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(54) Title: CONVERSION OF ETHERS TO OLEFINS

(57) Abstract: Ethers are cracked to olefins using a gamma-alumina catalyst in the presence of ammonia. The use of ammonia improves the selectivity to linear alpha olefins in comparison to cracking reactions in the absence of ammonia. The use of ammonia is convenient in comparison to known processes which employ alumina which has been treated with an amine. A preferred process produces octene-1 from 1-methoxyoctane.

Symrise AG, EX1039
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CONVERSION OF ETHERS TO OLEFINS

TECHNICAL FIELD

This invention relates to the synthesis of olefins from ethers in the
5 presence of an alumina catalyst and ammonia.

BACKGROUND ART

The manufacture of higher olefins from ethylene is a well known art.
The resulting olefins are subsequently used to prepare a wide variety of
products including detergents, synthetic lubricants, and high molecular
10 weight polymers and copolymers. Ethylene is a comparatively expensive
material, so the use of alternative feedstocks such as propylene, butene or
butadiene has also been investigated.

For example, United States Patent (USP) 4,356,333 (Yoshimura et
al.) discloses the dimerization of butadiene in an aqueous sulfolane
15 solution, using a palladium catalyst, to product n-octadienol. This normal
alcohol is useful for the manufacture of various synthetic resin modifiers
and chemicals. It may also be selectively hydrogenated to n-octanol
(which is useful in the synthesis of di-n-octyl phthalate which, in turn, is
used as a plasticizer). Finally, the n-octanol may be dehydrated to
20 produce octene. Thus, the synthesis of octene from butadiene involves
three steps - dimerization, selective hydrogenation and dehydration.

It will be appreciated by those skilled in the art that each of the
above described steps in the synthesis of octene from butadiene needs to
be executed in an efficient manner in order to optimize the production of
25 octene.

Similar processes have been reported in the patent literature. For
example, USP 4,234,752 (Wiu et al.) disclosed the dehydration of alcohols
in the presence of gamma-alumina. The gamma-alumina is preferably
treated with a base.

30 Similarly, the abstract of German Patent 3,915,493 (assigned to
Metallgesellschaft AG of Germany and Godrej Soaps Ltd. of India),

discloses the synthesis of olefins from fatty alcohols in the presence of alumina which has been treated with ammonia.

World Patent application WO 2004/052809 (assigned to Oxeno) teaches the preparation of olefins from ethers using an alumina (with alkali
5 or alkaline earth metal oxide) catalyst.

Finally, U.S. Patent application 2003/0065233 (assigned to Kuraray) discloses the synthesis of olefins from ethers or alcohols using alumina which has been treated with an organic amine.

However, the prior art does not disclose the conversion of ethers to
10 olefins in the presence of ammonia. We have now discovered that olefins may be very efficiently produced from ethers using an alumina catalyst which has been treated with ammonia.

DISCLOSURE OF INVENTION

The present invention provides a process for the conversion of at
15 least one ether to an olefin using a gamma-alumina catalyst, characterized in that process is conducted in the presence of ammonia.

In a preferred embodiment, octene-1 is selectively produced from 1-methoxyoctane using a gamma alumina catalyst which has been treated with ammonia.

BEST MODE FOR CARRYING OUT THE INVENTION

20 This invention generally relates to the production of olefins. More specifically, it relates to the preparation of olefins from ethers. Thus, the invention provides a process to "split" or "crack" an ether to provide an olefin.

25 The process of this invention generally comprises reacting the ether with gamma-alumina. We have discovered that the use of ammonia in the cracking reaction improves the efficiency of the process to crack the ether to the olefin. While not wishing to be bound by theory, it is believed that the ammonia may partially neutralize some of the acidic sites on the
30 gamma-alumina (or, alternatively, simply reduce the overall acidity of the gamma-alumina). The gamma-alumina still is highly active for the cracking reaction in the presence of ammonia, but an improved yield of the

desired alpha-olefin is obtained in comparison to reactions which are conducted in the absence of ammonia.

A further aspect of the invention relates to the preferred amount of ammonia required to provide a balance of (i) activity; and (ii) "selectivity to
5 alpha olefins". Another aspect of the invention relates to preferred reaction conditions, especially temperature and pressure.

In general, the market for alpha-olefins is better than the market for branched or internal olefins. Accordingly, it is desirable to maximize the yield of 1-olefins and minimize (i) double bond isomerization i.e. to
10 minimize the formation of internal olefins); and (ii) skeletal isomerization (i.e. to minimize the formation of "branched" olefins).

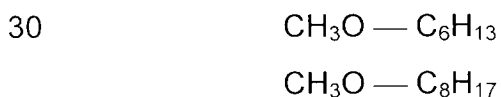
Ethers which are "cracked" to olefins in accordance with this invention contain from about 4 to about 20 carbon atoms. The ethers may be straight chain or branched. It is highly preferred that the ether is a
15 1-methoxy ether - i.e. that the functional ether group is " ---OCH_3 ".

Thus, the ethers which are preferably employed in the process of this invention may be illustrated by the following general formula:



where R is a hydrocarbyl group having from about 3 to about 19 carbon
20 atoms. It is preferred that the hydrocarbyl group R of the above formula is a saturated hydrocarbyl, especially a simple linear alkane. In general, the process of this invention uses "at least one" ether as a feedstock (i.e. a mixture of ethers may be used). However, it is preferred that the feed consists of substantially one ether. Thus, the preferred process of this
25 invention might be generally described as the cracking or splitting of a 1-methoxy alkane to form an olefin.

It is especially preferred that the hydrocarbyl group R is a linear alkane containing from 6 to 10 carbon atoms, especially the following three ethers:





The olefins which are preferably produced by the process of this invention correspond to the alpha olefin from which CH₃OR has been removed from the ether. Thus, the preferred alpha olefins (corresponding
5 to the three linear ethers noted above) are hexene-1, octene-1 and decene-1.

As previously noted, the present invention is characterized by the use of ammonia. In the absence of ammonia, the selectivity to alpha olefins is reduced, resulting in the production of isomerized olefins. Most
10 preferably, the ammonia is used by simply mixing it with the ether prior to the cracking reaction. This may be done, for example, by (i) adding ammonia gas (i.e. NH₃ gas) to the ether; or (ii) adding an aqueous solution of ammonia (NH₄OH) to the ether. For the preferred ethers, especially those in which the group R of formula I is a saturated linear alkane
15 containing from 6 to 10 carbon atoms, the "ammonia treatment" may be conventionally conducted at room temperature. It is preferred to have at least 25 parts per million by weight (ppm) ammonia based on the weight of the ether, with amounts of from 50 to 3,000 (especially 50 to 250) being especially preferred. The ammonia is preferably added to the ether prior
20 to introducing the ether into the cracking reactor. In this manner, it is possible to add larger amounts of ammonia and the total amount of ammonia is preferably less than the solubility/saturation point of the ammonia in the ether. As an alternative, two separate feeds (of (1) the ether(s); and (2) the ammonia) may be sent to the "cracking" reactor.

25 The process of the present invention is preferably conducted in the substantial absence of any solvent or diluent for the ether. However, the scope of the present invention does not preclude the use of a solvent or diluent.

The cracking reaction is conducted in the presence of gamma-
30 alumina. As used herein, the term "gamma-alumina" is meant to convey its conventional meaning, namely an alumina that is predominately in the gamma crystal form as determined by x-ray crystallography. Gamma-

alumina is in commercial use as a catalyst (or catalyst support) and it is a widely available item of commerce. The use of a commercially available gamma-alumina is preferred. Such gamma-aluminas may be purchased in different forms (e.g. particulates or extrudates); particle sizes, surface areas, and pore sizes and pore volumes. The choice of the most preferred type of gamma-alumina will be influenced by conventional design considerations, including the cost of the commercially available gamma-alumina products and the configuration of the cracking reactor.

Two examples of commercially available gamma alumina which may be used in the process of this invention are sold under the trademark PURALOX KR[®] by Sasol and the tradename AI-4126E by Engelhard.

PURALOX KR[®] alumina is reported to have a surface area of 300 m²/g and a pore volume of 1 ml/g whereas AI-4126E alumina is reported to have a surface area of 235 m²/g and a pore volume of 0.8 cubic centimeters per gram.

The ether is thermally cracked in a reactor. The most preferred temperatures, pressures and reaction times may be readily determined by routine experimentation. In general, a temperature range of from about 150°C to 500°C is suitable (preferably, from about 275°C to 450°C).

A pressure range of from about atmospheric pressure to 3,500 KPa is suitable (with a preferred range of from about 100 to 1,000 KPa).

The reaction may be conducted in a batch or continuous mode of operation. It is preferred to operate in a continuous mode with a space velocity of from about 0.1 to 20 reciprocal hours (h⁻¹) WHSV, particularly from about 0.3 to 15 h⁻¹ and more particularly from about 8 to 12 h⁻¹. The term WHSV as used herein is meant to convey its conventional meaning, namely weight hourly space velocity (expressed as reciprocal hours) and is obtained by dividing the mass flow rate of the ether by the mass of the catalyst (gamma-alumina) in the reaction.

The present invention provides a high selectivity to alpha-olefin products. However, some by-products may be produced, and these by-products may be readily separated from the desired alpha-olefins using

conventional separation techniques (e.g. solvent extraction or fractional distillation).

Further details are illustrated by the accompanying, non-limiting examples.

5 **Examples**

All "cracking" reactions were performed in a fixed bed tubular reactor. There are two separate heating zones in the system. The first zone, about 8" (about 20 cm) in length, is controlled at about 300°C to vaporize the feed liquid and to maintain the vapor temperature close to the
10 reaction temperature. The second zone contains a reactor having dimensions about 0.4" (about 1 cm) ID (internal diameter) x about 2" (about 5 cm) length. Both zones are controlled by independent thermocouples and temperature-control units. The ether (1-methoxyoctane) or "MOAN" was fed into the reactor at the top with a
15 syringe pump. The product stream is passed through a condenser and the liquid is collected for analysis by gas chromatography (purchased from Agilent).

Comparative Example 1

Alumina extrudates (purchased from Engelhard under the
20 tradename Al-4126 E, in the form of 1/16" extrudates, then crushed to 20-40 mesh) were stirred in an aqueous solution of NaOH for five hours with a mechanical stirrer. The mixture was filtered to remove water and some fines. The solid was washed with water, dried at 135°C overnight and then further dehydrated at 300°C for five hours to form the base treated alumina
25 catalyst. The catalyst was loaded into the reactor and was further stabilized at 300°C overnight under nitrogen flow before a run started. 1-methoxyoctane was fed into the reactor for a half hour before a product sample was taken for analysis. For any change of the reaction conditions, such as change of WHSV or reaction temperature, the reaction was
30 allowed to proceed for 0.5 hours before a sample was taken for analysis. The data from runs with NaOH-modified alumina are collected in Table 1.

Comparative Example 2

Alumina extrudates (Engelhard Al-4126 E crushed to 20-40 mesh) were dehydrated at 300°C for five hours. A portion of the dehydrated alumina was loaded in the reactor and heated at 300°C for 12 hours
5 before a run started.

An amine was added to 1-methoxyoctane to form a 1 wt % solution of the amine in 1-methoxyoctane, which was fed into the reactor for the cracking runs. The experiments were performed in a similar manner to those in Comparative Example 1. The results are collected in Table 2.

10 Example 1

Ammonia gas was slowly bubbled through 1-methoxyoctane (50 mL) for 1 hour to form a saturated ammonia solution in 1-methoxyoctane. Analysis of ammonia in methoxyoctane indicated that the solution was saturated after 30 minutes of bubbling (15 min, 2372 mg
15 NH₃/L; 30 min, 3016 mg NH₃/L; 60 min, 2924 mg NH₃/L; 90 min, 3294 mg NH₃/L). The NH₃ saturated methoxyoctane solution was used as feed to the cracking reactor. The data are presented in Table 3. (NH₃ helps to give higher conversion while maintaining high octene-1 selectivity.)

Example 2

20 An aqueous solution of NH₄OH (0.8mL, 28-30 wt %) was added to 1-methoxyoctane (50 mL) and the mixture was thoroughly mixed. The mixture was left to stand and only the organic layer was used for the cracking run. The experimental conditions were the same as in example 1 and the results are collected in Table 4.

25 Example 3

The conditions used in this Example were substantially the same as those of Example 1. Details are presented in Table 5.

Example 4

30 A second syringe pump was used to deliver ammonia from a gas-tight syringe into the feed stream. Table 6 and Table 7 show that when selectivity to 1-octene was high, conversion of MOAN can be tuned by varying the amount of ammonia delivered into the feed stream. Preferred

operating conditions (high WHSV) and results (high octene-1 selectivity) may be achieved at low levels of ammonia, as shown in the Tables. Unreacted MOAN and the produced n-octanol and dioctyl ether may be recycled to increase octene-1 yield. As shown in Table 8, octene-1

5 selectively was maintained at a very high level (>95%) at a WHSV between 8 and 12 using ammonia in an amount of from 50 to 250 ppm (based the weight of ammonia divided by the weight of MOAN).

TABLE 1
Cracking MOAN over NaOH Modified Alumina

Run #	Catalyst	Sample	Temp (°C)	WHSV (h ⁻¹)	Flow (ml/hr)	MOAN Conversion (%)	Selectivity To Octenes (%)	1-Octene Selectivity (%)	1-Octene Yield (%)	Di-N-Octyl/ether (%)
1	Al-4126 E 1/16" Extrudates (Engelhard)	A	300	3.5	7.7					
		B	300	3.0	6.6					
		C	300	4.0	8.8					
8	Al-4126 E 1/16" Extrudates (Engelhard) + 1% Na ₂ O	A	280	3.0	7.3	11.30	39.62	98.78	39.14	48.14
		F	300	4.0	9.7	12.36	38.65	98.71	38.15	42.20
		B	300	3.0	7.3	17.96	39.91	98.90	39.48	42.29
		C	300	2.0	4.9	23.37	41.86	98.94	41.42	38.16
	smaller pieces of extrudates	D	300	1.0	2.4	35.42	49.41	98.89	48.86	25.81
	only, 1-3mm	E	300	0.5	1.2	50.96	64.06	98.45	63.06	39.28
		G	320	3.0	7.3				0.00	#DIV/0!
9	Al-4126 E 1/16" Extrudates (Engelhard) + 0.5% Na ₂ O	A	280	3.0	7.2	25.96	56.22	98.78	55.53	28.06
		B	300	3.0	7.2	36.72	64.46	98.43	63.44	22.30
		C	300	2.0	4.8	39.02	70.37	98.41	69.25	17.03
		D	300	1.0	2.4	59.24	79.15	97.82	77.43	11.87
		E	300	0.5	1.2	78.72	88.56	96.14	85.14	5.40
	smaller pieces of extrudates	F	320	3.0	7.2	40.56	77.13	97.51	75.21	11.20
10	Al-4126 E 1/16" Extrudates (Engelhard) + 0.25% Na ₂ O	A	300	3.0	7.2	90.35	95.67	84.24	80.59	0.52
		B	300	2.0	4.8	94.09	96.06	79.54	76.40	0.25
		C	300	1.0	2.4	92.55	96.15	64.46	61.98	0.42
		D	300	0.5	1.2	98.34	96.63	45.32	43.80	0.22
	smaller pieces of extrudates	E	320	0.5	1.2	98.59	95.96	33.66	32.30	0.17
11	Davicat Al 2750 spheres	A	300	3.0	5.0	90.41	96.62	64.25	62.07	0.14
		B	300	2.0	3.4	99.32	92.62	58.48	54.17	0.03
		C	300	1.0	1.7	99.64	97.33	39.01	37.97	0.01
		D	300	0.5	0.8	99.76	96.28	15.62	15.04	0.00
		E	320	0.5	0.8	99.78	97.05	24.25	23.53	0.01

TABLE 2
Cracking MOAN over Alumina in the Presence of Amines

Run #	Catalyst	Sample	Temp (°C)	WHSV (h ⁻¹)	Flow (ml/hr)	MOAN Conversion (%)	Selectivity To Octenes (%)	1-Octene Selectivity (%)	1-Octene Yield (%)	Di-N-Octylether (%)
12	Al-4126 E 1/16" Extrudates (Engelhard) + 0.5% Na ₂ O	A	300	3.0	7.2	65.95	82.50	98.11	80.94	8.77
	300C calcination	B	300	2.0	4.8	75.22	87.77	97.70	85.76	5.49
		C	300	1.0	2.4	94.02	95.78	95.06	91.05	0.57
		D	300	0.5	1.2	97.33	97.44	87.43	85.19	0.25
	20-40 mesh	E	320	0.5	1.2	98.72	88.69	79.48	70.50	0.06
1	Al-4126 E 1/16" Extrudates (Engelhard)	A	300	3.5	7.7					
	trial run	B	300	3.0	6.6					
		C	300	4.0	8.8					
20	Al-4126 E 1/16" Extrudates (Engelhard) - 300C calcination	A	300	3.0	6.5	80.27	91.33	94.61	86.40	2.25
		B	300	2.0	4.3	84.11	91.78	95.46	87.61	2.10
		C	300	1.0	2.2	93.50	94.77	93.60	88.71	0.46
	1 wt % 2-Me2N-Pyridine dissolved in MOAN	D	300	0.5	1.1	96.37	95.43	89.36	85.28	0.35
		E	320	0.5	1.1	97.99	93.36	86.56	80.81	0.13
21	Al-4126 E 1/16" Extrudates (Engelhard) - 300C calcination	A	300	3.0	6.1	48.92	76.40	98.37	75.15	10.75
		B	300	2.0	4.1	64.19	82.00	97.30	79.79	8.09
		C	300	1.0	2.0	75.31	87.40	91.59	80.05	5.45
	1 wt % Me2N(CH ₂) ₆ NMe ₂ dissolved in MOAN	D	300	0.5	1.0	76.61	87.93	82.50	72.54	5.28
		E	320	0.5	1.0	78.36	91.79	65.24	59.89	1.64

TABLE 3
Cracking MOAN over Alumina in the Presence of Ammonia

Run #	Catalyst	Sample	Temp (°C)	WHSV (h ⁻¹)	Flow (ml/hr)	MOAN Conversion (%)	Selectivity To Octenes (%)	1-Octene Selectivity (%)	1-Octene Yield (%)	Di-N-Octylether (%)
1	Al-4126 E 1/16" Extrudates (Engelhard)	A	300	3.5	7.7					
		B	300	3.0	6.6					
		C	300	4.0	8.8					
30	Al-4126 E 1/16" Extrudates	A	300	3.0	8.3	81.91	77.40	97.42	75.40	2.46
		B	300	2.0	5.5	93.17	91.10	96.67	88.07	0.44
	NH3 bubbled through MOAN for 1 hr	C	300	1.0	2.8	98.90	94.78	92.69	87.86	0.06
		D	300	0.5	1.4	99.46	96.07	83.92	80.62	0.05
	20-40 mesh	F	300	5.0	13.8	71.02	79.82	97.92	78.16	5.63

TABLE 4
Cracking MOAN over Alumina in the Presence of Ammonia/H₂O

Run #	Catalyst	Sample	Temp (°C)	WHSV (h ⁻¹)	Flow (ml/hr)	MOAN Conversion (%)	Selectivity to Octenes (%)	1-Octene Selectivity (%)	1-Octene Yield (%)	Di-N-Octylether (%)
1	Al-4126 E 1/16" Extrudates (Engelhard)	A	300	3.5	7.7					
		B	300	3.0	6.6					
		C	300	4.0	8.8					
32	Al-4126 E 1/16" Extrudates	A	300	3.0	8.1	99.03	94.47	92.17	87.07	0.02
		B	300	2.0	5.4	99.77	96.07	87.81	84.36	0.01
	NH ₄ OH added to feed	C	300	1.0	2.7	99.97	96.25	75.13	72.31	0.02
		D	300	0.5	1.4	100.00	96.21	57.16	54.99	0.01
	20-40 mesh	E	300	0.5	1.4	100.00	94.25	32.73	30.85	0.01

TABLE 5
Cracking MOAN over Alumina in the Presence of Ammonia

Run #	Catalyst	Sample	Temp p (°C)	WHSV (h ⁻¹)	Flow (ml/hr)	MOAN Conversion to (%)	Selectivity to Octenes (%)	1-Octene Selectivity (%)	1-Octene Yield (%)	Di-N- Octylether (%)
1	Al-4126 E 1/16" Extrudates (Engelhard) trial run	A	300	3.5	7.7					
		B	300	3.0	6.6					
		C	300	4.0	8.8					
38	Al-4126 E 1/16" Extrudates 20-40 mesh	A	300	2.0	4.4	90.88	92.04	96.78	89.08	0.88
		B	300	1.0	2.2	98.50	95.31	93.31	88.93	0.06
	NH3 bubbled through MOAN for 1 hr	C	300	0.5	1.1	99.90	96.65	85.77	82.90	0.00
		D								
		N2 gas 50cc/min	300	0.5	1.1	99.44	96.52	94.41	91.12	0.06
		E								
		N2 gas 175cc/min	300	0.5	1.1	99.58	97.53	95.72	93.36	0.06

TABLE 6
Cracking MOAN over Alumina in the Presence of Different Amounts of Ammonia

Run #	NH3 (ml/hr)	NH3 (ppm)	Sample	Temp (°C)	WHSV (h ⁻¹)	Flow Rate (ml/hr)	C (%)	S _{C8s} (%)	S _{C8-1} (%)	(n-Octyl) ₂ O (%)	n-Octyl-OH	MeOH	MeOMe
1			A	300	3.5	7.7							
			B	300	3.0	6.6							
			C	300	4.0	8.8							
68	20	703	A	300	9.8	20	54.96	73.96	98.34	10.62	7.66	0.96	3.12
	20	703	B	300	9.8	20	53.06	76.95	98.33	10.20	7.49	0.60	1.18
	8.7	250	C	300	12.0	24.4	74.66	88.02	97.46	2.31	4.03	0.56	1.99
	8.7	500	D	300	6.0	12.2	77.34	90.29	97.34	2.39	3.68	0.21	0.41
	8.7	750	E	300	4.0	8.2	83.66	88.20	96.94	1.55	2.79	0.40	3.77
	8.7	1500	F	300	2.0	4.1	87.62	90.83	96.26	0.94	1.99	0.31	2.10

Catalyst: Engelhard Al-4126 E 1/16" extrudates, calcined at 300°C, 20-40 mesh

TABLE 7

Cracking MOAN over Alumina in the Presence of Different Amounts of Ammonia

Run #	NH3 (ml/hr)	NH3 (ppm)	Sample	Temp (°C)	WHSV (h ⁻¹)	Flow Rate (ml/hr)	C (%)	S _{C8s} (%)	S _{C8-1} (%)	(n-Octyl) ₂ O (n-Octyl-OH) (%)	MeOH	MeOMe
1			A	300	3.5	7.7						
			B	300	3.0	6.6						
			C	300	4.0	8.8						
70	0	0	A	300	4.0	7.5	100.00	95.69	65.39	0.01	0.01	1.55
	21.4	2140	B	300	4.0	7.5	55.21	67.41	97.59	14.37	8.23	3.14
	16.1	1610	C	300	4.0	7.5	62.39	76.12	98.24	8.80	6.82	2.58
	10.7	1070	D	300	4.0	7.5	84.99	91.81	93.95	0.80	2.18	2.65
	5.4	540	E	300	4.0	7.5	83.75	90.24	96.92	1.38	2.77	2.11
	1.1	100	F	300	4.0	7.5	91.87	93.66	95.61	0.4	1.44	1.43
73	1.1	100	B	300	4.0	7.5	97.13	94.78	93.73	0.06	0.53	1.85
	1.6	100	C	300	6.0	11.3	92.65	93.39	95.31	0.35	1.30	2.18
	2.2	100	D	300	8.0	15.1	89.77	92.36	95.80	0.54	1.70	2.60
	2.7	100	E	300	10.0	18.8	87.38	92.13	96.01	0.69	2.03	2.22

Catalyst: Sasol PURALOX KR extrudates, calcined at 300°C, 20-40 mesh

TABLE 8
Cracking MOAN over Alumina in the Presence of Different Amounts of Ammonia

Run #	NH3 (ml/hr)	NH3 (ppm)	Sample	Temp (°C)	WHSV (h ⁻¹)	Flow Rate (ml/hr)	C (%)	S _{C8s} (%)	S _{C8-1} (%)	(n-Octyl) ₂ O (%)	n-Octyl-OH	MeOH	MeOMe
76	0.0	0	A	300	8.0	13.1	99.50	96.82	88.88	0.01	0.08	0.18	3.05
	1.9	100	B	300	8.0	13.1	88.22	95.47	95.25	0.40	1.59	0.26	1.84
	4.7	250	C	300	8.0	13.1	78.30	92.16	97.06	1.70	3.35	0.57	4.66
	9.7	500	D	300	8.0	13.1	62.00	84.14	98.22	5.74	6.22	0.88	4.39
	18.7	1000	E	300	8.0	13.1	43.90	69.76	98.87	13.79	9.67	1.11	4.25
	28.1	1500	F	300	8.0	13.1	39.24	65.52	98.95	15.50	10.62	1.20	3.91
77	0.0	0	A	300	10.0	16.4	95.18	96.63	94.73	0.08	0.80	0.12	1.53
	1.2	50	B	300	10.0	16.4	85.86	94.63	96.43	0.66	2.23	0.33	1.61
	2.3	100	C	300	10.0	16.4	79.90	92.78	96.97	1.41	3.28	0.39	1.31
	3.5	150	D	300	10.0	16.4	78.59	92.61	97.04	1.48	3.30	0.51	2.02
	4.7	200	E	300	10.0	16.4	72.15	90.16	97.63	2.59	4.46	0.54	1.92
	5.6	200	F	300	12.0	19.6	72.27	90.54	97.61	2.32	4.39	0.56	1.47
	4.2	150	G	300	12.0	19.6	75.33	91.66	97.45	1.78	3.88	0.47	1.34
	2.8	100	H	300	12.0	19.6	80.12	92.88	97.22	1.22	3.17	0.62	4.55

Catalyst: Sasol PURALOX KR extrudates, calcined at 300°C, 20-40 mesh

INDUSTRIAL APPLICABILITY

This process improves the efficiency of converting lower value ethers into higher value olefins. The resulting olefins are useful as feedstocks for a wide variety of chemical processes, including the

5 synthesis of lube oils, detergents and polymers. A preferred process of this invention produces octene-1, which may be used as a comonomer for the production of ethylene-octene copolymers.

CLAIMS

1. A process for the conversion of at least one ether to an olefin using a gamma alumina catalyst, characterized in that process is conducted in the presence of ammonia.
- 5 2. The process of claim 1 wherein said at least one ether is defined by the formula:
$$\text{R} - \text{OCH}_3$$

wherein R is a hydrocarbonyl having from 3 to 19 carbon atoms.
3. The process of claim 1 when completed at a temperature of from
10 150°C to 500°C and a pressure of from atmospheric pressure to 3,500 KPa.
4. The process of claim 1 when conducted in a continuous mode of operation at a WHSV space velocity of from 0.1 to 20 h⁻¹.
5. The process of claim 2 wherein R is a linear alkane having from 6 to
15 10 carbon atoms.
6. The process of claim 1 wherein said at least one ether consists substantially of 1-methoxyoctane.
7. The process of claim 1 when conducted at a WHSV of from 8 to 12
h⁻¹ and ammonia concentration of from 50 to 250 ppm, based on the
20 weight of said at least one ether.
8. The process of claim 7 wherein said at least one ether consists substantially of 1-methoxyoctane.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CA2006/001666

A. CLASSIFICATION OF SUBJECT MATTER
IPC: **C07C 1/20** (2006.01)
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
C07C 1/* (2006.01)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic database(s) consulted during the international search (name of database(s) and, where practicable, search terms used)
Canadian Patent Database, Esp@cenet, Delphion, STN, Internet
keywords: gamma alumina, ammonia, olefin*, ether*, dehydrat*, conversion*, methoxyoctane, octene

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE3915493 (METALLGESELLSCHAFT AG, DE) 22 November 1990 (22-11-1990) (cited in application) whole document	1-8
A	US4234752 (PHILLIPS PETROLEUM COMPANY) 18 November 1980 (18-11-1980) (cited in application) whole document	1-8
A	US2003/0065233 A1 (KURARAY CO., JP) 03 April 2003 (03-04-2003) (cited in application) whole document	1-8

☒ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A" document defining the general state of the art which is not considered to be of particular relevance	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E" earlier application or patent but published on or after the international filing date	"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&" document member of the same patent family
"O" document referring to an oral disclosure, use, exhibition or other means	
"P" document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search

10 January 2007 (10-01-2007)

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/CA2006/001666

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	CA2506495 (OXENO OLEFINCHEMIE GMBH, DE) 24 June 2003 (24-06-2003) whole document , page 5	1-8
A	"Effect of the macroscopic distribution of components in nickel- vanadium-antimony/gamma-alumina catalyst granules on activity in the oxidative dehydrogenation of n-butane" Neftekhimiya (1992), 32(2), pages 113-124 CAS, Abstract 117:152528	1-8

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CA2006/001666

Patent Document Cited in Search Report	Publication Date	Patent Family Member(s)	Publication Date
DE3915493	22-11-1990	NONE	
US4234752	18-11-1980	BE885422 A1	26-03-1981
US2003065233	03-04-2003	CA2391143 A1 CN1172887C C EP1277719 A1 JP2003095994 A KR20030007164 A SG118141 A1	16-01-2003 27-10-2004 22-01-2003 03-04-2003 23-01-2003 27-01-2006
CA2506495	24-06-2004	AU2003274089 A1 BR0317091 A CN1723178 A DE10257499 A1 EP1569881 A1 JP2006509016T T KR20050084262 A MXPA05006186 A NO20053365 A PL376155 A1 US2006036121 A1 WO2004052809 A1	30-06-2004 25-10-2005 18-01-2006 01-07-2004 07-09-2005 16-03-2006 26-08-2005 26-08-2005 11-07-2005 27-12-2005 16-02-2006 24-06-2004