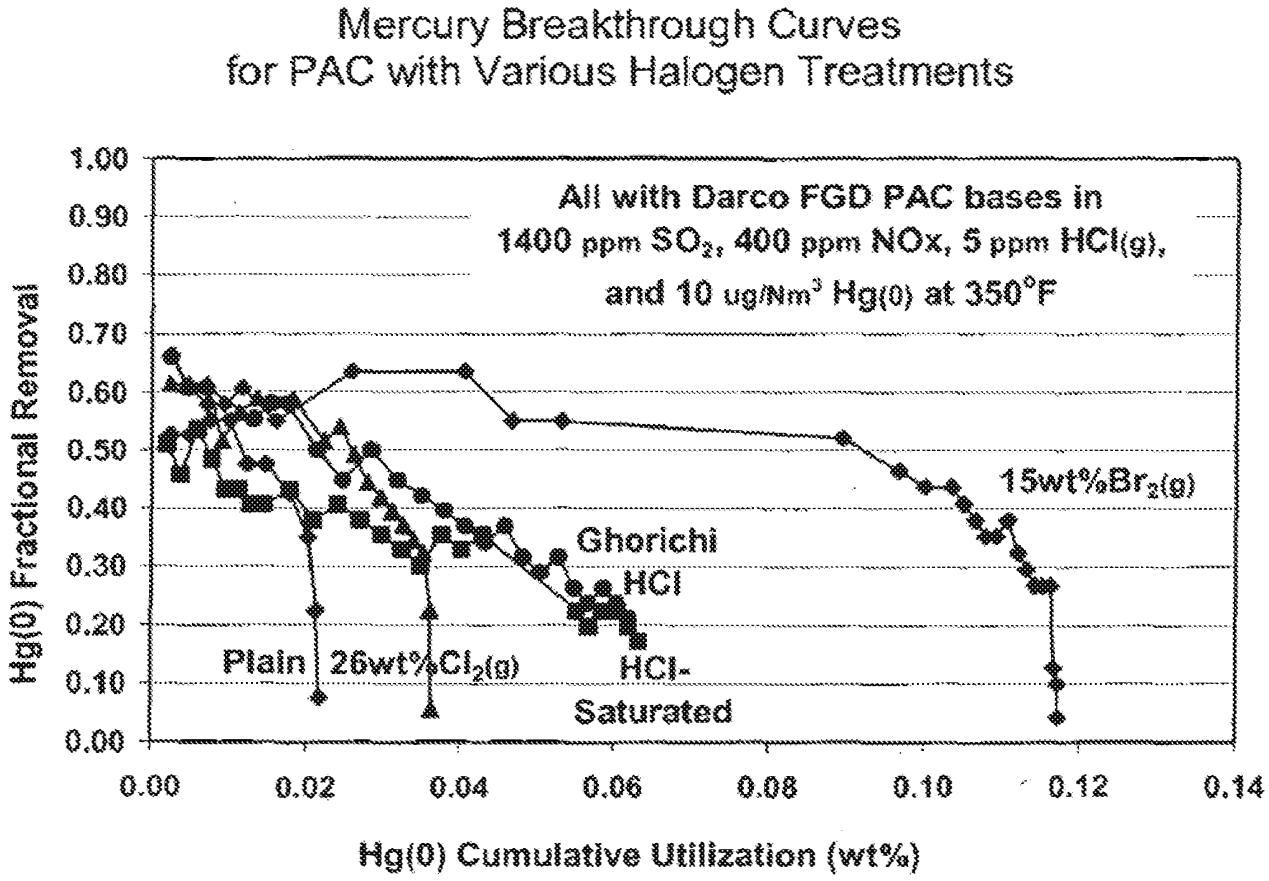
> ...the brominated carbons adsorbed considerably more mercury species than the untreated version, with the improvements averaging about 100%. Importantly, the bromine-gas-treated sorbents removed about as much oxidized mercury-chloride from the test gases as elemental mercury, indicating performance improvements with both kinds of common flue-gas mercury species.

Both of the Br_2-treated activated carbons in figure 12 showed increased removal of both elemental mercury and oxidized mercury as compared to the untreated activated carbon. However, the HBr-treated activated carbon in figure 12 had hardly any improvement in removal of oxidized Hg compared to the untreated activated carbon, which paragraph [0080] describes as one of two common flue-gas mercury species, and that the removal of both of these species is "important."

Nelson does not portray the mercury removal abilities of activated carbon treated with Cl_2 outside the flue gas as equivalent to that of activated carbon treated with HCl outside the flue gas.

At figure 11, reproduced below, Nelson shows mercury breakthrough curves for elemental mercury removal from a non-flue gas "mercury-challenge gas" for powdered activated carbon with various halogen treatments performed outside the flue gas.

Figure 11.



At paragraph [0077], reproduced below, Nelson discusses figure 11.

> [0077] The sample that had been exposed to gaseous chlorine, $Cl_2(g)$, exhibited some improvement in mercury removal performance relative to the plain, untreated PAC. Two samples of HCl-treated PACs showed even higher ultimate mercury capacities, but poorer kinetics. One of these samples had been pretreated by flowing gas-phase HCl through the PAC sample until it no longer added mass. The other, acquired from Ghorishi et al., was produced by a dilute liquid-phase HCl treatment described in their publications. The elemental mercury breakthrough curves of the two HCl-treated PACs were very similar, exhibiting a slow and steady drop-off in performance, indicative of poor mercury adsorption kinetics. In contrast, the brominated sample of this invention broke through very sharply and captured more than five times the elemental mercury of the untreated PAC.

At paragraph [0077], Nelson states that the HCl-treated powdered activated carbons had higher capacities for elemental mercury, but showed poorer kinetics. Although some information about how the Cl_2- and HCl-treated activated carbons would behave in a flue gas can be learned from figure 11, a flue gas contains additional species that were not present in the "mercury challenge gas", and, further, can include other forms of mercury other than the elemental mercury measured by the breakthrough test of figure 11, such as oxidized mercury. Nelson does not perform mercury-removal testing of HCl-treated activated carbons in a flue gas. However, Nelson in figure 11, paragraph [0077], and paragraph [0012] refers to HCl-treated activated carbon from Ghorishi et al., which had about the same performance in figure 11 as the HCl-saturated activated carbon prepared by Nelson. At paragraph [0012] Nelson describes a publication by this author, Ghorishi, S.B., Keeney, R.M., Jozewicz, W.S., Serre, S.D. and Gullett, B.K., 2001, In-flight capture of elemental mercury by a chlorine-impregnated activated carbon, Annual Air and Waste Management Association(AWMA) Conference, Orlando, FL, Vol. 24, No. 28 ("Ghorishi").

Ghorishi's conclusion at page 11 states that over 80% mercury removal was accomplished from a flue gas using activated carbon treated outside the flue gas with HCl. Comparing these results to Nelson's results shown in figures 14 and 15, 80% mercury removal is better than the about 58% removal by Cl_2-treated activated carbon in figure 14, is better than the about 22% removal by Cl_2-treated activated carbon in figure 15, and is better than the maximum mercury removal of HBr-

or Br_2-treated activated carbons in figure 15. Therefore, one of ordinary skill in the art hypothetically reviewing Nelson would not only conclude that activated carbon treated outside the flue gas with HCl not only has higher capacity for elemental mercury than Cl_2-treated activated carbon as shown in Nelson's figure 11, but also from comparing Ghorishi to Nelson that activated carbon treated outside the flue gas with HCl has better mercury removal performance in flue gas than Cl_2-treated activated carbon. Accordingly, even if, merely for the sake of argument, one of ordinary skill in the art were to conclude from Nelson's statements at paragraph [0092] that activated carbon treated with HBr or Br_2 outside the flue gas have similar mercury removal abilities, this would not lead to the conclusion that activated carbon treated with HBr outside the flue gas has better mercury removal abilities than activated carbon treated with HCl outside the flue gas.

Nelson never directly compares the mercury-removal ability of HBr-treated activated carbon with HCl-treated activated carbon. With Nelson clearly indicating that HBr-treated activated carbon has inferior mercury-removal ability as compared to Br_2-treated activated carbon, and that HCl-treated activated carbon has superior mercury-removal ability as compared to Cl_2-treated activated carbon, there is no way that one of ordinary skill in the art hypothetically considering Nelson could conclude that HBr-treated activated carbon has equivalent or superior mercury-removal ability compared to HCl-treated activated carbon.

No part of Nelson describes or suggests that HBr or Br^- even have the same effectiveness for mercury sequestration when used to treat activated carbons as HCl or Cl^-, let alone that HBr or Br^- are more effective for mercury sequestration when used to treat activated carbons than HCl or Cl^-. A person of ordinary skill in the art would have no reason to modify Felsvang's HCl or Cl^- process with a different promoter to form an effective carbon sorbent for mercury removal if the resulting mercury-removal efficiency could not be reasonably predicted to be the same or greater as that of Felsvang's original process. Therefore, a person of ordinary skill in the art would not be motivated to replace Felsvang's HCl or Cl^- treatment of activated carbon with Nelson's HBr treatment. Independent claim 1 is patentable for at least this reason.

I(A)(3). Reply to Examiner's response to arguments.

The Office Action states:

> The applicant traverses the combination of Felsvang and Nelson combination stating that there is no motivation for a person of ordinary skill in the art to use Nelson's bromide additives in Felsvang's process. The applicant contends that one having ordinary skill in the art would not be motivated to replace Felsvang's chloride-treatment with treatment by another material as the prior art does not disclose the bromide additives performing the same or better mercury-removal efficiency.
>
> The examiner disagrees. See Fig. 14 of Nelson which shows that about 3 times the amount of chlorine treated PAC was required to achieve the same degree of mercury removal as with bromine. (paragraph [0085]). Also see the absorption rate in the table on page 8. Further as the rejection above states. Both chlorine and bromine are known within the art to treat activated carbon and therefore it would be well within the capability of one having ordinary skill in the art to *either replace the Cl with or include in addition to* the halogen or halide promoter comprising HBr, Br^-, or a combination thereof to promote activated carbon (Nelson paragraphs [0017] and [0041]) so as to provide an effective carbon sorbent for mercury.

The Office Action states that Fig. 14 of Nelson shows that about 3 times the amount of chlorine treated PAC was required to achieve the same degree of mercury removal as with bromine, citing to paragraph [0085]. The Office Action also cites to the absorption rate in the table on page 8.

Although figures 14 and 15 illustrate HBr-treated activated carbon and Cl_2-treated activated carbon, Cl_2-treated activated carbon is not HCl- or Cl^--treated carbon and these figures fail to show any comparison to HCl- or Cl^--treated activated carbon.

At paragraph [0085], Nelson states:

> sorbents of this invention. See **FIG. 14**. About three times as much chlorine-gas treated PAC was required to achieve the same degree of mercury removal as with bromine. The

Figure 14 of Nelson is reproduced below:

Figure 14.

Duct-Injection Pilot Plant with ESP

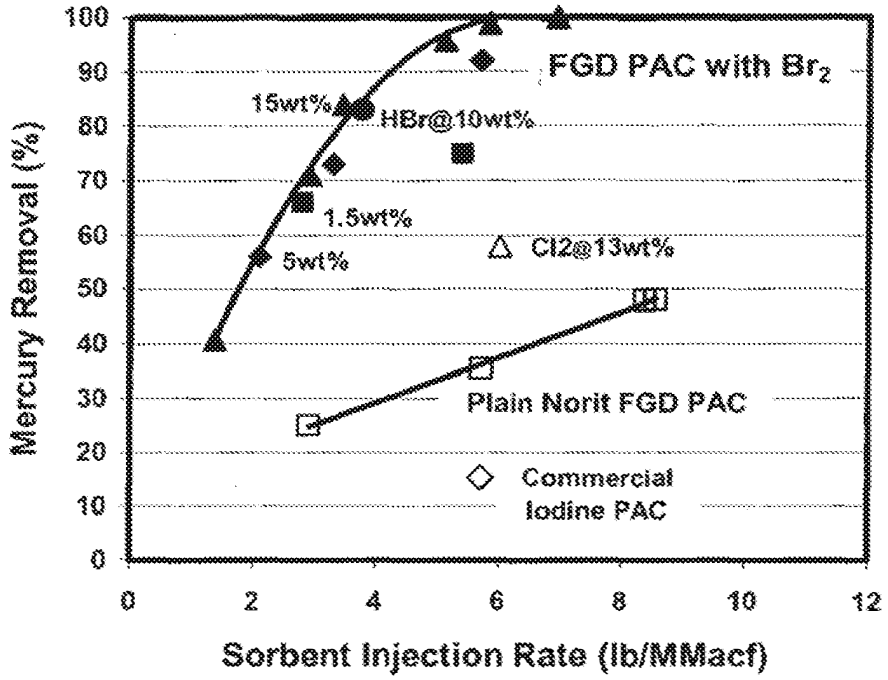


Figure 14 shows mercury removal percent from seven different types of activated carbons: commercial iodine activated carbon, plain Norit activated carbon, 13 wt% Cl_2-treated activated carbon, 10 wt% HBr-treated activated carbon, 1.5 wt% Br_2-treated activated carbon, 5 wt% Br_2-treated activated carbon, and 15 wt% Br_2-treated activated carbon. No HCl- or Cl^--treated activated carbon is shown in Figure 14 or described in any of Examples 5-7 (the only Examples demonstrating the use of HBr-treated activated carbon). Paragraph [0085] states that about three times as much chlorine-gas treated activated carbon was required to achieve the same degree of mercury removal as with bromine, which can only be a comparison between the 13 wt% Cl_2-treated activated carbon and the 5 wt% Br_2-treated activated carbon which had a percent mercury removal that was about the same.

At paragraph [0017], Nelson states:

> [0017] The particular advantages of using bromine, rather than iodine or iodides, or chlorine or chlorides, with activated carbons for mercury control have not been previously appreciated. Gaseous bromine and hydrogen bromide have been combined with carbon substrates before, but not to sequester mercury from hot combustion-gas streams. For example, Greinke U.S. Pat. No. 5,372,619 found that bromine-treated carbon can make a superior natural-gas storage medium. In another example, SKC Inc. sells a small tube with hydrobromic acid-treated charcoal to sample air for ethylene oxide. However, with both of these uses it is important that the adsorption targets, natural gas and ethylene oxide, be easily desorbable from the carbon, the exact opposite of what is required in a mercury vapor sequestration application. In a similar vein, in U.S. Pat. No. 6,475,461 Ohsaki describes a process for treating carbon substrates with gaseous bromine or chlorine, but then explicitly desorbs them to achieve his desired product. Seki U.S. Pat. No. 3,961,020; Yoshida and Seki et al. U.S. Pat. No. 4,174,373; and Knoblauch et al. U.S. Pat. No. 5,179,058 impregnate activated carbon with bromine to produce a catalyst for reacting nitrogen oxide with ammonia to form nitrogen and water. In this application too, the bromine of the carbon does not act as a sequestration agent, permanently tying up its target. Rather, it serves as a catalyst, taking part in a repeated series of desired chemical reactions, but not becoming permanently consumed by any of them. Perhaps it is understandable that the tenacity of carbon-bromine-mercury complexes could be overlooked.

The first sentence of paragraph [0017] refers to the "...particular advantages of using bromine..." for treatment of activated carbons for mercury control, which must mean either elemental bromine (Br_2) or the element bromine generally, and is not a specific reference to bromides (Br^-). The "...particular advantages of using bromine..." is compared to iodine (I_2), iodides (I^-), chlorine (Cl_2), and chlorides (Cl^-), but no specific comparison is made between bromides (Br^-) and chlorides (Cl^-). However, it does not make sense for Nelson to refer to the element bromine generally while specifically distinguishing between chlorine (Cl_2) and chlorides (Cl^-), and iodine (I_2) and iodides (I^-) in the same sentence. If Nelson wanted to compare both

elemental bromine (Br_2) and hydrogen bromide (HBr) to the other halides specifically disclosed in the first sentence, Nelson would have specifically distinguished between bromine (Br_2) and bromides (Br^-); therefore, "...bromine..." in the first sentence of paragraph [0017] would be interpreted as elemental bromine (Br_2), and not as the element bromine generally.

No "...particular advantages of using bromine..." are explicitly described in paragraph [0017], with the remainder of the paragraph focusing on the failure of the prior art to use bromine with activated carbon for mercury control, describing various disadvantages of other processes, such as the desorbability of Br_2, HBr, or Cl_2 from the activated carbon, or the failure of the Br_2 or HBr to act as a mercury sequestration agent. The paragraph concludes with a statement that it is understandable that "...the tenacity of carbon-bromine-mercury complexes..." could be overlooked, which must refer to complexes including either elemental bromine (Br_2) or the element bromine generally, with no specific reference to bromide (Br^-) or complexes formed therefrom. The concluding statement of paragraph [0017] is directed toward the discussion in the bulk of paragraph [0017]—the prior art fails to use bromine with activated carbon for mercury control and therefore fails to generate carbon-bromine-mercury complexes—rather than as a statement of any relative advantage of bromine over other halogens or halides. The "...tenacity of carbon-bromine-mercury complexes..." is not specifically compared to the strength of any other complexes, such as carbon-chlorine-mercury complexes, carbon-chloride-mercury complexes, carbon-iodine-mercury complexes, or carbon-iodide-mercury complexes; therefore, at best, the "...tenacity..." of the complexes described in the last sentence of paragraph [0017] can be regarded as a general statement, rather than as a comparative one. Paragraph [0017] fails to attribute any advantage of Nelson's invention specifically to HBr or Br^-, and, moreover, fails to describe or suggest that HBr or Br^- treatment of activated carbon could provide equal, let alone better, mercury removal than HCl or Cl^- treatment of the activated carbon.

At paragraph [0044], Nelson states:

> **[0044]** Production of the new mercury sorbent materials is simple and inexpensive. The carbon material and the bromine gas need simply be contacted with each other for the advantageous mercury-reactive surface compounds to quickly form. Elemental bromine is a liquid at ambient temperature, but turns to a gas at only a modestly elevated temperature. Hydrogen bromide is a gas at even ambient temperature. Using a gas-phase carbon reactant considerably simplifies the production of the sorbent and leads to the low costs which are a requirement for a sorbent to be used as a once-through duct injectant. Any common mixing method and equipment can be use to contact the gaseous bromine species with the carbon-based substrates, although it is preferably lined with corrosion-resistant material, because the bromine species can be quite corrosive. It is also preferable that the mixing of bromine gas and carbon be done at an elevated temperature. This keeps the bromine gas in the gaseous form, but also minimizes the amount of any bromine physically-adsorbed into the pores of the carbon. Such physically adsorbed bromine is not chemically bound to the carbon lattice and can be emitted in handling, in storage, and especially, when the sorbent is injected into a hot flue gas.

Paragraph [0044] expands on the general advantage described in paragraph [0021] of simple and inexpensive generation and use of the treated activated carbon sorbent. Paragraph [0044] also describes that elevated temperature during treatment can provide an advantage of reduced physical-adsorption of the elemental bromine or the hydrogen bromide, which helps to avoid emission during handling, storage, and during injection into a hot flue gas. The advantages are not described or suggested to include equal or greater mercury-removal ability of HBr- or Br^--treated activated carbon as compared to HCl- or Cl^--treated activated carbon.

The Office Action states:

> The applicant contends that the Nelson reference does not disclose HBR and Br⁻ being more effect with activated carbons than chlorides.
>
> The examiner disagrees. The Nelson reference discloses that HBr is used to provide bromide to the system. Example 5, paragraph [0083] states that the brominated PACs were treated with HBr or Br_2. Figures 14 and 15 disclose that HBr treated PAC performs better than chlorine treated PAC. Further one having ordinary skill in the art would expect PAC treated with HBr or Br_2 would result in a very similar modified PAC as they both include bromide (see paragraph [0092] which discloses that each of the brominated PACs performed similarly). The examiner also points to paragraph [0087] of Nelson which discloses that PAC adsorption of gaseous hydrogen bromide being ten times faster than it was for chlorine.

The Office Action states that the Nelson reference discloses that HBr is used to provide bromide to the system, and that Example 5, paragraph [0083] states that brominated PACs were treated with HBr or Br_2. Applicant cannot find the language of providing HBr "to the system" in Nelson; paragraph [0083] in Example 5 describes treating powdered activated carbons with different amounts of gaseous $Br_2(g)$ or HBr prior to injecting the activated carbons into the flue gas. However, Nelson fails to describe or suggest that treatment of activated carbon with HBr provides the same, let alone better, mercury removal efficiency as activated carbon treated with HCl or Cl^-.

With regard to figures 14 and 15, as explained above, although figures 14 and 15 illustrate HBr-treated activated carbon and Cl_2-treated activated carbon, Cl_2-treated activated carbon is not HCl- or Cl^--treated carbon and these figures fail to show any comparison to HCl- or Cl^--treated activated carbon. Figure 14 shows mercury removal percent from seven different types of activated carbons: commercial iodine activated carbon, plain Norit activated carbon, 13 wt% Cl_2-treated activated carbon, 10 wt% HBr-treated activated carbon, 1.5 wt% Br_2-treated activated carbon, 5 wt% Br_2-treated activated carbon, and 15 wt% Br_2-treated activated carbon. No HCl- or Cl^--treated activated carbon is shown in Figure 14 or described in any of Examples 5-7 (the only Examples demonstrating the use of HBr-treated activated carbon). Paragraph [0085] states that about three times as much chlorine-gas treated activated carbon was required to achieve the same degree of mercury removal as with bromine, which can only be a comparison between the 13 wt% Cl_2-treated activated carbon and the 5 wt% Br_2-treated activated carbon which had a percent mercury removal that was about the same. Figure 15 shows mercury removal percent from five different types of

activated carbons: Norit activated carbon, 13 wt% Cl_2-treated activated carbon, 9 wt% HBr-treated activated carbon, 5 wt% Br_2-treated activated carbon, and 15 wt% Br_2-treated activated carbon. No HCl- or Cl^--treated activated carbon is shown in Figure 15 or described in any of Examples 5-7 (the only Examples demonstrating the use of HBr-treated activated carbon).

The Office Action states that paragraph [0087] of Nelson discloses that PAC adsorption of gaseous hydrogen bromide was ten times faster than it was for chlorine. At paragraph [0087], and the following table, Nelson states:

> **[0087]** Manufacture of the elemental bromine sorbents was much faster than for the others. The elemental bromine was adsorbed and reacted with the PACs much faster than was the elemental chlorine, for example—one-hundred-times faster. This allowed for quick and inexpensive manufacture of these sorbents. See the table below with rate data in terms of grams of gas adsorbed per kilogram of PAC per minute. The PAC adsorption of gaseous hydrogen bromide, HBr(g), was ten times faster than it was for chlorine.

Gaseous Halogen	Final Loading on FGD PAC (wt %)	Adsorption Rate (gm of gas) (kg PAC = min)	Concentration in Storage Vessel (ppm)
Br_2 (g)	5%	10	0
Br_2 (g)	15%	10	0.5
HBr (g)	9%	1	N.A.
Cl_2 (g)	13%	0.1	>40

Paragraph [0087] states that the activated carbon adsorbed elemental bromine (Br_2) and hydrogen bromide (HBr) faster than chlorine (explicitly shown as Cl_2 in the Table). The table shows the amount of treatment material (Br_2, HBr, or Cl_2) absorbed on the activated carbon and the rate of adsorption of the treatment material on the activated carbon. Paragraph [0087] and the table that follows make no statements describing or suggesting mercury removal rates of the treated activated carbon.

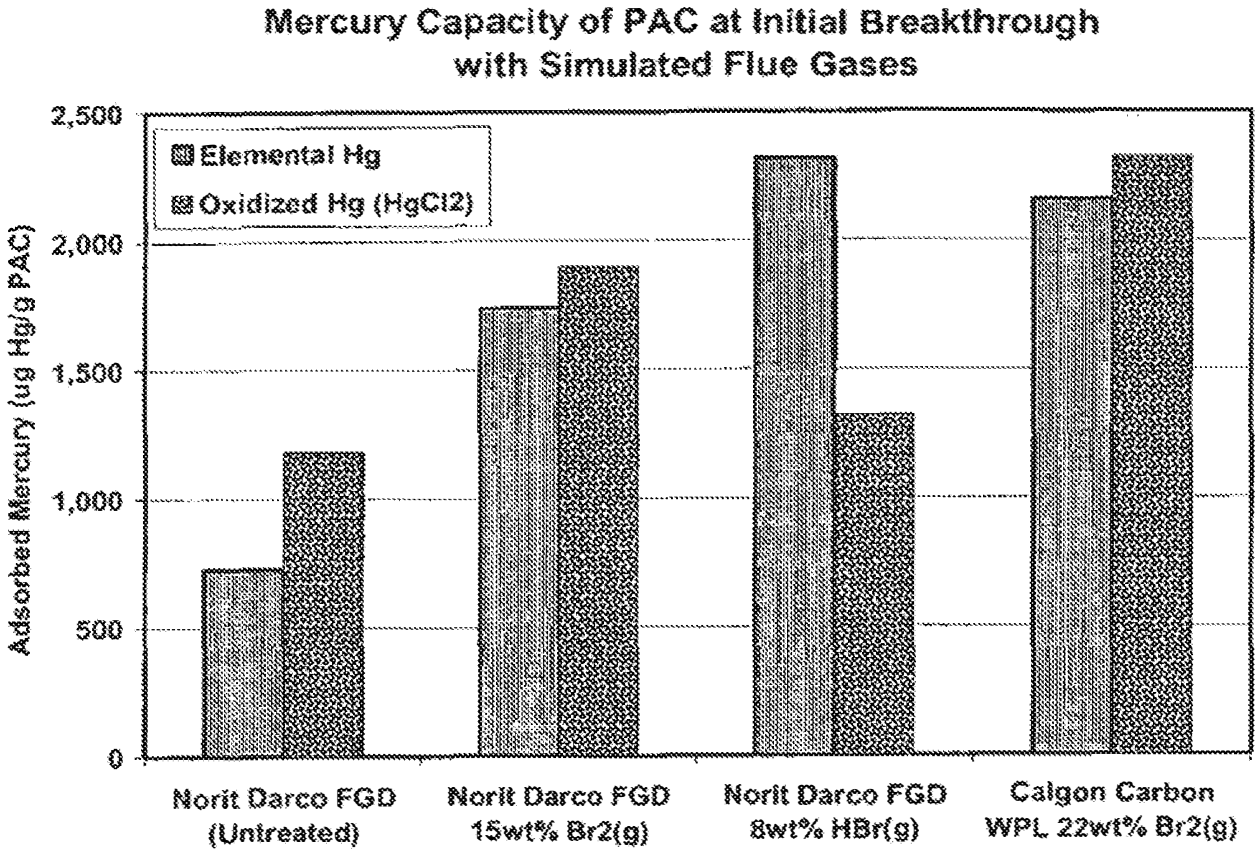
The Office Action states that one having ordinary skill in the art would expect activated carbon treated with HBr or Br_2 would result in a very similar modified PAC as they both include bromide, citing to paragraph [0092] as allegedly disclosing that each of the brominated PACs

performed similarly. Applicant notes Declaration C at item 18 which explains that Br_2 is not and does not include Br^-. At paragraph [0092], Nelson states:

> **[0092]** The brominated sorbents of this invention, on the other hand, performed very well with this difficult flue gas, achieving about 50% mercury removal with only 2 lb/MMacf of sorbent consumption and almost 70% removal at an injection rate of 4 lb/MMacf. PACs brominated with Br_2 to 5 wt % and 15 wt %, and with HBr to 9 wt % all performed similarly.

Paragraph [0092] refers to the data shown in Figure 15. However, Figure 15 shows mercury removal percent from five different types of activated carbons: Norit activated carbon, 13 wt% Cl_2-treated activated carbon, 9 wt% HBr-treated activated carbon, 5 wt% Br_2-treated activated carbon, and 15 wt% Br_2-treated activated carbon. No HCl- or Cl^--treated activated carbon is shown in Figure 15 or described in any of Examples 5-7 (the only Examples demonstrating the use of HBr-treated activated carbon).

Taken in the context of the entire document, figures 14-15 and paragraph [0092] fails to describe or suggest equivalent mercury-removal performance of HBr-treated activated carbon and Br_2-treated activated carbon. With regard to figure 14, Nelson states at paragraph [0084] that "[t]here was no much difference in performance between the various brominated samples, probably because in the duct-injection mode they only used a small fraction of their available mercury-adsorption capacity." Therefore, Nelson states that figure 14 does not provide an accurate comparison between the brominated samples, because the full mercury-adsorption capacity was not utilized. In figure 15, for all data points showing HBr-treated activated carbon, a higher sorbent injection rate was needed to achieve equivalent mercury-removal performance as the Br_2-treated activated carbons (i.e., the HBr data points for a given mercury-removal percentage are always to the right of the Br_2 data points for that mercury-removal percentage), indicating HBr-treated activated carbon to have less mercury-removal ability than Br_2-treated activated carbons. In figure 12, reproduced below, Nelson compares the mercury capacity of untreated activated carbon, 15 wt% Br_2-treated activated carbon, 8 wt% HBr-treated activated carbon, and 22 wt%Br_2-treated activated carbon.



Paragraph [0080], discussing figure 12, states that:

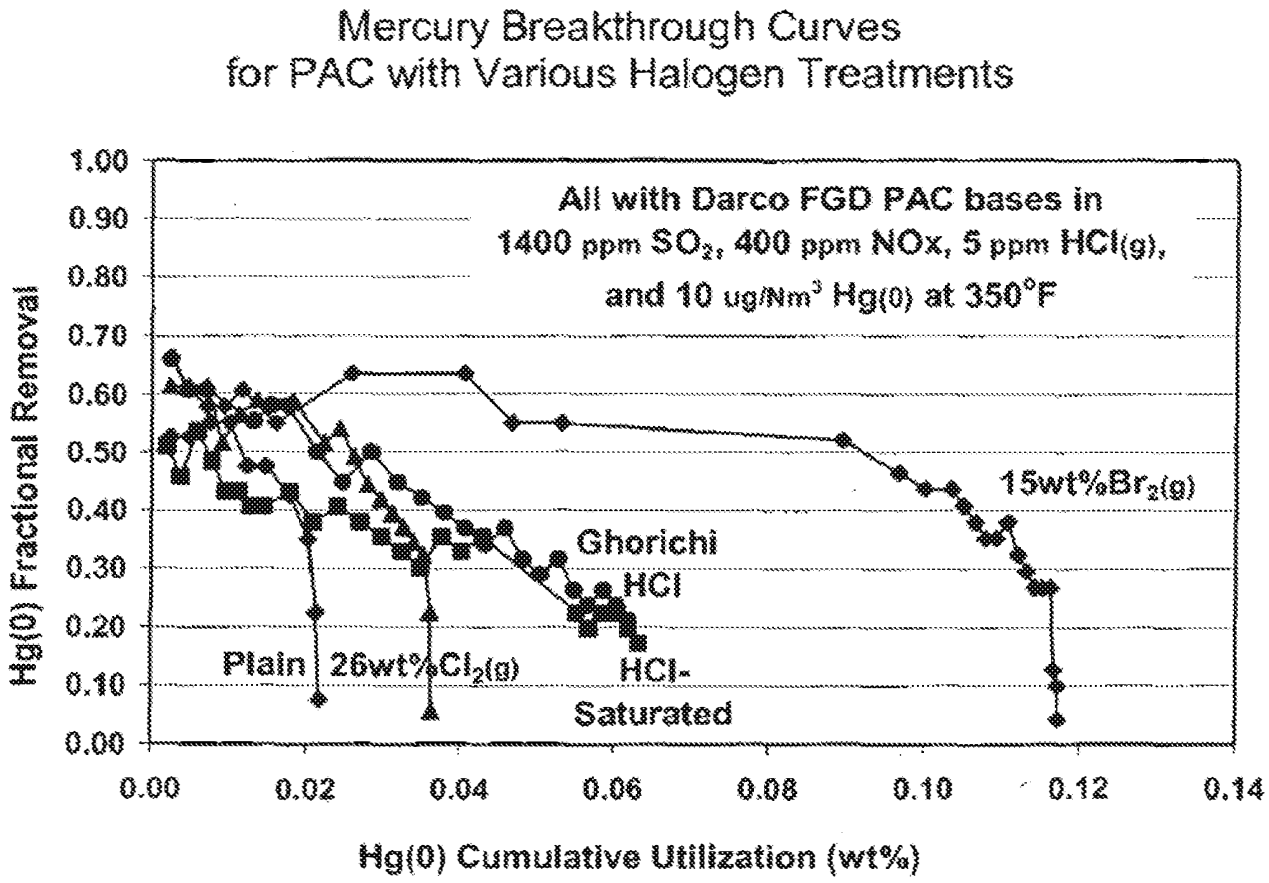
> ...the brominated carbons adsorbed considerably more mercury species than the untreated version, with the improvements averaging about 100%. Importantly, the bromine-gas-treated sorbents removed about as much oxidized mercury-chloride from the test gases as elemental mercury, indicating performance improvements with both kinds of common flue-gas mercury species.

Both of the Br_2-treated activated carbons in figure 12 showed increased removal of both elemental mercury and oxidized mercury as compared to the untreated activated carbon. However, the HBr-treated activated carbon in figure 12 had hardly any improvement in removal of oxidized Hg compared to the untreated activated carbon, which paragraph [0080] describes as one of two common flue-gas mercury species, and that the removal of both of these species is "important."

Nelson does not portray the mercury removal abilities of activated carbon treated with Cl_2 outside the flue gas as equivalent to that of activated carbon treated with HCl outside the flue gas.

At figure 11, reproduced below, Nelson shows mercury breakthrough curves for elemental mercury removal from a non-flue gas "mercury-challenge gas" for powdered activated carbon with various halogen treatments performed outside the flue gas.

Figure 11.



At paragraph [0077], reproduced below, Nelson discusses figure 11.

> [0077] The sample that had been exposed to gaseous chlorine, $Cl_2(g)$, exhibited some improvement in mercury removal performance relative to the plain, untreated PAC. Two samples of HCl-treated PACs showed even higher ultimate mercury capacities, but poorer kinetics. One of these samples had been pretreated by flowing gas-phase HCl through the PAC sample until it no longer added mass. The other, acquired from Ghorishi et al., was produced by a dilute liquid-phase HCl treatment described in their publications. The elemental mercury breakthrough curves of the two HCl-treated PACs were very similar, exhibiting a slow and steady drop-off in performance, indicative of poor mercury adsorption kinetics. In contrast, the brominated sample of this invention broke through very sharply and captured more than five times the elemental mercury of the untreated PAC.

At paragraph [0077], Nelson states that the HCl-treated powdered activated carbons had higher capacities for elemental mercury, but showed poorer kinetics. Although some information about how the Cl_2- and HCl-treated activated carbons would behave in a flue gas can be learned from figure 11, a flue gas contains additional species that were not present in the "mercury challenge gas", and, further, can include other forms of mercury other than the elemental mercury measured by the breakthrough test of figure 11, such as oxidized mercury. Nelson does not perform mercury-removal testing of HCl-treated activated carbons in a flue gas. However, Nelson in figure 11, paragraph [0077], and paragraph [0012] refers to HCl-treated activated carbon from Ghorishi et al., which had about the same performance in figure 11 as the HCl-saturated activated carbon prepared by Nelson. At paragraph [0012] Nelson describes a publication by this author, Ghorishi, S.B., Keeney, R.M., Jozewicz, W.S., Serre, S.D. and Gullett, B.K., 2001, In-flight capture of elemental mercury by a chlorine-impregnated activated carbon, Annual Air and Waste Management Association(AWMA) Conference, Orlando, FL, Vol. 24, No. 28 ("Ghorishi").

Ghorishi's conclusion at page 11 states that over 80% mercury removal was accomplished from a flue gas using activated carbon treated outside the flue gas with HCl. Comparing these results to Nelson's results shown in figures 14 and 15, 80% mercury removal is better than the about 58% removal by Cl_2-treated activated carbon in figure 14, is better than the about 22% removal by Cl_2-treated activated carbon in figure 15, and is better than the maximum mercury removal of HBr-

or Br_2-treated activated carbons in figure 15. Therefore, one of ordinary skill in the art hypothetically reviewing Nelson would not only conclude that activated carbon treated outside the flue gas with HCl not only has higher capacity for elemental mercury than Cl_2-treated activated carbon as shown in Nelson's figure 11, but also from comparing Ghorishi to Nelson that activated carbon treated outside the flue gas with HCl has better mercury removal performance in flue gas than Cl_2-treated activated carbon. Accordingly, even if, merely for the sake of argument, one of ordinary skill in the art were to conclude from Nelson's statements at paragraph [0092] that activated carbon treated with HBr or Br_2 outside the flue gas have similar mercury removal abilities, this would not lead to the conclusion that activated carbon treated with HBr outside the flue gas has better mercury removal abilities than activated carbon treated with HCl outside the flue gas.

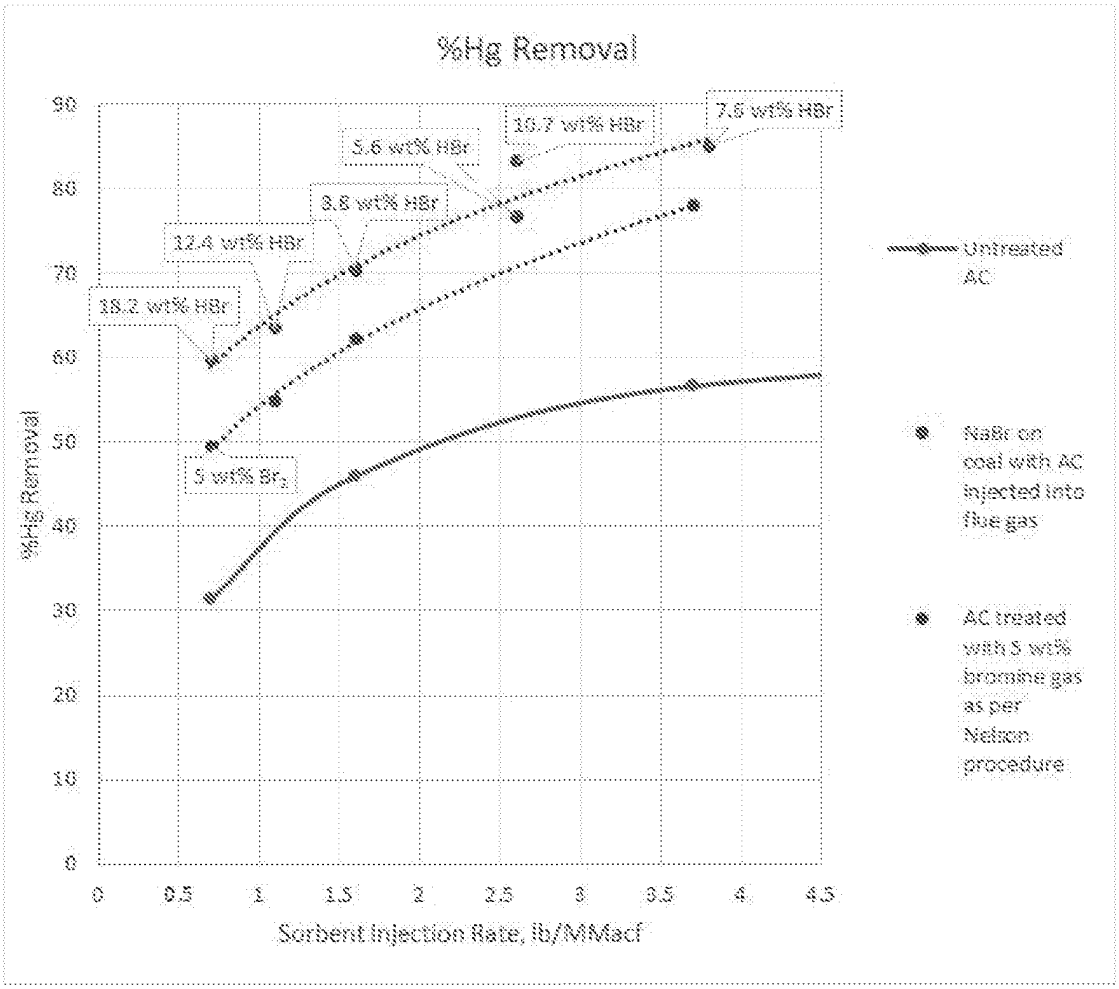
Nelson never directly compares the mercury-removal ability of HBr-treated activated carbon with HCl-treated activated carbon. With Nelson clearly indicating that HBr-treated activated carbon has inferior mercury-removal ability as compared to Br_2-treated activated carbon, and that HCl-treated activated carbon has superior mercury-removal ability as compared to Cl_2-treated activated carbon, there is no way that one of ordinary skill in the art hypothetically considering Nelson could conclude that HBr-treated activated carbon has equivalent or superior mercury-removal ability compared to HCl-treated activated carbon.

I(B). In-flight promotion versus treatment outside the flue gas.

I(B)(1). In-flight promotion with HBr or Br^- promoters is more effective for mercury removal than treating the sorbent with HBr, Br^-, or Br_2 outside the mercury-containing gas.

The inventors of the present application have discovered that by combusting coal in the presence of a HBr or Br^- promoter, and by placing an activated carbon sorbent in the mercury-containing gas, as presently claimed, the activated carbon can be promoted by the promoter in-flight in the mercury-containing gas, and further, that in-flight HBr or Br^- promotion of the activated carbon is more effective for mercury removal than use of an activated carbon that is treated with HBr, Br^-, or Br_2 outside the flue gas.

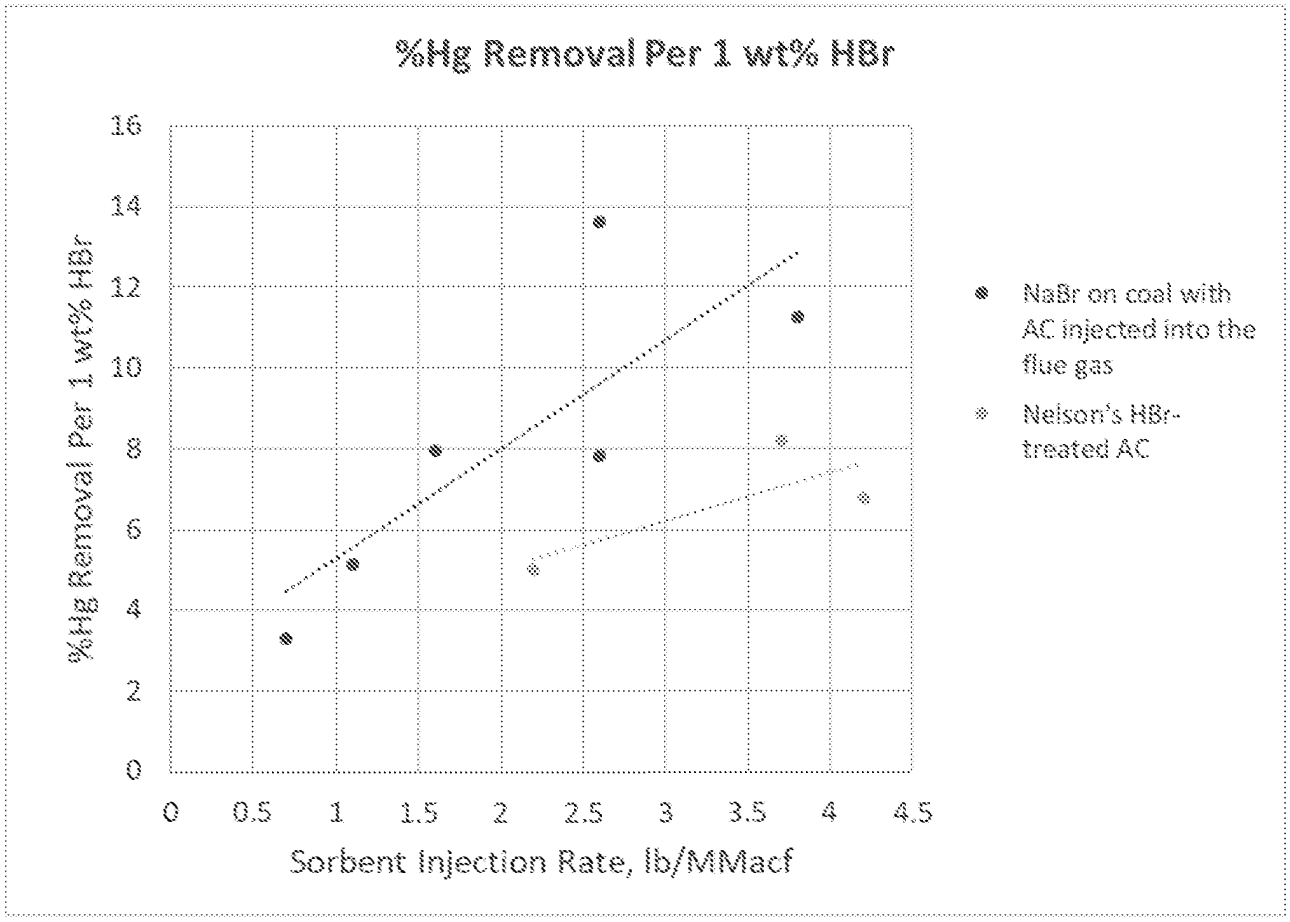
As explained in Declaration B, pilot-scale testing was performed with activated carbon alone (untreated) injected into the flue gas, the activated carbon treated with Br_2 outside the flue gas as per the Nelson procedure (see, Declaration B at item 7), and with NaBr added to coal prior to introduction to the furnace with injection of untreated activated carbon into the flue gas. The same activated carbon was used for each sample. See, Declaration B at items 8-11. The plot given in Declaration B at item 11 is reproduced below.



The data in the plot above from item 11 of Declaration B show that the NaBr added to coal prior to introduction to the furnace with injection of untreated activated carbon into the flue gas (in-flight promotion with Br^-) provided a higher percent of mercury removal at all tested sorbent injection rates as compared to the activated carbon alone (untreated) and compared to the activated carbon treated with Br_2 outside the flue gas described herein at item 6 as per the Nelson procedure.

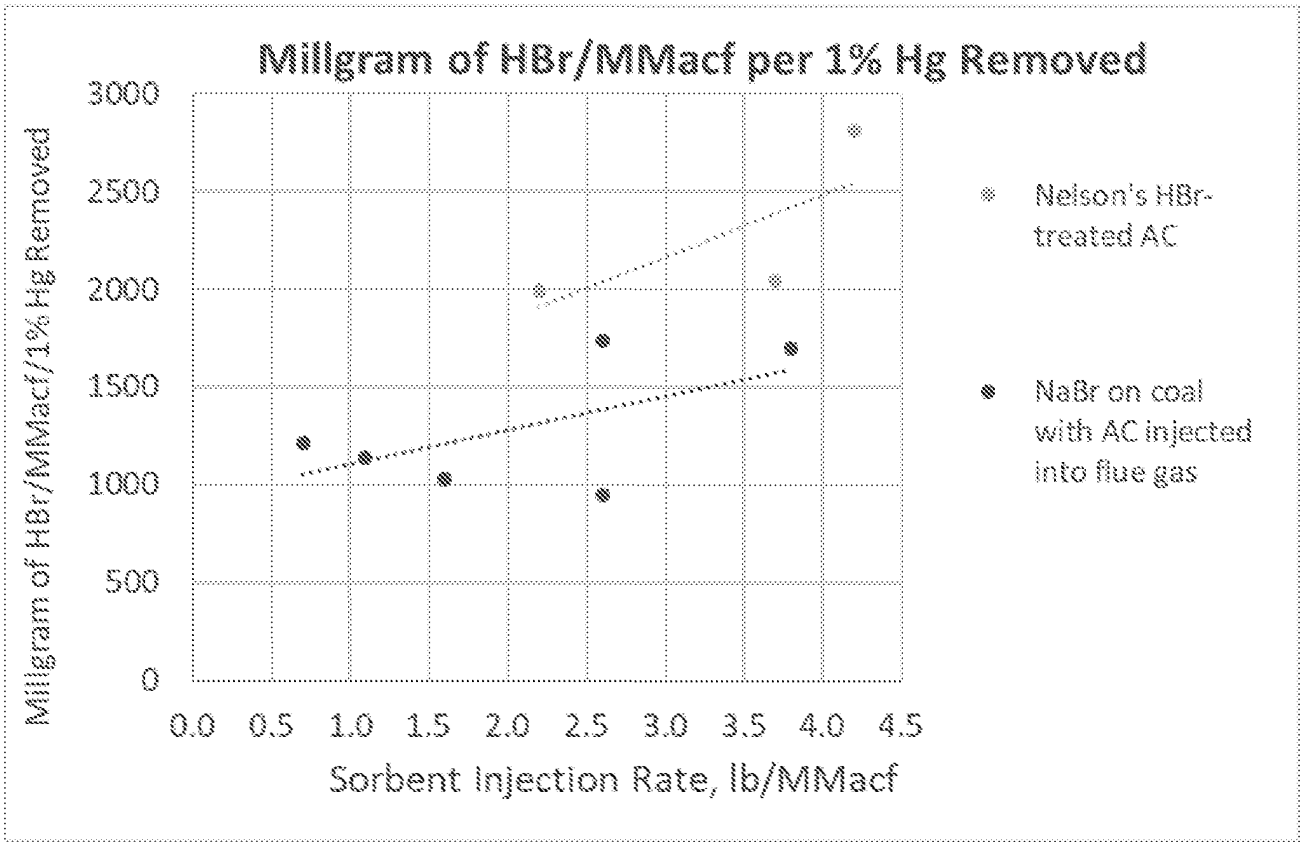
With NaBr added to the coal and activated carbon injected into the flue gas, there was a significant reduction in the amount of sorbent required to acheive similar mercury removal compared to the activated carbon treated with Br_2 outside the flue gas. For example, to acheive 70% mercury removal, 2.5 lb/MMacf of Br_2-treated carbon was required, as compared to 1.6 lb/MMacf with NaBr added to the coal and activated carbon injected into the flue gas; an additional (2.5-1.6/1.6)*100% or 56% treated sorbent was required to achieve the same leval of mercury removal. See, Declaration B at items 2-5 and 12.

The percent mercury removal per 1 wt% HBr versus the sorbent injection rate was compared with NaBr added to coal prior to introduction to the furnace with injection of untreated activated carbon into the flue gas using the pilot-scale plant, and with Nelson's activated carbon treated with HBr outside the flue gas. The data for Nelson's activated carbon treated with HBr outside the flue gas was taken directly from Nelson. The first plot given in Declaration B at item 13 is reproduced below, but only showing the HBr data.



The data in the plot above, derived from the first plot at item 13 of Declaration B, show that the NaBr added to coal prior to introduction to the furnace with injection of untreated activated carbon into the flue gas provided a significantly higher (about 2x) percent mercury removal per 1 wt% HBr at all tested sorbent injection rates as compared to Nelson's activated carbon treated with HBr outside the flue gas. See, Declaration B at item 14.

The data from the pilot-scale plant was also plotted to show the milligrams of HBr/MMacf per 1% mercury removal versus the sorbent injection rate with NaBr added to coal prior to introduction to the furnace with injection of untreated activated carbon into the flue gas, and for Nelson's activated carbon treated with HBr outside the flue gas. The second plot given in Declaration B at item 13 is reproduced below.



The data in the plot above, derived from the second plot at item 13 of Declaration B, show that NaBr added to coal prior to introduction to the furnace with injection of untreated activated

carbon into the flue gas provided a significantly lower milligrams of HBr/MMacf per 1% mercury removal at all tested sorbent injection rates as compared to Nelson's activated carbon treated with HBr outside the flue gas, indicating more efficient (approximately 2x) use of HBr for mercury removal during in-flight promotion of activated carbon than treatment of activated carbon outside the flue gas. See, Declaration B at item 14.

As explained at item 9 of Declaration D, Nelson's experimental setup in Examples 5 and 7 and the experimental setup described at item 8 of Declaration B inject activated carbon sorbent into a flue gas upstream of an ESP and use no scrubber, making the procedures comparable. However, the higher HCl concentration in Nelson's Example 7 flue gas allows for easier mercury removal, due to HCl acting as a promotor of the activated carbon, as compared to the pilot-scale setup described at item 8 of Declaration B. Further, the higher mercury concentration in Nelson's Example 5 makes it easier for Nelson's sorbents to remove the same overall percentage of mercury from the flue gas, as compared to the pilot-scale setup described at item 8 of Declaration B. Therefore, if Nelson's Example 5 and 7 HCl and mercury concentrations were changed to match those of the pilot-scale setup described at item 8 of Declaration B, Nelson's sorbents would remove a lower percentage of mercury than found in Nelson's Examples 5 and 7, meaning that Nelson's sorbents would exhibit an even lower (and less efficient) percent mercury removal per 1 wt% HBr at any sorbent injection rate than shown in the second plot above (derived from the first plot at item 13 of Declaration B), and would exhibit an even higher (and less efficient) milligrams of HBr/MMacf per 1% mercury removal at any sorbent injection rate than shown in the third plot above (derived from the second plot at item 13 of Declaration B).

I(B)(2). There is no way a person of ordinary skill in the art could predict that in-flight promotion of a sorbent with HBr or Br^- promoters is more effective for mercury removal than use of a sorbent that is treated with the same promoters outside the flue gas.

The M.P.E.P. at the beginning of § 2143.02 states (emphasis added) "[a] rationale to support a conclusion that a claim would have been obvious is that all the claimed elements were known in the prior art and one skilled in the art could have combined the elements as claimed by known methods with no change in their respective functions, *and the combination would have yielded nothing more than predictable results to one of ordinary skill in the art.*"

As admitted by the Office Action, Felsvang fails to describe or suggest HBr or Br^- promoters. Felsvang also fails to describe or suggest that treatment of an activated carbon with a HCl or Cl^- additive outside of flue gas has any advantages over in-flight promotion of an activated carbon with an HCl or Cl^- promoter. Further, as shown herein at **I(D)**, treatment of activated carbon outside the flue gas with HCl provides better mercury removal than in-flight promotion of activated carbon with HCl or Cl^-. Therefore, a person of ordinary skill in the art hypothetically having Felsvang in-hand would have no clue that in-flight promotion of activated carbon with a halide could give the same or better percent mercury removal over halide treatment outside of the flue gas, and would be led away from Felsvang's process if they investigated the relative mercury removal of treatment of the activated carbon with HCl or Cl^- outside the flue gas versus in-flight treatment with HCl or Cl^- in the flue gas.

Nelson mentions treating activated carbon outside of flue gas, and then adding the activated carbon to flue gas. Nelson fails to describe or suggest in-flight promotion of an activated carbon with a halide in the flue gas. Therefore, a person of ordinary skill in the art hypothetically having Nelson in-hand would *also* have no idea that in-flight promotion of activated carbon with a halide could have any advantages over halide treatment outside of the flue gas.

There is no way to predict from the presently cited references the superior mercury capture discovered by the present inventors that occurs when activated carbon is promoted with HBr or Br^- promoters in-flight in the mercury-containing gas, as occurs when following the present claims. The Office Action states at the end of the second full paragraph on page 4 that Nelson's additives would be combined with Felsvang's process "...so as to provide an effective carbon sorbent for mercury." However, a person of ordinary skill in the art would have no idea that in-flight promotion with HBr or Br^- promoters could work better than Nelson's HBr-treatment outside the flue gas. Felsvang fails to describe or suggest that in-flight promotion provides a sorbent with even the same (let alone superior) properties as a sorbent treated outside the flue gas, and, as explained herein at **I(D)**, treatment of activated carbon outside the flue gas with HCl actually provides better mercury removal than in-flight promotion of activated carbon with HCl or Cl^-; similarly, Nelson fails to describe in-flight promotion, let alone that in-flight promotion provides the same or superior mercury removal ability as compared to treatment outside the flue gas.

The only way that a person of ordinary skill in the art could discover that in-flight promotion of activated carbon with HBr or Br^- promoters is more effective for mercury removal than HBr treatment outside the flue gas would not be from the cited references alone; instead, the person of ordinary skill would need to actually modify Felsvang with Nelson as alleged, and then compare the mercury removal of Felsvang's modified process to Nelson's sorbent treated outside the flue gas.[8] However, the person of ordinary skill carrying out such a combination would be surprised to find that in-flight promotion with HBr or Br^- is more effective for mercury removal than HBr treatment of the sorbent outside the flue gas. The process giving rise to these surprising results was discovered by the inventors of the present application. Surprising results are a hallmark of patentability; only by having the present application in-hand could such results be predicted, and a need to resort to hindsight analysis to predict the advantages of the combination asserted by the Office Action is indicative that the presently claimed invention is not obvious over the cited references. Accordingly, independent claim 1 is patentable over Felsvang in view of Nelson for at least this additional reason.

I(B)(3). Reply to Examiner's response to arguments.

The Office Action states:

> The applicant contends that the bromide promoters are more effective for mercury removal than treating the sorbent with bromide or bromine additives outside the mercury-containing gas. The applicant further provides a graph to demonstrate these unexpected results.

[8] In the event the Examiner intends to argue that such advantages are inherent in the cited art, Applicant notes that the claimed invention is not specifically disclosed in the prior art. The Examiner cannot reason inherency in a §103 context based on a mere proposed or hypothetical combination of features from cited references. Such reasoning would merely reflect the Examiner's reliance on impermissible hindsight. See, M.P.E.P. § 2112(IV).

> These unexpected results are not commensurate with the scope of the claims. The applicant is claiming HBr and Br^- while the graph only demonstrates HBr. Further the comparisons between the prior art and that of the current invention do no demonstrate unexpected results. The applicants data is unclear as it is either HBr (as specified in the actual graph) or NaBr (as specified in the legend). Further the 18.2 data point has no labeling on what the promoter is. None of the data point include what amount is being specified, wt%, vol% etc. The results would be expected by one having ordinary skill in the art as the wt% (if we are to assume the amount specified is wt) of the amount supported on the upper most line is greater than that of the wt% on the middle trending line. Further claim 1 does not include NaBr on coal. Lastly is unclear if the results are because of the different components being reacted or because of the different method being used. In order to establish that the method being used has unexpected results the components used must be the same for both methods.

As explained in Declaration C at item 28, when NaBr is added to coal, gaseous NaBr is formed in the flue gas, and HBr is formed in the flue gas. As explained in Declaration C at item 33, NaBr is a salt that includes Na^+ and Br^-. Therefore, placing NaBr on the coal (as specified in the legend of the plot given at item 11 of Declaration B) results in formation of HBr and Br^- in the flue gas (as specified in the graph), and the results shown are commensurate with the scope of the claims. In the graphs in Declaration B all halides in the flue gas formed from halide salts placed on the coal are assumed to be in the form of the respective hydrogen halide for comparative purposes, although these could be in the form of the gaseous halide salt or the hydrogen halide—this assumption is made for consistency across all the graphs in Declaration B. As the graphs show trends between %Hg removal and halide content of the flue gas, so long as the amounts of the different halides present in the flue gas are compared in a consistent way it does not matter whether they are in the form of the hydrogen halide or the halide ion in the flue gas for purposes of comparing relative %Hg removal.

The data table at item 10 of Declaration B shows that the 18.2 data point of the plot shown at item 11 corresponds to 18.2 wt% HBr, and that all of the labels on the data set "NaBr on coal with AC injected into flue gas" indicate wt% HBr. Additionally, for increased clarity, Declaration B is revised to indicate wt% and properly labels the 18.2 data point in the plot shown at item 11.

The Office Action states that the results would be expected by one having ordinary skill in the art because the amount of HBr on the upper line, representing NaBr on coal with AC injected into the flue gas, are greater than the wt% of the middle trending line, representing AC treated with

5 wt% bromine outside the flue gas as per the Nelson procedure. Applicant does not agree that the results are not unexpected. The unexpected results described in the Response are that in-flight promotion of a sorbent with HBr or Br^- promoters is more effective for mercury removal than use of a sorbent that is treated with the same promoters outside the flue gas (as explained herein at **I(B)**, using the first and second plots from item 13 of Declaration B), and that in-flight promotion with HBr or Br^- promoters is more effective for mercury removal than in-flight promotion with HCl or Cl^- promoters (as explained herein at **I(C)**). Applicant included the plot at item 11 primarily to show that adding NaBr to coal and injecting untreated AC into the flue gas is an effective way to remove mercury.

The Office Action states that it is not clear whether the results are because of different components being reacted or because of the different method being used. However, all of the data shown in the plot at item 11 of Declaration B is shown in the tables at items 9 and 10 of Declaration B, which is all derived from the same pilot-scale test unit described at item 8 of Declaration B, using the same components, the same type of AC, and the same method, with the only variations between the data sets being the type of treatment of the AC (i.e., no treatment, treatment with Br_2 outside the flue gas prior to injection, and adding NaBr to coal while injecting untreated AC into the flue gas); item 11 of Declaration B has been revised to clarify this point.

The Office Action states:

> The second graph on page 12 comparing NaBr on coal to HBr treated AC and it is unclear if the results are because of the different components being reacted or because of the different method being used. In order to establish that the method being used has unexpected results the components used must be the same for both methods. To do that the graph would have to be comparing HBr in the present method to HBr is the prior art method. Further the applicant has not shown the amount of promoter supported by each (wt%) data point. Lastly claim 1 does not include NaBr on coal.

The second graph on page 12 of the last Response was the first graph from item 13 of Declaration B. The Office Action states that the components used must be the same for both methods, such that the graph compares HBr in the present method to HBr in the prior art method. However, as explained in Declaration C at item 28, when NaBr is added to coal, gaseous NaBr is formed in the flue gas, and HBr is formed in the flue gas. As explained in Declaration C at item 33, NaBr is a salt that includes Na^+ and Br^-. Therefore, placing NaBr on the coal results in formation of

HBr and Br^- in the flue gas. All of the NaBr is assumed to be converted to HBr in the graph, such that the components being compared are the same for both methods.

Although the data set "NaBr on coal with AC injected into flue gas" is shown in the table in item 10 and is derived from the pilot-scale test unit described at item 8 of Declaration B, while the data set "Nelson's HBr-treated AC" is from Nelson, as explained at item 9 of Declaration D and at **I(B)(1)** herein, data from Nelson's experimental setup and from the pilot-scale unit of item 8 of Declaration B are validly comparable—further, Nelson's conditions used in Examples 5 and 7 allow for easier mercury removal than in the pilot-scale unit of item 8 of Declaration B, such that if Nelson's Example 5 and 7 HCl and mercury concentrations were changed to match those of the pilot-scale setup described at item 8 of Declaration B, Nelson's sorbents would remove a lower percentage of mercury than found in Nelson's Examples 5 and 7.

The Office Action states that "the application has not shown the amount of promoter supported by each (wt%) data point." However, the y-axis indicates the percent mercury removal per 1 wt% HBr; therefore, the wt% promoter data is part of what is shown on the graph. Further, the table at item 10 indicates the specific amount of HBr for each data point.

The Office Action states:

> The third graph on page 13 compares HBr treated AC and NaBr on coal with AC injected into flue gas. The graph states Milligram of HBr/MMacf/1%Hg Removed. As HBr is not a part of the current application data points it is unclear how to interpret this graph. Claim 1 does not include NaBr on coal. Further is unclear if the results are because of the different components being reacted or because of the different method being used. In order to establish that the method being used has unexpected results the components used must be the same for both methods.

The third graph on page 13 of the last Response was the second graph from item 13 of Declaration B. The Office Action states that HBr is not a part of the current application data points, and that claim 1 does not include NaBr on coal. However, as explained in Declaration C at item 28, when NaBr is added to coal, gaseous NaBr is formed in the flue gas, and HBr is formed in the flue gas. As explained in Declaration C at item 33, NaBr is a salt that includes Na^+ and Br^-. Therefore, placing NaBr on the coal results in formation of HBr and Br^- in the flue gas. All of the NaBr is assumed to be converted to HBr in the graph, such that the components being compared are the same for both methods.

Although the data set "NaBr on coal with AC injected into flue gas" is shown in the table in item 10 and is derived from the pilot-scale test unit described at item 8 of Declaration B, while the data set "Nelson's HBr-treated AC" is from Nelson, as explained at item 9 of Declaration D and at **I(B)(1)** herein, data from Nelson's experimental setup and from the pilot-scale unit of item 8 of Declaration B are validly comparable—further, Nelson's conditions used in Examples 5 and 7 allow for easier mercury removal than in the pilot-scale unit of item 8 of Declaration B, such that if Nelson's Example 5 and 7 HCl and mercury concentrations were changed to match those of the pilot-scale setup described at item 8 of Declaration B, Nelson's sorbents would remove a lower percentage of mercury than found in Nelson's Examples 5 and 7.

The Office Action states:

> The applicant contends that there is no way a person of ordinary skill in the art could predict from the cited references that in-flight promotion of a sorbent with bromide promoters is more effective for mercury removal.
>
> The examiner contends that the applicant has not established that it is more effective.

Applicant respectfully disagrees. As explained above, the data does provide evidence that in-flight promotion of a sorbent with HBr or Br^- promoters is more effective for mercury removal than use of a sorbent that is treated with the same promoters outside the flue gas.

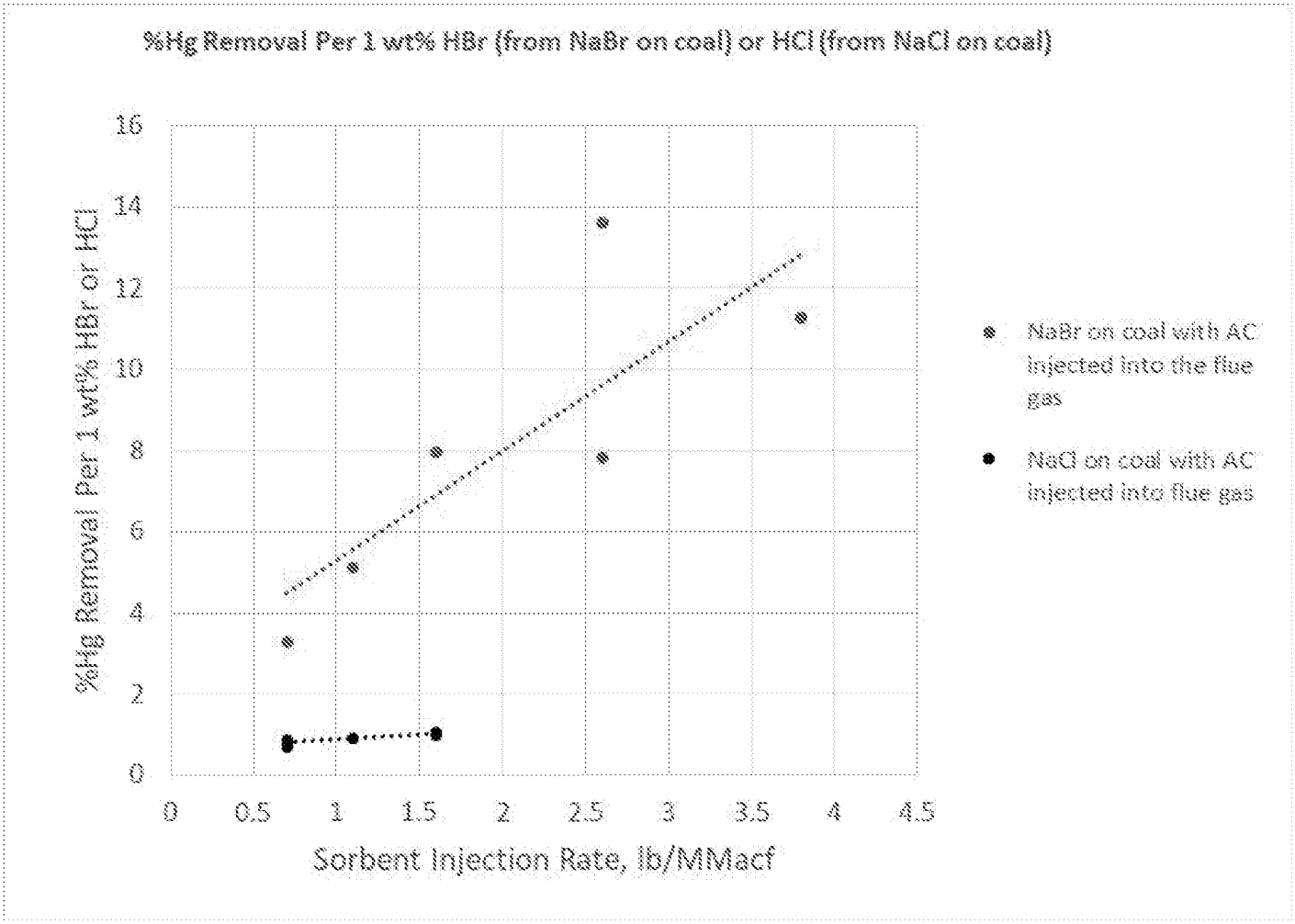
I(C). In-flight promotion with HBr or Br^- versus HCl or Cl^-.

I(C)(1). In-flight promotion with HBr or Br^- promoters is more effective for mercury removal than in-flight promotion with HCl or Cl^- promoters.

The inventors of the present application have discovered that that in-flight HBr or Br^- promotion of an activated carbon in a mercury-containing flue gas is significantly more effective for mercury removal than in-flight HCl or Cl^- promotion of an activated carbon.

As explained in Declaration B, pilot-scale testing was performed with NaBr or NaCl added to coal prior to introduction to the furnace with injection of untreated activated carbon into the flue gas. The same activated carbon was used for each sample. See, Declaration B at items 8-10. The

first plot given in Declaration B at item 13 is reproduced below, but not showing the data from Nelson's HBr-treated AC.



The data in the plot above, derived from the first plot at item 13 of Declaration B, show that the NaBr added to coal prior to introduction to the furnace with injection of untreated activated carbon into the flue gas provided a significantly higher (about 6-8x) percent mercury removal per 1 wt% HBr or HCl at all tested sorbent injection rates compared to the NaCl added to coal prior to introduction to the furnace with injection of untreated activated carbon into the flue gas. See, Declaration B at item 14.

I(C)(2). There would be no way for a person of ordinary skill in the art to predict this advantage from the from the cited references.

As explained herein at **I(A)(2)(d)**, Nelson fails to describe or suggest that treatment of activated carbon with HBr or Br^- could provide any mercury-removal improvement, or even the same mercury-removal activity, compared to Felsvang.

The only way that a person of ordinary skill in the art could discover that in-flight promotion with HBr or Br^- promoters is more effective for mercury removal than in-flight promotion with HCl or Cl^- promoters would not be from the cited references alone; instead, the person of ordinary skill would need to actually modify Felsvang with Nelson as alleged, and then to compare the mercury removal of Felsvang's modified process to Felsvang's original process.[9] However, the person of ordinary skill carrying out such a combination would be surprised to find that promotion of activated carbon with HBr or Br^- could provide any mercury-removal improvement, or even the same mercury-removal activity, compared to Felsvang. The process giving rise to these surprising results was discovered by the inventors of the present application. Surprising results are a hallmark of patentability; only by having the present application in-hand could such results be predicted, and a need to resort to hindsight analysis to predict the advantages of the combination asserted by the Office Action is indicative that the presently claimed invention is not obvious over the cited references. Accordingly, independent claim 1 is patentable over Felsvang in view of Nelson for at least this additional reason.

I(C)(3). Reply to Examiner's response to arguments.

The Office Action states:

[9] In the event the Examiner intends to argue that such advantages are inherent in the cited art, Applicant notes that the claimed invention is not specifically disclosed in the prior art. The Examiner cannot reason inherency in a §103 context based on a mere proposed or hypothetical combination of features from cited references. Such reasoning would merely reflect the Examiner's reliance on impermissible hindsight. See, M.P.E.P. § 2112(IV).

The applicant contends that one having ordinary skill in the art would not have predicted in-flight chloride promotion of activated carbon to be more effective for mercury removal that in-fligh chloride promotion.

The examiner disagrees. Nelson discloses that bromide is a better promoter of AC for the

II(C)(1). The applicant contends that one having ordinary skill in the art would not have predicted in-flight chloride promotion of activated carbon to be more effective for mercury removal that in-fligh chloride promotion.

The examiner disagrees. Nelson discloses that bromide is a better promoter of AC for the purpose of mercury removal as shown above. Therefore one having ordinary skill in the art would expect an inflight bromide promoted sorbent to superior to and inflight chloride promoted sorbent.

The applicant argues that one having ordinary skill in the art would not predict this advantage from the cited references.

The examiner disagrees for the reasons stated above.

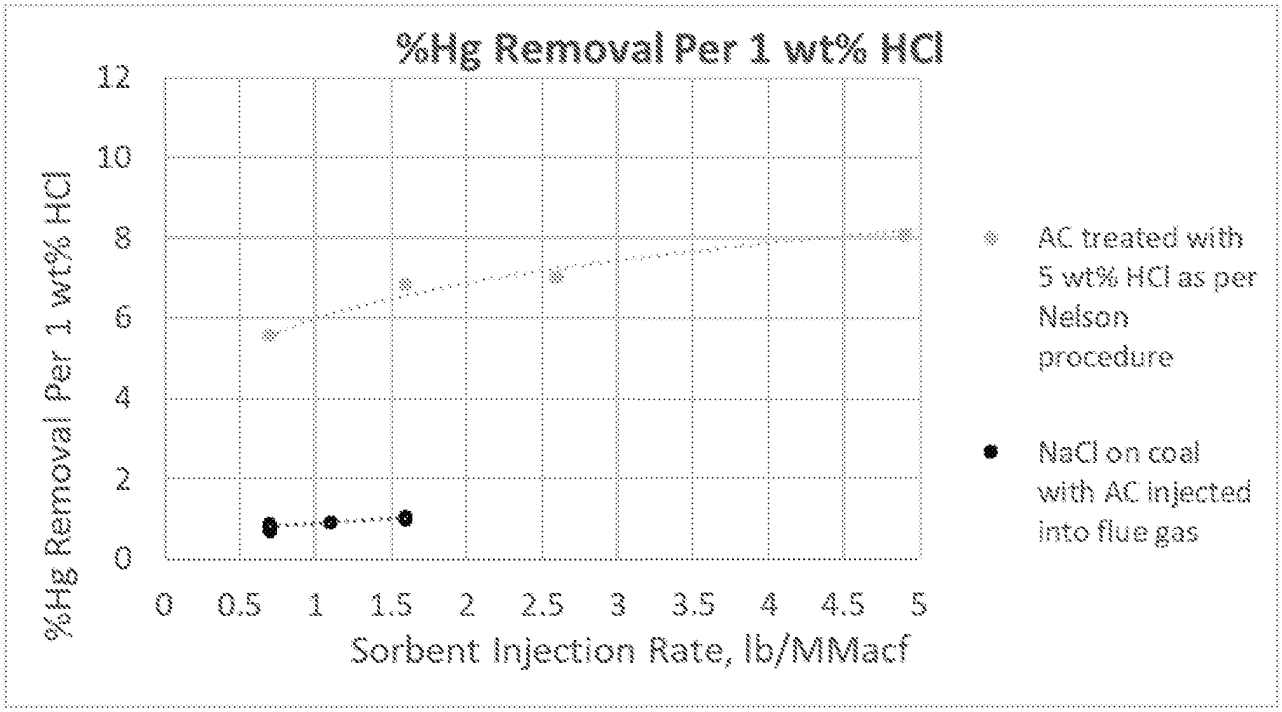
However, as explained herein at **I(A)(2)(d)** and **I(A)(3)**, Nelson fails to describe or suggest that HBr-treatment of activated carbon provides better mercury removal ability than HCl-treated activated carbon; therefore, there is no way one of ordinary skill in the art could reasonably predict from Felsvang and Nelson that treatment of activated carbon with HBr or Br^- could provide any mercury-removal improvement, or even the same mercury-removal activity, compared to Felsvang.

I(D). A person of ordinary skill in the art would find that treatment of activated carbon outside the flue gas with HCl as per Nelson's process actually provides more effective mercury removal per wt% HCl than treatment of activated carbon with HCl or Cl^- in the flue gas.

I(D)(1). Even if a person of ordinary skill in the art compared the mercury removal of Felsvang to activated carbons treated with HCl outside of the flue gas, they would not determine that in-flight promotion provides the same or better mercury removal properties per wt% HCl.

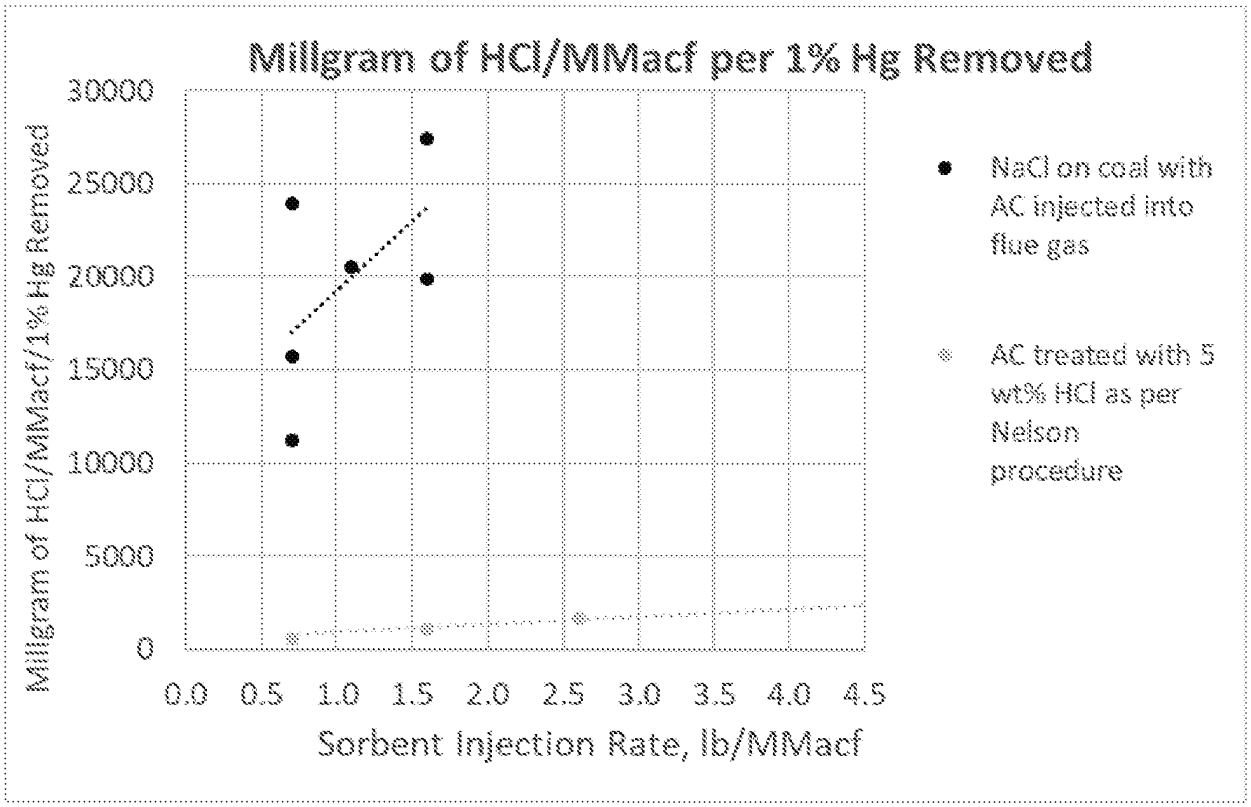
As explained herein at **I(A)(2)(c)**, Felsvang fails to describe or suggest that in-flight promotion of activated carbon with HCl or Cl^- in the flue gas provides better mercury removal than treatment of activated carbon outside the flue gas with HCl. A person of ordinary skill would notice the extremely poor improvement (if any improvement actually occurred) caused by addition of activated carbon in Felsvang's sole Example showing the use of activated carbon (Example 4) (see **I(A)(2)(c)** herein) and would question whether Felsvang's process is an efficient way to use activated carbon for mercury removal as compared to Nelson's process. Merely for the sake of argument, if one of ordinary skill in the art were to investigate Felsvang's embodiments including activated carbon and compare the relative mercury-removal ability to that of activated carbon treated with HCl outside the flue gas, as explained below, they would find that treatment of activated carbon outside the flue gas with HCl as per Nelson's process actually provides more effective mercury removal per wt% HCl than treatment of activated carbon with HCl or Cl^- in the flue gas, which would lead one of ordinary skill in the art away from using Felsvang's process.

As explained in Declaration B, pilot-scale testing was performed with activated carbon treated with HCl outside the flue gas as per the Nelson procedure (see, Declaration B at item 7), and with NaCl added to coal prior to introduction to the furnace with injection of untreated activated carbon into the flue gas. The same activated carbon was used for each sample. See, Declaration B at items 8-10. The first plot given in Declaration B at item 15 is reproduced below.



The data in the plot above from the item 15 of the Declaration B show that activated carbon treated with HCl outside the flue gas as per the Nelson procedure provided a much higher percent of mercury removal per 1 wt% HCl at all tested sorbent injection rates as compared to NaCl added to coal prior to introduction to the furnace with injection of untreated activated carbon into the flue gas. See, Declaration B at item 16.

The pilot-scale data was also plotted to show the milligrams of HCl/MMacf per 1% mercury removal versus the sorbent injection rate with NaCl added to coal prior to introduction to the furnace with injection of untreated activated carbon into the flue gas, and for the activated carbon treated with HCl outside the flue gas described herein at item 7 as per the Nelson procedure. The second plot given in Declaration B at item 15 is reproduced below.



The data in the second plot above from item 15 of Declaration B show that the milligrams of HCl/MMacf per 1% mercury removal versus the sorbent injection rate with NaCl added to coal prior to introduction to the furnace with injection of untreated activated carbon into the flue gas was significantly higher as compared to the activated carbon treated with HCl outside the flue gas described herein at item 7 as per the Nelson procedure, indicating more efficient use of HCl for mercury removal by treatment of activated carbon outside the flue gas than by promotion in-flight.

I(D)(2). Reply to response to arguments.

The Office Action states:

> The applicant contends that "Even if a person of ordinary skill in the art compared the mercury removal of Felsvang's activated carbons promoted with Chloride in the flue gas to activated carbond treated with HCl outside of the flue gas, they would not determine that in-flight promotion provides the same or better mercury removal properties".

> This appears to be merely conjecture by the applicant as no factual evidence has been presented.
>
> The graphs on pages 18 and 19, has NaCl compared to HCl. It is unclear if the results are because of the different components being reacted or because of the different method being used. In order to establish that the method being used has unexpected results the components used must be the same for both methods. Further the examiner points to the y-axis which has HCl which is not included in one set (NaCl) of the data points so it is unclear how the data points are being obtained.

The Office Action states that Applicant's contention that a person of ordinary skill in the art comparing Felsvang's process to treatment of activated carbon with HCl outside the flue gas would find that in-flight promotion provides less mercury removal is conjecture and is unsupported by factual evidence. However, Applicant's contention is not conjecture and is supported by data provided in Declaration B, as described herein at **I(D)(1)**; therefore, Applicant does not understand this statement of the Office Action.

The Office Action states that the graphs have NaCl compared to HCl, and that the y-axis has HCl which is not included in one set (NaCl) of the data points so it is unclear how the data points are being obtained. However, as explained in Declaration C at item 28, when NaCl is added to coal, gaseous NaCl is formed in the flue gas, and HCl is formed in the flue gas. NaCl is a salt that includes Na^+ and Cl^-. Therefore, placing NaCl on the coal results in formation of HCl and Cl^- in the flue gas. In the graphs in Declaration B all halides in the flue gas formed from halide salts placed on the coal are assumed to be in the form of the respective hydrogen halide for comparative purposes, although these could be in the form of the gaseous halide salt or the hydrogen halide—this assumption is made for consistency across all the graphs in Declaration B. As the graphs show trends between %Hg removal and halide content of the flue gas, so long as the amounts of the different halides present in the flue gas are compared in a consistent way it does not matter whether they are in the form of the hydrogen halide or the halide ion in the flue gas for purposes of comparing relative %Hg removal.

The Office Action states that in order to establish that the method being used has unexpected results the components used must be the same for both methods. However, the data sets in the first and second plots at item 15 of Declaration B were taken from the table at item 10, which was produced using the same pilot-scale setup described at item 8, using the same components, the same

type of AC, and the same method, with the only variations between the data sets being the type of treatment of the AC (i.e., AC treated with 5 wt% HCl outside the flue gas prior to injection into the flue gas, or placing NaCl on the coal and injection of untreated AC into the flue gas); item 15 of Declaration B has been revised to clarify this point.

I(E). Objective evidence of non-obviousness of the claimed invention.

Applicant herein discusses objective evidence of nonobviousnesss presented in Declaration A. The M.P.E.P. at §716.01(a) states that:

> Affidavits or declarations, when timely presented, containing evidence of criticality or unexpected results, commercial success, long-felt but unsolved needs, failure of others, skepticism of experts, etc., must be considered by the examiner in determining the issue of obviousness of claims for patentability under 35 U.S.C. 103.

The M.P.E.P. at §716.01(d) states that:

> When an applicant timely submits evidence traversing a rejection, the examiner must reconsider the patentability of the claimed invention. The ultimate determination of patentability must be based on consideration of the entire record, by a preponderance of evidence, with due consideration to the persuasiveness of any arguments and any secondary evidence.

As explained in Declaration A at items 1-6, before the priority date of the presently claimed invention, the EPA called for new mercury removal technology in the 1990s, evidencing recognition of a problem and long-felt but unsolved needs that the presently claimed invention provides a solution for.

As explained in Declaration A at items 7-8, before the priority date of the presently claimed invention, the EPA espoused the conventional wisdom in favor of pre-treated sorbents, not in-flight sorbent enhancement in the flue gas, evidencing a teaching away from the presently claimed invention by others.

As explained in Declaration A at items 9-11, before the priority date of the presently claimed invention, Sidney Nelson touted brominated sorbent, not in-flight sorbent enhancement in the flue gas, evidencing a teaching away from the presently claimed invention by others.

As explained in Declaration A at items 12-13, after the priority date of the presently claimed invention, the EPA continued to teach away from in-flight sorbent enhancement in the flue gas, evidencing a teaching away from the presently claimed invention by others and skepticism by experts that the presently claimed invention could provide effective and efficient mercury control.

As explained in Declaration A at items 14-15, before the priority date of the presently claimed invention, the Department of Energy funded research into in-flight sorbent enhancement in the flue gas, evidencing recognition of a problem and long-felt but unsolved needs that the presently claimed invention provides a solution for.

As explained in Declaration A at item 16, after the priority date of the presently claimed invention, in-flight sorbent enhancement in the flue gas was finally recognized as a critical advancement, evidencing praise by others for the presently claimed invention.

As explained in Declaration A at items 17-19, after the priority date of the presently claimed invention, in-flight sorbent enhancement in the flue gas experienced commercial success and was copied by Sidney Nelson and other competitors, evidencing copying of the presently claimed invention by others.

Dependent claims 4 and 6-20 are directly or indirectly dependent on independent claim 1. As such, these claims incorporate all the features of claim 1. Accordingly, dependent claims 4 and 6-20 are patentable for at least the reasons given herein for patentability of independent claim 1.

Applicant therefore respectfully requests reconsideration and withdrawal of the rejection of claims 1, 4, and 6-20 under 35 U.S.C. § 103(a) over Nelson in view of Felsvang.

Double Patenting Rejections

II. Double patenting rejections.

II(A). The Office Action rejected claims 1, 4, and 6-20 on the ground of nonstatutory double patenting over claims 1-30 of U.S. patent no. 7,435,286 in view of U.S. patent no. 5,435,980 ("Felsvang").

This rejection is respectfully traversed. Applicant does not admit that claims 1, 4, and 6-20 are obvious over claims 1-30 of U.S. patent no. 7,435,286 in view of Felsvang.

As the current pending claims stand rejected on other grounds and are still subject to amendment, Applicant takes note of these rejections but do not take further action at this time inasmuch as no pending claim has yet to be allowed. Applicant will re-evaluate this rejection, upon an indication of allowable claims.

II(B). The Office Action rejected claims 1, 4, and 6-20 on the ground of nonstatutory double patenting over claims 1-25 of patent no. 8,168,147 in view of U.S. patent no. 5,435,980 ("Felsvang").

This rejection is respectfully traversed. Applicant does not admit that claims 1, 4, and 6-20 are obvious over claims 1-25 of U.S. patent no. 8,168,147 in view of Felsvang.

As the current pending claims stand rejected on other grounds and are still subject to amendment, Applicant takes note of these rejections but do not take further action at this time inasmuch as no pending claim has yet to be allowed. Applicant will re-evaluate this rejection, upon an indication of allowable claims.

II(C). The Office Action rejected claims 1, 4, and 6-20 on the ground of nonstatutory double patenting over claims 1-60 of U.S. patent no. 8,512,655 in view of U.S. patent no. 5,435,980 ("Felsvang").

This rejection is respectfully traversed. Applicant does not admit that claims 1, 4, and 6-20 are obvious over claims 1-60 of U.S. patent no. 8,512,655 in view of Felsvang.

As the current pending claims stand rejected on other grounds and are still subject to amendment, Applicant takes note of these rejections but do not take further action at this time inasmuch as no pending claim has yet to be allowed. Applicant will re-evaluate this rejection, upon an indication of allowable claims.

II(D). The Office Action rejected claims 1, 4, and 6-20 on the ground of nonstatutory double patenting over claims 1-60 of U.S. patent no. 8,821,819 in view of U.S. patent no. 5,435,980 ("Felsvang").

This rejection is respectfully traversed. Applicant does not admit that claims 1, 4, and 6-20 are obvious over claims 1-60 of U.S. patent no. 8,821,819 in view of Felsvang.

As the current pending claims stand rejected on other grounds and are still subject to amendment, Applicant takes note of these rejections but do not take further action at this time inasmuch as no pending claim has yet to be allowed. Applicant will re-evaluate this rejection, upon an indication of allowable claims.

II(E). The Office Action rejected claims 1, 4, and 6-20 on the ground of nonstatutory double patenting over claims 1-33 of U.S. patent no. 9,757,689 in view of U.S. patent no. 5,435,980 ("Felsvang").

This rejection is respectfully traversed. Applicant does not admit that claims 1, 4, and 6-20 are obvious over claims 1-33 of U.S. patent no. 9,757,689 in view of Felsvang.

As the current pending claims stand rejected on other grounds and are still subject to amendment, Applicant takes note of these rejections but do not take further action at this time inasmuch as no pending claim has yet to be allowed. Applicant will re-evaluate this rejection, upon an indication of allowable claims.

II(F). The Office Action rejected claims 1, 4, and 6-20 on the ground of nonstatutory double patenting over claims 1-20 of U.S. patent no. 9,468,886 in view of U.S. patent no. 5,435,980 ("Felsvang").

This rejection is respectfully traversed. Applicant does not admit that claims 1, 4, and 6-20 are obvious over claims 1-20 of U.S. patent no. 9,468,886 in view of Felsvang.

As the current pending claims stand rejected on other grounds and are still subject to amendment, Applicant takes note of these rejections but do not take further action at this time inasmuch as no pending claim has yet to be allowed. Applicant will re-evaluate this rejection, upon an indication of allowable claims.

II(G). The Office Action rejected claims 1, 4, and 6-20 on the ground of nonstatutory double patenting over claims 1-30 of U.S. patent no. 8,652,235 in view of U.S. patent no. 5,435,980 ("Felsvang").

This rejection is respectfully traversed. Applicant does not admit that claims 1, 4, and 6-20 are obvious over claims 1-30 of U.S. patent no. 8,652,235 in view of Felsvang.

As the current pending claims stand rejected on other grounds and are still subject to amendment, Applicant takes note of these rejections but do not take further action at this time inasmuch as no pending claim has yet to be allowed. Applicant will re-evaluate this rejection, upon an indication of allowable claims.

II(H). The Office Action provisionally rejected claims 1, 4, and 6-20 on the ground of nonstatutory double patenting over claims 1-16 of copending application no. 15/295,594 in view of U.S. patent no. 5,435,980 ("Felsvang").

This rejection is respectfully traversed. Applicant does not admit that claims 1, 4, and 6-20 are obvious over claims 1-16 of copending application no. 15/295,594 in view of Felsvang.

As the current pending claims stand rejected on other grounds and are still subject to amendment, Applicant takes note of these rejections but do not take further action at this time inasmuch as no pending claim has yet to be allowed. Applicant will re-evaluate this rejection, upon an indication of allowable claims.

II(I). The Office Action provisionally rejected claims 1, 4, and 6-20 on the ground of nonstatutory double patenting over claims 8-20 of copending application no. 15/589,359 in view of U.S. patent no. 5,435,980 ("Felsvang").

This rejection is respectfully traversed. Applicant does not admit that claims 1, 4, and 6-20 are obvious over claims 8-20 of copending application no. 15/589,359 in view of Felsvang.

As the current pending claims stand rejected on other grounds and are still subject to amendment, Applicant takes note of these rejections but do not take further action at this time inasmuch as no pending claim has yet to be allowed. Applicant will re-evaluate this rejection, upon an indication of allowable claims.

II(J). The Office Action provisionally rejected claims 1, 4, and 6-20 on the ground of nonstatutory double patenting over claims 1-20 of copending application no. 15/853,029 in view of U.S. patent no. 5,435,980 ("Felsvang").

This rejection is respectfully traversed. Applicant does not admit that claims 1, 4, and 6-20 are obvious over claims 1-20 of copending application no. 15/853,029 in view of Felsvang.

As the current pending claims stand rejected on other grounds and are still subject to amendment, Applicant takes note of these rejections but do not take further action at this time inasmuch as no pending claim has yet to be allowed. Applicant will re-evaluate this rejection, upon an indication of allowable claims.

II(K). The Office Action provisionally rejected claims 1, 4, and 6-20 on the ground of nonstatutory double patenting over claims 1-20 of copending application no. 14/712,558 in view of U.S. patent no. 5,435,980 ("Felsvang").

This rejection is respectfully traversed. Applicant does not admit that claims 1, 4, and 6-20 are obvious over claims 1-20 of copending application no. 14/712,558 in view of Felsvang.

As the current pending claims stand rejected on other grounds and are still subject to amendment, Applicant takes note of these rejections but do not take further action at this time inasmuch as no pending claim has yet to be allowed. Applicant will re-evaluate this rejection, upon an indication of allowable claims.

II(L). The Office Action provisionally rejected claims 1, 4, and 6-20 on the ground of nonstatutory double patenting over claims 1-20 of copending application no. 15/951,970 in view of U.S. patent no. 5,435,980 ("Felsvang").

This rejection is respectfully traversed. Applicant does not admit that claims 1-20 are obvious over claims 1-20 of copending application no. 15/951,970 in view of Felsvang.

As the current pending claims stand rejected on other grounds and are still subject to amendment, Applicant takes note of these rejections but do not take further action at this time inasmuch as no pending claim has yet to be allowed. Applicant will re-evaluate this rejection, upon an indication of allowable claims.

II(M). The Office Action provisionally rejected claims 1, 4, and 6-20 on the ground of nonstatutory double patenting over claims 1-20 of copending application no. 15/382,114 in view of U.S. patent no. 5,435,980 ("Felsvang").

This rejection is respectfully traversed. Applicant does not admit that claims 1-20 are obvious over claims 1-20 of copending application no. 15/382,114 in view of Felsvang.

As the current pending claims stand rejected on other grounds and are still subject to amendment, Applicant takes note of these rejections but do not take further action at this time inasmuch as no pending claim has yet to be allowed. Applicant will re-evaluate this rejection, upon an indication of allowable claims.

II(N). The Office Action provisionally rejected claims 1, 4, and 6-20 on the ground of nonstatutory double patenting over claims 1-20 of copending application no. 15/853,029 in view of U.S. patent no. 5,435,980 ("Felsvang").

This rejection is respectfully traversed. Applicant does not admit that claims 1, 4, and 6-20 are obvious over claims 1-20 of copending application no. 15/853,029 in view of Felsvang. This rejection appears to be a duplicate of the rejection listed herein at **II(J)**.

As the current pending claims stand rejected on other grounds and are still subject to amendment, Applicant takes note of these rejections but do not take further action at this time inasmuch as no pending claim has yet to be allowed. Applicant will re-evaluate this rejection, upon an indication of allowable claims.

II(O). The Office Action provisionally rejected claims 1, 4, and 6-20 on the ground of nonstatutory double patenting over claims 1-20 of copending application no. 15/978,760 in view of U.S. patent no. 5,435,980 ("Felsvang").

This rejection is respectfully traversed. Applicant does not admit that claims 1, 4, and 6-20 are obvious over claims 1-20 of copending application no. 15/978,760 in view of Felsvang.

As the current pending claims stand rejected on other grounds and are still subject to amendment, Applicant takes note of these rejections but do not take further action at this time inasmuch as no pending claim has yet to be allowed. Applicant will re-evaluate this rejection, upon an indication of allowable claims.

II(P). The Office Action provisionally rejected claims 1, 4, and 6-20 on the ground of nonstatutory double patenting over claims 1-10, 14, and 21-25 of copending application no. 15/974,343 in view of U.S. patent no. 5,435,980 ("Felsvang").

This rejection is respectfully traversed. Applicant does not admit that claims 1, 4, and 6-20 are obvious over claims 1-10, 14, and 21-25 of copending application no. 15/974,343 in view of Felsvang.

As the current pending claims stand rejected on other grounds and are still subject to amendment, Applicant takes note of these rejections but do not take further action at this time inasmuch as no pending claim has yet to be allowed. Applicant will re-evaluate this rejection, upon an indication of allowable claims.

CONCLUSION

It is respectfully submitted that the claims are in condition for allowance, and notification to that effect is earnestly requested. The Examiner is invited to telephone the undersigned at (612) 349-9580 to facilitate prosecution of this application.

If necessary, please charge any additional fees or deficiencies, or credit any overpayments to Deposit Account No. 19-0743.

Respectfully submitted,

SCHWEGMAN LUNDBERG & WOESSNER, P.A.
P.O. Box 2938
Minneapolis, MN 55402-0938
(612) 373-6900

Date July 10, 2019

By /Nicholas P. Lanzatella/

Nicholas P. Lanzatella
Reg. No. 63,803

IN THE CLAIMS

Please amend the claims as follows:

1. (Currently Amended) A method for reducing mercury in a mercury-containing gas, the method comprising:

combusting coal in a combustion chamber, the coal[[that]] compris[[es]]ing an additive comprising Br_2, HBr, [[Br^-]]a bromide compound, or a combination thereof, to form the mercury-containing gas~~, wherein the combusting of the coal is performed at a coal combustion facility site~~;

collecting mercury in the mercury-containing gas [[on]]with a sorbent comprising~~to produce a cleaned gas, wherein the sorbent comprises a promoted~~ activated carbon~~that is promoted in-flight in a gas stream at the coal combustion facility site comprising contacting activated carbon dispersed in the gas stream with at least one promoter comprising HBr, Br^-, or a combination thereof~~.

2.-3. (Canceled)

4. (Canceled)

5. (Canceled)

6. (Canceled)

7. (Canceled)

8. (Canceled)

9. (Original) The method of claim 1, further comprising injecting an alkaline sorbent into the mercury-containing gas stream.

10. (Original) The method of claim 9, wherein the alkaline sorbent is selected from the group consisting of alkali elements, alkaline earth elements, alkali salts, alkaline earth salts, and combinations thereof.

11. (Canceled)

12. (Original) The method of claim 1, wherein the activated carbon is chosen from powdered activated carbon, granular activated carbon, carbon black, carbon fiber, aerogel carbon, pyrolysis char, and combinations thereof.

13. (Canceled)

14. (Canceled)

15. (Canceled)

16. (Currently Amended) The method of claim 1, wherein the sorbent has a composition comprising from about 1 to about 30 grams of ~~promoter~~the element bromine per 100 grams of activated carbon.

17. (Canceled)

18. (Original) The method of claim 1, comprising collecting greater than 70 wt% of the mercury in the mercury-containing gas.

19. (Currently Amended) The method of claim 1, comprising collecting greater than 70 wt% of the mercury in the mercury-containing gas [[on]]with the sorbent.

20. (Currently Amended) The method of claim 1, ~~wherein the method is a method for reducing mercury in the mercury-containing gas to a desired level, the method~~ further comprising:

~~monitoring~~measuring mercury content of ~~the cleaned gas~~the mercury-containing gas; and

~~controlling~~modifying, in response to the ~~monitored~~measured mercury content ~~of the cleaned gas~~,

an injection rate of injecting [[a]]the sorbent comprising activated carbon into the mercury-containing gas,

~~a rate at which the~~an amount of the additive comprising the Br_2, HBr, bromide compound, or a combination thereof, ~~promoter is~~ added to the coal~~sorbent comprising activated carbon~~, or

a combination thereof~~,~~

~~so that the mercury content of the cleaned gas is maintained at or below the desired level~~.

21. (New) The method of claim 20, wherein the measuring of the mercury content of the mercury-containing gas is performed substantially continuously.

22. (New) The method of claim 1, further comprising:

modifying, in response to a measured mercury content,

an injection rate of injecting the sorbent comprising activated carbon into the mercury-containing gas,

an amount of the Br_2, HBr, bromide compound, or a combination thereof, added to the coal, or

a combination thereof.

23. (New) The method of claim 1, wherein the coal comprises a subbituminous coal.

24. (New) The method of claim 1, wherein the coal comprises a lignite coal.

25. (New) The method of claim 1, wherein the coal comprises the added Br_2, HBr, the bromide compound, or a combination thereof, added to the coal before the coal enters the combustion chamber.

26. (New) The method of claim 1, wherein the combustion chamber comprises the added Br_2, HBr, the bromide compound, or a combination thereof.

27. (New) The method of claim 1, wherein the coal is combusted in the combustion chamber at a coal-combustion facility, wherein the Br_2, HBr, bromide compound, or combination thereof, is added to the coal before the coal enters the combustion chamber, wherein the addition of the Br_2, HBr, bromide compound, or combination thereof, to the coal is performed at the coal-combustion facility.

28. (New) The method of claim 1, wherein the coal is combusted in the combustion chamber at a coal-combustion facility, wherein the Br_2, HBr, bromide compound, or combination thereof, is added to the coal before the coal enters the combustion chamber, wherein the addition of the Br_2, HBr, bromide compound, or combination thereof, to the coal is performed at a site other than the coal-combustion facility.

29. (New) The method of claim 1, wherein the combustion chamber is an electric utility coal combustion chamber.

30. (New) The method of claim 1, wherein the combustion chamber is a coal combustion furnace.

31. (New) The method of claim 1, wherein the mercury-containing gas comprises about 1 g to about 30 g of the element bromine per 100 g of the sorbent.

32. (New) The method of claim 1, wherein the sorbent that collects the mercury comprises the element bromine and mercury.

33. (New) The method of claim 1, wherein the sorbent in the mercury-containing gas comprises about 1 g to about 30 g of the added Br_2, HBr, the bromide compound, or a combination thereof, per 100 g of the sorbent.

34. (New) The method of claim 1, wherein the Br_2, HBr, or the bromide compound is contacted with the sorbent in vapor form, gaseous form, liquid form, or in an organic solvent.

35. (New) The method of claim 1, wherein the sorbent injected into the mercury-containing gas is a sorbent obtained by contacting a base sorbent with a halogen or halide promoter prior to injection of the sorbent to the mercury-containing gas.

36. (New) The method of claim 1, wherein the sorbent injected into the mercury-containing gas is free of contact with a halogen or halide promoter prior to injection of the sorbent into the mercury-containing gas.

37. (New) The method of claim 1, wherein the injection of the sorbent into the mercury-containing gas occurs upstream of a particulate separator or a scrubber.

38. (New) The method of claim 37, wherein the particulate separator comprises an electrostatic precipitator, a baghouse, a fabric filter, or a combination thereof.

39. (New) The method of claim 1, wherein the coal comprises added halide sorbent enhancement additive that comprises the added Br_2, HBr, the bromide compound, or combination thereof.

40. (New) The method of claim 1, wherein the sorbent enhancement additive comprises the bromide compound.

41. (New) A method of separating mercury from a mercury-containing gas, the method comprising:

combusting coal in a combustion chamber, wherein

the coal comprises added Br_2, HBr, bromide compound, or a combination thereof, added to the coal before the coal enters the combustion chamber, or

the combustion chamber comprises added Br_2, HBr, bromide compound, or a combination thereof, or

a combination thereof;

collecting mercury in the mercury-containing gas with a sorbent comprising activated carbon.

42. (New) A method of separating mercury from a mercury-containing gas, the method comprising:

combusting coal in a combustion chamber, to provide the mercury-containing gas, wherein the mercury-containing gas comprises a halogen or halide promoter comprising HBr, Br^-, or a combination thereof, wherein

the coal comprises added Br_2, HBr, bromide compound, or a combination thereof, added to the coal before the coal enters the combustion chamber, or

the combustion chamber comprises added Br_2, HBr, bromide compound, or a combination thereof, or

a combination thereof;

collecting mercury in the mercury-containing gas with a sorbent comprising activated carbon;

separating the sorbent contacted with the mercury from the mercury-containing gas;

measuring the mercury content of the mercury-containing gas; and

modifying, in response to the measured mercury content of the mercury-containing gas,

an injection rate of injecting the sorbent into the mercury-containing gas,

an amount of the Br_2, HBr, bromide compound, or a combination thereof, added to the coal or the combustion chamber, or

a combination thereof.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Inventor(s): Edwin S. Olson et al. Examiner: AMBER ROSE ORLANDO
Application No.: 15/997,091 Group Art Unit: 1776
Filed: June 4, 2018 Docket No.: 4820.001U10
Confirmation No.: 5161
Title: SORBENTS FOR THE OXIDATION AND REMOVAL OF MERCURY

AMENDMENT & RESPONSE UNDER 37 C.F.R. § 1.116

Mail Stop AF
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Applicant has received the Final Office Action dated January 11, 2019. Please enter the following.

This response is accompanied by a Petition, as well as the appropriate fee, to obtain a three-month extension of the period for responding to the Office Action, thereby moving the deadline for response from April 11, 2019 to July 11, 2019.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
15/997,091	06/04/2018	Edwin S. Olson	4820.001US10	5161

21186 7590 07/16/2019
SCHWEGMAN LUNDBERG & WOESSNER, P.A.
P.O. BOX 2938
MINNEAPOLIS, MN 55402

EXAMINER
ORLANDO, AMBER ROSE

ART UNIT	PAPER NUMBER
1776	

NOTIFICATION DATE	DELIVERY MODE
07/16/2019	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

SLW@blackhillsip.com
uspto@slwip.com

Decision Granting Request for Prioritized Examination (Track I)	**Application No.** 15/997,091	**Applicant(s)** Olson et al.	
	Examiner BRIAN W BROWN	**Art Unit** OPET	**AIA (FITF) Status** No

1. THE REQUEST FILED 10 July 2019 IS **GRANTED** .

The above-identified application has met the requirements for prioritized examination

A. ☑ for an original nonprovisional application (Track I).
B. ☐ for an application undergoing continued examination (RCE).

2. **The above-identified application will undergo prioritized examination**. The application will be accorded special status throughout its entire course of prosecution until one of the following occurs:

A. filing a **petition for extension of time** to extend the time period for filing a reply;

B. filing an **amendment to amend the application to contain more than four independent claims, more than thirty total claims** , or a multiple dependent claim;

C. filing a **request for continued examination** ;

D. filing a notice of appeal;

E. filing a request for suspension of action;

F. mailing of a notice of allowance;

G. mailing of a final Office action;

H. completion of examination as defined in 37 CFR 41.102; or

I. abandonment of the application.

Telephone inquiries with regard to this decision should be directed to BRIAN BROWN at (571)272-5338.

In his/her absence, calls may be directed to Petition Help Desk at (571) 272-3282.

/BRIAN W BROWN/ Petitions Examiner, OPET	

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
15/997,091	06/04/2018	Edwin S. Olson	4820.001US10	5161

21186 7590 08/23/2019

SCHWEGMAN LUNDBERG & WOESSNER, P.A.
P.O. BOX 2938
MINNEAPOLIS, MN 55402

EXAMINER	
ORLANDO, AMBER ROSE	

ART UNIT	PAPER NUMBER
1776	

NOTIFICATION DATE	DELIVERY MODE
08/23/2019	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

SLW@blackhillsip.com
uspto@slwip.com

Office Action Summary	**Application No.** 15/997,091	**Applicant(s)** Olson et al.	
	Examiner AMBER R ORLANDO	**Art Unit** 1776	**AIA (FITF) Status** No

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTHS FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☑ Responsive to communication(s) filed on 07/10/2019.

☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2a)☐ This action is **FINAL.** 2b) ☑ This action is non-final.

3)☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

4)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims*

5) ☑ Claim(s) 1,9-10,12,16 and 18-42 is/are pending in the application.

5a) Of the above claim(s) _____ is/are withdrawn from consideration.

6) ☐ Claim(s) _____ is/are allowed.

7) ☑ Claim(s) 1,9-10,12,16 and 18-42 is/are rejected.

8) ☐ Claim(s) _____ is/are objected to.

9) ☐ Claim(s) _____ are subject to restriction and/or election requirement

* If any claims have been determined allowable, you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to **PPHfeedback@uspto.gov.**

Application Papers

10)☐ The specification is objected to by the Examiner.

11)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

Certified copies:

a)☐ All b)☐ Some** c)☐ None of the:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

** See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☐ Notice of References Cited (PTO-892)

2) ☑ Information Disclosure Statement(s) (PTO/SB/08a and/or PTO/SB/08b) Paper No(s)/Mail Date _____.

3) ☑ Interview Summary (PTO-413) Paper No(s)/Mail Date _____.

4) ☐ Other: _____.

DETAILED ACTION

Notice of Pre-AIA or AIA Status

The present application is being examined under the pre-AIA first to invent provisions.

Continued Examination Under 37 CFR 1.114

A request for continued examination under 37 CFR 1.114, including the fee set forth in 37 CFR 1.17(e), was filed in this application after final rejection. Since this application is eligible for continued examination under 37 CFR 1.114, and the fee set forth in 37 CFR 1.17(e) has been timely paid, the finality of the previous Office action has been withdrawn pursuant to 37 CFR 1.114. Applicant's submission filed on 07/10/2019 has been entered.

Claim Rejections - 35 USC § 112

The following is a quotation of 35 U.S.C. 112(b):
(b) CONCLUSION.—The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the inventor or a joint inventor regards as the invention.

The following is a quotation of 35 U.S.C. 112 (pre-AIA), second paragraph:
The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the applicant regards as his invention.

Claims 1, 9, 10, 12, 16 and 18-42 are rejected under 35 U.S.C. 112(b) or 35 U.S.C. 112 (pre-AIA), second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which the inventor or a joint inventor, or for pre-AIA the applicant regards as the invention.

Claim 11 is rejected under 35 U.S.C. 112(b) or 35 U.S.C. 112 (pre-AIA), second paragraph, as being incomplete for omitting essential steps, such omission amounting to a gap between the steps. See MPEP § 2172.01. The omitted steps are: the sorbent being added to the mercury containing gas stream.

Double Patenting

The nonstatutory double patenting rejection is based on a judicially created doctrine grounded in public policy (a policy reflected in the statute) so as to prevent the unjustified or improper timewise

extension of the "right to exclude" granted by a patent and to prevent possible harassment by multiple assignees. A nonstatutory double patenting rejection is appropriate where the conflicting claims are not identical, but at least one examined application claim is not patentably distinct from the reference claim(s) because the examined application claim is either anticipated by, or would have been obvious over, the reference claim(s). See, e.g., *In re Berg*, 140 F.3d 1428, 46 USPQ2d 1226 (Fed. Cir. 1998); *In re Goodman*, 11 F.3d 1046, 29 USPQ2d 2010 (Fed. Cir. 1993); *In re Longi*, 759 F.2d 887, 225 USPQ 645 (Fed. Cir. 1985); *In re Van Ornum*, 686 F.2d 937, 214 USPQ 761 (CCPA 1982); *In re Vogel*, 422 F.2d 438, 164 USPQ 619 (CCPA 1970); *In re Thorington*, 418 F.2d 528, 163 USPQ 644 (CCPA 1969).

A timely filed terminal disclaimer in compliance with 37 CFR 1.321(c) or 1.321(d) may be used to overcome an actual or provisional rejection based on nonstatutory double patenting provided the reference application or patent either is shown to be commonly owned with the examined application, or claims an invention made as a result of activities undertaken within the scope of a joint research agreement. See MPEP § 717.02 for applications subject to examination under the first inventor to file provisions of the AIA as explained in MPEP § 2159. See MPEP §§ 706.02(l)(1) - 706.02(l)(3) for applications not subject to examination under the first inventor to file provisions of the AIA. A terminal disclaimer must be signed in compliance with 37 CFR 1.321(b).

The USPTO Internet website contains terminal disclaimer forms which may be used. Please visit www.uspto.gov/patent/patents-forms. The filing date of the application in which the form is filed determines what form (e.g., PTO/SB/25, PTO/SB/26, PTO/AIA/25, or PTO/AIA/26) should be used. A web-based eTerminal Disclaimer may be filled out completely online using web-screens. An eTerminal Disclaimer that meets all requirements is auto-processed and approved immediately upon submission. For more information about eTerminal Disclaimers, refer to www.uspto.gov/patents/process/file/efs/guidance/eTD-info-I.jsp.

Claims 1, 9, 10, 12, 16 and 18-42 are rejected on the ground of nonstatutory double patenting as being unpatentable over claims 1-30 of U.S. Patent No. US 7,435,286 ('286) in view of Felsvang et al. US 5,435,980.

'286 discloses the claimed invention except for the coal comprising the additive.

Felsvang et al. and disclose this limitation as shown above.

It would have been obvious to one having ordinary skill in the art to have modified the '286 reference to include the limitations of claims 2 and 3 (Felsvang et al. column 5, 60-65 and column 4, lines 42-45) so as to supplement the halogen content of the system so as to increase the mercury sorption capability.

This is a provisional nonstatutory double patenting rejection because the patentably indistinct claims have not in fact been patented.

Claims 1, 9, 10, 12, 16 and 18-42 are rejected on the ground of nonstatutory double patenting as being unpatentable over claims 1-25 of U.S. Patent No. US 8,168,147 ('147) in view of Felsvang et al. US 5,435,980.

'286 discloses the claimed invention except for the coal comprising the additive.

Felsvang et al. and disclose this limitation as shown above.

It would have been obvious to one having ordinary skill in the art to have modified the '147 reference to include the limitations of claims 2 and 3 (Felsvang et al. column 5, 60-65 and column 4, lines 42-45) so as to supplement the halogen content of the system so as to increase the mercury sorption capability.

This is a provisional nonstatutory double patenting rejection because the patentably indistinct claims have not in fact been patented.

Claims 1, 9, 10, 12, 16 and 18-42 are rejected on the ground of nonstatutory double patenting as being unpatentable over claims 1-60 of U.S. Patent No. US 8,512,655 ('655) in view of Felsvang et al. US 5,435,980.

'655 discloses the claimed invention except for the coal comprising the additive.

Felsvang et al. and disclose this limitation as shown above.

It would have been obvious to one having ordinary skill in the art to have modified the '655 reference to include the limitations of claims 2 and 3 (Felsvang et al. column 5, 60-65 and column 4, lines 42-45) so as to supplement the halogen content of the system so as to increase the mercury sorption capability.

This is a provisional nonstatutory double patenting rejection because the patentably indistinct claims have not in fact been patented.

Claims 1, 9, 10, 12, 16 and 18-42 are rejected on the ground of nonstatutory double patenting as being unpatentable over claims 1-60 of U.S. Patent No. US 8,821,819 ('819) in view of Felsvang et al. US 5,435,980.

'819 discloses the claimed invention except for the coal comprising the additive.

Felsvang et al. and disclose this limitation as shown above.

It would have been obvious to one having ordinary skill in the art to have modified the '819 reference to include the limitations of claims 2 and 3 (Felsvang et al. column 5, 60-65 and column 4, lines 42-45) so as to supplement the halogen content of the system so as to increase the mercury sorption capability.

This is a provisional nonstatutory double patenting rejection because the patentably indistinct claims have not in fact been patented.

Claims 1, 9, 10, 12, 16 and 18-42 are rejected on the ground of nonstatutory double patenting as being unpatentable over claims 1-33 of U.S. Patent No. US 9,757,689 ('689) in view of Felsvang et al. US 5,435,980.

'689 discloses the claimed invention except for the coal comprising the additive.

Felsvang et al. and disclose this limitation as shown above.

It would have been obvious to one having ordinary skill in the art to have modified the '689 reference to include the limitations of claims 2 and 3 (Felsvang et al. column 5, 60-65 and column 4, lines 42-45) so as to supplement the halogen content of the system so as to increase the mercury sorption capability.

This is a provisional nonstatutory double patenting rejection because the patentably indistinct claims have not in fact been patented.

Claims 1, 9, 10, 12, 16 and 18-42 are rejected on the ground of nonstatutory double patenting as being unpatentable over claims 1-20 of U.S. Patent No. US 9,468,886 ('886) in view of Felsvang et al. US 5,435,980.

'886discloses the claimed invention except for the coal comprising the additive.

Felsvang et al. and disclose this limitation as shown above.

It would have been obvious to one having ordinary skill in the art to have modified the '886 reference to include the limitations of claims 2 and 3 (Felsvang et al. column 5, 60-65 and column 4, lines 42-45) so as to supplement the halogen content of the system so as to increase the mercury sorption capability.

This is a provisional nonstatutory double patenting rejection because the patentably indistinct claims have not in fact been patented.

Claims 1, 9, 10, 12, 16 and 18-42 are rejected on the ground of nonstatutory double patenting as being unpatentable over claims 1-30 of U.S. Patent No. 8,652,235 ('235) in view of Felsvang et al. US 5,435,980.

'235discloses the claimed invention except for the coal comprising the additive.

Felsvang et al. and disclose this limitation as shown above.

It would have been obvious to one having ordinary skill in the art to have modified the '235 reference to include the limitations of claims 2 and 3 (Felsvang et al. column 5, 60-65 and column 4, lines 42-45) so as to supplement the halogen content of the system so as to increase the mercury sorption capability.

This is a provisional nonstatutory double patenting rejection because the patentably indistinct claims have not in fact been patented.

Claims 1, 9, 10, 12, 16 and 18-42 are provisionally rejected on the ground of nonstatutory double patenting as being unpatentable over claims 1-16 of copending Application No. 15/295594 ('594) in view of Felsvang et al. US 5,435,980.

'594 discloses the claimed invention except for the coal comprising the additive.

Felsvang et al. and disclose this limitation as shown above.

It would have been obvious to one having ordinary skill in the art to have modified the '594 reference to include the limitations of claims 2 and 3 (Felsvang et al. column 5, 60-65 and column 4, lines 42-45) so as to supplement the halogen content of the system so as to increase the mercury sorption capability.

This is a provisional nonstatutory double patenting rejection because the patentably indistinct claims have not in fact been patented.

Claims 1, 9, 10, 12, 16 and 18-42 are provisionally rejected on the ground of nonstatutory double patenting as being unpatentable over claims 8-20 of copending Application No. 15/589359 ('359).

Although the claims at issue are not identical, they are not patentably distinct from each other because while the current claim set includes different wording it the limitations correspond to '359.

This is a provisional nonstatutory double patenting rejection because the patentably indistinct claims have not in fact been patented.

Claims 1, 9, 10, 12, 16 and 18-42 are provisionally rejected on the ground of nonstatutory double patenting as being unpatentable over claims 1-20 of copending Application No. 15/853029 ('029) in view of Felsvang et al. US 5,435,980.

'029 discloses the claimed invention except for the coal comprising the additive.

Felsvang et al. and disclose this limitation as shown above.

It would have been obvious to one having ordinary skill in the art to have modified the '029 reference to include the limitations of claims 2 and 3 (Felsvang et al. column 5, 60-65 and column 4, lines 42-45) so as to supplement the halogen content of the system so as to increase the mercury sorption capability.

This is a provisional nonstatutory double patenting rejection because the patentably indistinct claims have not in fact been patented.

Claims 1, 9, 10, 12, 16 and 18-42 are provisionally rejected on the ground of nonstatutory double patenting as being unpatentable over claims 1-20 of copending Application No. 14/712558 ('558). Although the claims at issue are not identical, they are not patentably distinct from each other because while the current claim set includes different wording it the limitations correspond to '558.

This is a provisional nonstatutory double patenting rejection because the patentably indistinct claims have not in fact been patented.

Claims 1, 9, 10, 12, 16 and 18-42 are provisionally rejected on the ground of nonstatutory double patenting as being unpatentable over claims 1-20 of copending Application No. 15/951970 ('970). Although the claims at issue are not identical, they are not patentably distinct from each other because while the current claim set includes different wording, the limitations correspond to '970.

This is a provisional nonstatutory double patenting rejection because the patentably indistinct claims have not in fact been patented.

Claims 1, 9, 10, 12, 16 and 18-42 are provisionally rejected on the ground of nonstatutory double patenting as being unpatentable over 1-20 of copending Application No. 15/382114 ('114) in view of Felsvang et al. US 5,435,980.

'114 discloses the claimed invention except for the coal comprising the additive.

Felsvang et al. and disclose this limitation as shown above.

It would have been obvious to one having ordinary skill in the art to have modified the '114 reference to include the limitations of claims 2 and 3 (Felsvang et al. column 5, 60-65 and column 4, lines 42-45) so as to supplement the halogen content of the system so as to increase the mercury sorption capability.

This is a provisional nonstatutory double patenting rejection because the patentably indistinct claims have not in fact been patented.

Claims 1, 9, 10, 12, 16 and 18-42 are provisionally rejected on the ground of nonstatutory double patenting as being unpatentable over 1-20 of copending Application No. 15/853029 ('029) in view of Felsvang et al. US 5,435,980.

'029 discloses the claimed invention except for the coal comprising the additive.

Felsvang et al. and disclose this limitation as shown above.

It would have been obvious to one having ordinary skill in the art to have modified the '029 reference to include the limitations of claims 2 and 3 (Felsvang et al. column 5, 60-65 and column 4,

lines 42-45) so as to supplement the halogen content of the system so as to increase the mercury sorption capability.

This is a provisional nonstatutory double patenting rejection because the patentably indistinct claims have not in fact been patented.

Claims 1, 9, 10, 12, 16 and 18-42 are provisionally rejected on the ground of nonstatutory double patenting as being unpatentable over 1-20 of copending Application No. 15/978,760 ('760) in view of Felsvang et al. US 5,435,980.

'760 discloses the claimed invention except for the coal comprising the additive.

Felsvang et al. and disclose this limitation as shown above.

It would have been obvious to one having ordinary skill in the art to have modified the '760 reference to include the limitations of claims 2 and 3 (Felsvang et al. column 5, 60-65 and column 4, lines 42-45) so as to supplement the halogen content of the system so as to increase the mercury sorption capability.

This is a provisional nonstatutory double patenting rejection because the patentably indistinct claims have not in fact been patented.

Claims 1, 9, 10, 12, 16 and 18-42 are provisionally rejected on the ground of nonstatutory double patenting as being unpatentable over 1-10, 14 and 21-25 of copending Application No. 15/974,343 ('343).

Although the claims at issue are not identical, they are not patentably distinct from each other because while the current claim set includes different wording, the limitations correspond to '760.

This is a provisional nonstatutory double patenting rejection because the patentably indistinct claims have not in fact been patented.

Conclusion

Any inquiry concerning this communication or earlier communications from the examiner should be directed to AMBER ROSE ORLANDO whose telephone number is (571)270-3149. The examiner can normally be reached on Monday-Thursday 7:00-5:30.

Examiner interviews are available via telephone, in-person, and video conferencing using a USPTO supplied web-based collaboration tool. To schedule an interview, applicant is encouraged to use the USPTO Automated Interview Request (AIR) at http://www.uspto.gov/interviewpractice.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Duane Smith can be reached on (571)272-1166. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

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