

Dr. Patrick Brant

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2012-YE 2018

Chief Polymer Scientific Advisor, Global R&D, ExxonMobil Chemical, Baytown, TX

(Non-regular; unique position in company created through XOM board approval)

No formal reporting or managerial relationships, no rating or ranking; significant freedom to come and go as I wish, interact across and outside company

Engage with organization informally, carry out research of interest to me. Provide feedback (mentor) to individuals, team leaders, managers where I could add value

Last EMCC Position Before Retirement (2000-2011)

Chief Polymer Scientist, Global R&D, ExxonMobil Chemical (EMC)

This is the highest technical position in EMC. It is an executive level position approved by the XOM Board. The primary basis for granting the position was major financial impact through technology advances. Examples of greatest financial impact are found primarily within the metallocene catalysis arena - catalyst synthesis, process, product, and market advances - where I contributed substantially to technologies that have generated, in aggregate, billions of \$ over the years.

Chief scientist responsibilities include program identification, initiation, leadership, stewardship, technical career planning, annual assessment of health of technology organization and steps to optimize organization performance, as well as intellectual property oversight. Interface with managers, marketing, customers, businesses; represent XOM through invited external talks and other scientific endeavors; external consultant and program selections, funding to leverage XOM research; occasional interviews.

While a Chief, I also engaged with Tonen Chemical, an XOM affiliate based in Japan. I worked with Tonen as co-lead of their technology in battery separator films (BSF's) for lithium ion batteries (LIB's). Tonen was a pioneer in the BSF "wet process". I worked closely with the BSF business for nearly 4 years on all aspects of their technology for portable electronics and the nascent electric

vehicle market. This included a detailed understanding of resin selections (uhmw polyethylene and polypropylene) that could be deployed in the wet process, BSF membrane evaluation, and cooperation with strategic BSF customers and LIB end users around the world, but primarily in Asia.

Graduate Education

1977 PhD, Inorganic Chemistry, University of Arizona, Tucson, Arizona

Post-Doctoral Experience

1977 with Professor Dick Walton, Purdue University, West Lafayette, Indiana

1978 National Research Council Fellowship, Naval Research Laboratory, Washington, DC

Professional Experience

1979-1981 Research Chemist, Chemistry Division, Naval Research Laboratory

1981-2018 EMC, Baytown, TX

1989-1993 Manager, Adhesion and Interfacial Science Group (approximately 15 Ph.D. and technicians)

2012-Present As appropriate, consult for others if no conflict with ExxonMobil Corp

2019-Present Technical advisor with A2O start-up in Vancouver, B.C. and with Professor Laurel Shaefer, Dept. of Chemistry, at UBC; focus is on catalytic hydroalkylation of olefins (install amines) in monomer substrates, hydrocarbon oligomers, and polymers.

2022-Present Pursuit of new synthetic approach for grafting oligomers and polymers to nanoparticles for efficient, cost effective nanocomposite synthesis; provisional patent filed, claims granted.

2022-Present – With Professor Alamgir Karim (Dept. of Chemical Engineering, University of Houston), co-advise post-doctoral student on synthesis strategy for grafting polyethylene to inorganics.

Research and Development Experience

- Since 1989: Synthesis and characterization of new polyolefins made with metallocene and other single-site catalysts; from bench to commercial (eg. Exceed™ linear low density polyethylene (LLDPE), Exact™ plastomers, Enable™ LLDPE, Achieve™ polypropylene).
- Development of a suite of novel characterization tools that can assess performance of homogeneous and supported Ziegler-Natta and metallocene catalysts from lab to commercial plants. Structure-property relationships developed for catalyst performance such as reactivity profile, bulk density, fouling, and poison control. Example of one such tool: Luminescence and time-resolved luminescence applied to homogeneous and supported metallocene catalysts to evaluate their activation and electronic structure.
- Design principles for scalable synthesis of supported olefin polymerization catalysts for improved slurry and fluidized bed gas phase reactor operability (wall chemistry, for example; factors affecting sheeting and fouling; plant operability windows for catalysts).
- Detailed morphological studies of mono- and heterophasic polyolefin granules generated with Ziegler-Natta and metallocene catalysts. Optimum morphology for excellent bulk density (critical variable for plant operability).
- Engage with each step of catalyst and polymer product scale-up, from lab to customer.
- Structure-property-process relationships of polyolefins and polyolefin blends, including balance of melt and solid-state behavior. Primary focus on markets involving film and molding applications.
- Adhesion and design of polyolefin-based hot melt and pressure sensitive adhesives; roles of polymer, wax, tackifier, and functional polymer components in same.
- Stretch cling film design and development of quantitative model for cling.
- Polyolefin functionalization, degradation; reactions of functionalized polyolefins to generate new comb block polyolefins with tailored topology
- Pioneered catalyst design for synthesis of selectively reactive vinyl terminated polyolefins in 85-99% yield; use of same for preparing long chain branched and bottlebrush polyolefins, as well as comb block polyolefins; extensive exploration of functionalization, placing functionality exclusively at one chain terminus.
- From 2008-2011, co-led technology team, largely based in Japan, targeting innovations in polyolefin-based separator membranes for lithium ion batteries; primary focus on large format batteries for HEV/EV. Business sold in 2011.
- Work with key customers such as Cypress Packaging, Rochester, NY – a pioneer in modified atmosphere packaging for fresh produce - on polyolefin design solutions for

flexible and rigid food packaging with emphasis on polymer gas transport properties and organoleptics. Lead teams that solved major organoleptics problems in XOM and at customers.

- Pioneering work on uni- and biaxial orientation of metallocene LLDPE, now referred to as BOPE. These approaches hold considerable potential for simplifying packaging, rendering such packaging more readily recyclable and sustainable.
- Surface functionalization of polyolefins; characterization of same by X-ray photoelectron spectroscopy (XPS), secondary ion mass spectrometry (SIMS), and a variety of other tools
 - Corona discharge, plasma, flame treatments; chemical treatments for surface passivation
 - Adhesion, interfacial design; fundamental studies for example on factors governing adhesion of polyethylene and polypropylene
- Extensive use of advanced characterization tools throughout career: X-ray photoelectron spectroscopy (XPS), electron spin resonance (ESR), small angle oscillatory and extensional rheology, atomic force microscopy (AFM), scanning transmission electron microscopy (STEM), low voltage SEM (LVSEM), and tools for evaluating melt and solid state mechanical properties.
- Extensive experience with polyolefin blends, including TPO's, ICP's; blend compatibilization; structure-property-process focus on automotive applications
- Scalable routes to long chain branched isotactic polypropylene and high density polyethylene
- New propylene polymerization process – supercritical/high propylene concentration homogeneous polymerization to make all polypropylenes from highly crystalline isotactic polypropylene to amorphous propylene products, along with any desired crystallinity for application; extensive exploration of this novel catalyst-process space

Other Experience

- 1993: Industrial Fellow, University of Minnesota, Department of Chemical Engineering and Material Science with Professor Frank Bates
- 1991-2010: EMCC representative for Center of Interfacial Engineering & IPRIME (university-industry consortia), University of Minnesota

- 2002-2010: Teach Introduction to Polymer Structure-Property Relationships for EMC employees
- Litigation, depositions, expert witness
- 2001-2005: Member of Chemical Research Committee; worldwide annual internal technology meeting for ExxonMobil Chemical
- Over 75 refereed publications in top journals
- Well over 150 granted U.S. patents
- Variety of invited external talks: symposia, universities, key customers
- Media; interviews for print and video, one commercial that ran worldwide from 2008-2009
- Co-leader *Frontiers in Polymer Science and Engineering: Report of a 2016 National Science Foundation (NSF) Workshop run by Professor Frank Bates, University of Minnesota*; responsible for section on academic, industry, government partnerships

Awards

- Many internal EMC awards including Outstanding Exxon Scientist Award, 1985
- External innovation awards
 - ICIS 2008 Best Product Innovation Award
 - George Mason University College of Science Distinguished Alumni Award

Current Interests

- New scalable routes to nanocomposites
- Catalytic hydroalkylation (HAA) of vinyl moieties in olefinic polymers
 - Scaling of same; markets, applications
- Polyolefin design for new polyolefin films
- Heterophasic granule morphology; potential utility of same
- Comb block polyolefins
 - Synthesis, self-assembly, morphology

- Utility in blends; compatibilizers
- Melt flow properties
- New coatings; covalently attached brushes
- New elastomeric polyolefins
- Engine oil additives
- Functional polyolefins for design of new materials
- Novel impact copolymer designs, TPO's, TPV's; polypropylene -based blends

Some Recent Publications

López-Barrón, C. R.; Brant, P.; Eberle, A. P. R.; Crowther, D. C. Linear rheology and structure of molecular bottlebrushes with short side chains *J. Rheology* **2015**, *59*, 865-883

Lopez-Barron, C.R.; Brant, P.; Shivokhin, M.; Lu, J.; Kang, S.; Throckmorton, J.A.; Mouton, T.; Pham, T.; Savage, R.C. Strain hardening enhancement in long-chain hyperbranched comb-block copolymers via side chains anchoring, *Macromolecules* **2018**, *51*, 5720-5731

Yakovlev, S.; Fiscus, D.; Brant, P.; Butler, J.H.; Bucknall, D.G.; Downing, K. H. Mechanism of Stress Induced Crystallization of Polyethylene, *Polymer* **2019**, *175*, 25-31

Brant, P.; Brown, G.M.; Narvaez, A. Impact of Order of Catalytic Ethylene and Propylene Polymerization on Nanometer Scale Isotactic Polypropylene-Polyethylene Blend Morphology in Nascent Heterophasic Granules Revealed by Low Voltage Scanning Electron Microscopy and Scanning Transmission Electron Microscopy, *J. Appl. Polym. Sci.* **2021**,
<https://doi.org/10.1002/app.51938>

Brant, P.; Yakovlev, S.; Raney, M.; Brown, G.M.; Narvaez, A. Discovery of Polyolefin Granule Products That Can Be Deconstructed into Individual, Fully Separable Grains Provides New Insights into Grain Growth and Material Design, *Macromolecules* **2021**, *54*, 2187–2201

Scott, S.S.; Roşca, S.-C.; Gilmour, D.J.; Brant, P.; Schafer, L.L. Commodity Polymers to Functional Aminated Materials: Single-Step and Atom-Economic Synthesis by Hydroaminoalkylation, *ACS MacroLett.* **2021**, *10*, 1266–1272

Brant, P.; Ng, M.K.; Vadlamudi, M.; Crowther, D.J.; Ruff, C.J.; Younker, J.M.; Patrone, P.; Lee, J.E., Revisiting Fox-Flory: detailed study of glass-transition temperature for polypropylene systems, *submitted*

Selected Patents

	PAT. NO.	Title
1	<u>7,550,528</u>	<u>Functionalized olefin polymers</u>
2	<u>7,541,402</u>	<u>Blend functionalized polyolefin adhesive</u>
3	<u>7,456,021</u>	<u>Analysis method</u>
4	<u>7,439,312</u>	<u>Branched crystalline polypropylene</u>
5	<u>7,432,336</u>	<u>Catalysts for propylene copolymers</u>
6	<u>7,429,634</u>	<u>Polymer production at supercritical conditions</u>
7	<u>7,354,979</u>	<u>Polymer production at supercritical conditions</u>
8	<u>7,279,536</u>	<u>Polymer production at supercritical conditions</u>
9	<u>7,238,747</u>	<u>Plasticized polypropylene thermoplastics</u>
10	<u>7,163,993</u>	<u>Electrical devices from polymer resins prepared with ionic catalysts</u>
11	<u>6,916,882</u>	<u>Plasticized polypropylene thermoplastics</u>
12	<u>6,818,704</u>	<u>Plasticized polypropylene thermoplastics</u>
13	<u>6,750,306</u>	<u>Hyperbranched polymers by coordination polymerization</u>
14	<u>6,639,020</u>	<u>Plasticized polypropylene thermoplastics</u>
15	<u>6,590,055</u>	<u>Electrical devices from polymer resins prepared with ionic catalysts</u>

- 16 [6,562,920](#) Processes for the preparation polyolefin resins using supported ionic catalysts
- 17 [6,451,915](#) Thermoplastic elastomers having improved processing and physical property balance
- 18 [6,444,302](#) Breathable films and method for making
- 19 [6,423,420](#) Oriented coextruded films
- 20 [6,413,900](#) Metallocene stabilized alumoxane
- 21 [6,294,631](#) Hyperbranched polymers by coordination polymerization
- 22 [6,225,412](#) Plastic toughened plastics
- 23 [6,180,808](#) Metallocene stabilized alumoxane
- 24 [6,121,383](#) Thermosplastic vulcanizates from blends of a polypropylene and elastic .alpha.-olefin/cyclic olefin copolymers
- 25 [6,087,291](#) Polymerization catalyst systems
- 26 [5,958,319](#) Polyolefin films having increased gas permeability and method for making
- 27 [5,863,853](#) Polymerization catalyst systems, their production and use
- 28 [5,763,532](#) Blends of polypropylene and elastic alpha-olefin/cyclic olefin copolymers
- 29 [5,723,545](#) Blends of a semi-crystalline polymer and elastic .alpha.-olefin/cyclic olefin copolymers
- 30 [5,712,352](#) Polymerization process
- 31 [5,538,790](#) Cling film
- 32 [5,475,075](#) Ethylene/longer .alpha.-olefin copolymers
- 33 [5,444,145](#) Ethylene/branched olefin copolymers
- 34 [5,352,744](#) Method for hydrogenating polymers and products therefrom
- 35 [5,317,070](#) Syndiotactic hot melt adhesive
- 36 [5,281,653](#) Fullerene-polymer compositions

- 37 [5,225,257](#) Fluorine treatment of stretch/cling films
- 38 [5,212,001](#) Tackified ethylene-acrylate cling layers in stretch/cling films
- 39 [5,173,343](#) Narrow molecular weight distribution ethylene-acrylate cling layer in stretch/cling films
- 40 [5,154,981](#) Tackified ethylene-acrylate cling layers in stretch/cling films
- 41 [5,147,708](#) Thermoplastic films for use in stretch/cling applications
- 42 [5,114,763](#) Tackified polyethylene layers in stretch/cling films