

# Michigan Green Chemistry Governor's Award

The Michigan Green Chemistry Governor's Award Program recognizes advances that either incorporate the principles of green chemistry into chemical design, manufacture, or use, or that promote activities which support or implement those technologies.

The Awards program, which is Michigan specific, is governed by the following focus areas:



### **Greener Synthetic Pathways**

This focus area involves implementing a novel, green pathway for a new chemical product or material. It may also involve using a novel, green pathway to redesign the synthesis of an existing product.



#### **Greener Reaction Conditions**

This focus area involves improving conditions other than the overall design or redesign of a synthesis.



### **Design of Greener Chemicals and Materials**

This focus area involves designing and deploying chemical products or materials that are less hazardous than the products or technologies they replace.



# **Design and Implementation of Greener Processes**

This focus area involves designing and deploying a process where hazardous and/or toxic chemicals are reduced or eliminated such that the resulting process will be environmentally benign, economically sound, and implementable, while still ensuring product quality.



# **Education or Advocacy of Green Chemistry**

This focus area involves educating or advocating for the advancement of green chemistry in Michigan.

#### **ACADEMIC**

# Vijaykumar Mannari, PhD.

Eastern Michigan University

# Sustainable and Advanced Coatings Materials Based on Soybean Oil

There has been considerable interest and efforts in developing bio-based platform materials that can replace fast-depleting petroleum based resources for meeting the needs of advanced materials while reducing their environmental footprint. Dr. Mannari's research group at Eastern Michigan University has developed low-cost, soybean oil-based, functional derivatives - Functional Soy Building Blocks (FSBB), as platform materials for making a range of oligomers and polymers for applications in environmentally preferable, advanced coatings. The FSBBs have been derived from commercially available commodity soy-products - epoxidized soybean oil and its downstream products.

The manufacturing process is a single-step, solvent-free, low energy input process with no by-product formation. The acid catalyst used is consumed during the reaction, and it uses conventional equipment and control systems. Leveraging unique chemical structure, morphology, and reactivity of FSBBs, and using molecular design and principles of green chemistry and engineering, they have developed a range of value-added oligomers and polymers that can replace conventional petro-based components currently used in advanced coating formulations. Thus, it is believed that the overall life-cycle impact of products based on these FSBBs will be much lower than petro-based products and substantially lower than other soy-based commercial products.

Current conventional UV-cure coating formulations use acrylic functional oligomers dissolved in low molecular weight monomeric acrylates, called reactive diluents. These reactive diluents, besides presenting some technical issues, are hazardous, toxic, and a source of dermatitis and respiratory issues for the users. These problems are well recognized and there is an acute need for safer alternatives. Acrylated soy-derivatives developed by Dr. Mannari are aimed to effectively address these problems. Due to their low viscosity (due to hyper-branched design) combined with high acrylate functionality; they are capable of completely eliminating reactive diluents, thereby making UV-cure compositions significantly safer.

The above mentioned soy building blocks have been used to successfully develop advanced coating materials, including water-borne, high-solids, and UV-curable, and have demonstrated sustainability benefits. Besides environmental benefits, lower cost, and high bio-based content, the unique benefits of this technology are the use of soybean oil - a major Michigan crop - and the design of materials and processes that ensure a low barrier for commercialization that will help Michigan manufacturing industries in a faster time-to-market.



# The Dow Chemical Company

Tom Burns, R&D Director, Dow Building & Construction R&D Inken Beulich, Sr. R&D Manager
Shari Kram, Research Scientist
John Hull, Research Scientist
Dan Beaudoin, Research Scientist
Chris Lukas, Product Stewardship Manager
Ron Leng, Fellow
John Davis, Research Scientist
Mark Soderquist, Principal Research Scientist
Doug Greminger, Research Scientist
Cathy Delcambre, Sr. Research Manager

Ted Morgan, Fellow
Bill Stobby, Principle Research Scientist
Bruce King, Research Scientist
Mark Beach, Principal Research Scientist
Elle Matteucci, Associate Scientist
Chris Bloom, Global EH&S Product Leader
Dave Gorman, Research Scientist
Steve Mork, Sr. IP Attorney
Joe Kiefer, Research Scientest
Craig Rowlands, Toxicology Leader

# **Dow Polymeric Flame Retardant**

A new flame retardant (FR), designed for use in polystyrene (PS) foam insulation, has been invented in Michigan, developed in Michigan and commercialized globally. With impending regulation and phase-out of hexabromocyclododecane (HBCD), the long-term global incumbent FR for PS foam, the PS foam industry needed an alternative FR that could provide an improved Environmental, Health, and Safety (EH&S) profile while cost-effectively matching HBCD for fire safety, foam properties, and processing performance. The Dow Polymeric FR has met this challenge, leading the global PS foam industry to select it as the new FR standard for both extruded (XPS) and expanded (EPS) polystyrene foam insulation applications.

The Dow Polymeric FR was designed and developed to mimic the performance of HBCD, but with an improved EH&S profile due in large part to its polymeric nature. As a large (polymeric) molecule, it is not anticipated to pass through living cell membranes. This is an improvement when compared to HBCD, which is a small molecule. HBCD has been classified as persistent, bioaccumulative, and as a potential concern for toxicity to human health according to the United States Environmental Protection Agency. The improved EH&S performance of the Dow Polymeric FR has been supported via a testing regimen combined with predictive modeling programs and assessment methodologies (including bioavailability).

Other key performance criteria achieved by the Dow Polymeric FR include PS foam compatibility, good thermal stability under foam processing conditions, and efficient release of the FR active species under fire conditions. This innovative technology is based on a novel molecular structure made via a patented selective bromination process from a new block copolymer of polystyrene and polybutadiene with high vinyl content.

The Dow Polymeric FR, which will replace approximately 24,000 metric tons (MT) per year of HBCD, has preserved the \$5.6B PS foam insulation industry, which annually produces 3.1 million MT of foam that, as an energy-efficient building insulation material, avoids a total of 1.7 gigatons of carbon dioxide equivalent greenhouse gases over its service lifetime.

This award is a recognition that green chemistry is about continuous improvement, and that the process towards safer chemicals may be marked by steps, including consideration of designing out certain hazards. The study of flame retardant chemicals will continue, and further research and progress is necessary at many levels.

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