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FACT SHEET:
PolyFox™ Fluorochemicals

Summary

PolyFox™ is a family of novel fluorine-based polymers that are very different from conventional fluorochemicals available in the world today. The unique environmental characteristics, strong performance attributes and high tailorability of PolyFox fluorochemicals make them excellent candidates for a broad range of applications.

Perhaps the most striking feature of PolyFox fluorochemicals is that they are considered environmentally preferable because they are made only with short chain length perfluoro alcohols (C4 or less) as opposed to longer chain length perfluoro alcohols (C6 or greater). These short chain length perfluoro alcohols and the perfluoro carboxylic acids to which they may degrade in the environment have been shown by peer reviewed academic research[1] not to bioconcentrate.

It has been demonstrated in peer reviewed academic studies[2,3] that longer perfluoro chain length alcohols can degrade into Perfluorooctanoic Acid (PFOA) and higher homologue perfluoro carboxylic acids in the environment. This potential for degradation to PFOA and higher homologue perfluoro carboxylic acids has prompted environmental concerns by U.S., Canadian, European and Asian regulatory bodies. These concerns extend to the fate of products made from the longer chain perfluoro alcohols because of the tendency of the environmental degradants of these alcohols to bioconcentrate.

In sharp contrast, PolyFox fluorochemicals produced by OMNOVA Solutions are based on short carbon side chains (for example, C1 or C2). They neither contain, nor will they degrade to, PFOA or higher homologue carboxylic acids that are of concern to the USEPA and other regulatory agencies. PolyFox products have received regulatory approval in the US and other key markets and show great potential as replacements for traditional fluorinated products in many applications. At the same time, PolyFox fluorochemicals have demonstrated excellent performance characteristics previously considered to be unachievable with short chain chemistries.

Currently, PolyFox fluorochemicals are found in products such as floor polishes, overprint varnishes, wood stains, automotive clear coats, ink jet inks, electronics coatings, powder/pigment dispersions, adhesives and household cleaners. Recently, a water-borne 2-part anti-graffiti coating has been developed based on PolyFox technology that is creating strong market interest.

OMNOVA continues to broaden PolyFox development and commercialization efforts in partnership with leading companies in specific application areas. Working collaboratively, OMNOVA and its partners are evaluating PolyFox C1- and C2-based products as potential replacements in existing as well as new applications, such as repellents and stain resist treatments for the textile, carpet, paper, nonwovens and leather industries.

Chemistry

PolyFox fluorochemicals are unique hydrocarbon polyether polyols with fluorinated side chains of controlled chain length. They may be manufactured by substituting a fluorinated alcohol onto a halogenated methyl oxetane and undergoing ring opening polymerization. Both the degree of polymerization (molecular weight) and the length of fluorinated side chains can be controlled precisely.

PolyFox materials typically have reactive sites at each end of the molecule and a wide range of end group chemistries have been commercially practiced, including sulfates, alcohols, acids and acrylates.

In addition, copolymers with PEO (polyethylene oxide) and PEO-PPO (polyethylene-polypropylene oxide) have been produced to influence solubility and other properties. Current commercially available PolyFox grades contain either CF_3 (C1) or C_2F_5 (C2) perfluoro side chains. Side chains with perfluoro carbon length greater than C4 will not be considered at this time for incorporation into the PolyFox product line for environmental reasons.

Applications

OMNOVA's first commercialized PolyFox products were fluorosurfactants. These low molecular weight fluoropolymers can be used to improve flow, wetting and leveling of water-based, solvent-based or 100% solids UV-curable paints and coatings, and in cleaners, caulks, and adhesives.

In addition to providing excellent surface appearance in applications such as floor polishes, PolyFox fluorosurfactants have been found to improve durability performance such as scratch resistance, abrasion resistance, anti-blocking and cleanability in many different coating systems.

In addition to these applications, PolyFox fluorochemicals also are sold commercially as wax modifiers and deaeration aids.

OMNOVA Solutions uses PolyFox materials internally to enhance coating performance on its decorative vinyl films for dry erasability (**memerase**® flexible dry-erase wall surfaces), for scratch and gloss improvement (**radiance**™ Flat Laminates), and for abrasion and cleanability improvements (**surf(x)**® 3D Laminates).

Development projects underway at OMNOVA have shown PolyFox technology to improve moisture repellency and chemical resistance and cleanability on a wide variety of hard and soft surfaces. In these new applications, PolyFox materials are used as reactive intermediates to produce high molecular weight fluorochemical performance to provide repellency and stain resistance conventionally achieved only with longer chain fluorochemicals.

PolyFox products provide these attributes without the environmental concerns associated with longer chain fluorochemicals.

Performance

The PolyFox line of fluorochemicals exhibits significant performance benefits.

First among the benefits in the fluorosurfactant area is the non-foaming tendency of PolyFox materials. The formation and stabilization (persistence) of foam has been a long-standing problem for users of fluorosurfactants and, in fact, this characteristic has prevented the use of fluorosurfactants in some applications. PolyFox fluorosurfactants typically do not cause foam at all. Furthermore, any foam that may be formed from other ingredients in coating and cleaner formulations is not stabilized or exacerbated by the presence of PolyFox materials in those systems.

PolyFox fluorosurfactant products also deliver flow, wetting and leveling benefits at moderately higher surface tension values than conventional longer chain fluorosurfactants, which can be an advantage for applications where multiple coats are applied. Second and third coats (and repair coats) can have severe adhesion problems if the surface tension in the first coat is too low. In the case of PolyFox fluorosurfactants, high gloss, bubble-free, smooth first coats with moderately higher surface energies can result in second and third coats that are easier to apply and perform better.

Environmental Considerations

Background

In 2000, 3M Company voluntarily withdrew all of its fluorochemical products containing C8 perfluoro chemistries from the U.S. market due to environmental concerns. Since that time, regulatory bodies and fluorochemical producers of longer chain fluorochemicals have been studying the environmental impact of these chemicals and their degradation products.

On Wednesday, January 25, 2006, USEPA Administrator Stephen L. Johnson invited fluoropolymer and telomer manufacturers to participate in a global stewardship program on PFOA, precursor chemicals that can break down to PFOA, and related higher homologue chemicals. Participating companies were asked to commit to reducing PFOA from emissions and product content by 95 percent no later than 2010, and to work toward eliminating PFOA from emissions and product content no later than 2015. As of March 1, 2006, commitment letters were received from all eight invited companies. For further details on this Product Stewardship Challenge Program the USEPA has established a web site at http://www.epa.gov/oppt/pfoa/pubs/stewardship/index.html.

Test Results – PolyFox

Professor Scott Mabury at the University of Toronto, and others, have studied the environmental consequences and degradation pathways[2,3] of a wide range of fluorochemicals, as well as a variety of the transport and degradation mechanisms.

Professor Mabury's work has shown that short perfluoroalkyl chain (C1 and C2) products, such as OMNOVA Solutions' currently available PolyFox products, do not bioaccumulate or bioconcentrate[1] to any significant degree. OMNOVA's PolyFox products also have been tested by Professor Mabury's group and shown to have little or no tendency to bio-degrade in the environment. In addition, studies of biodegradation conducted by Good Laboratory Practice (GLP) certified labs show PolyFox products are extremely resistant to degradation. A wide range of related test results are available for review with interested parties.

Regulatory Approvals

Before commercializing the family of PolyFox products, the chemistry was reviewed in detail with the USEPA to identify potential concerns and establish test and acceptance criteria in light of the intense scrutiny being given to long chain perfluorinated compounds. Physical test data and the use of chemical structure based toxicological models have indicated that side chain lengths of C4 and below are not bioaccumulative. Also, these short chain lengths have not presented toxicological concerns during testing or regulatory screening.

Commercially available PolyFox products based on C1 and C2 side chain structures have been extensively tested for both acute and longer term toxicological effects and have been rigorously screened by regulatory agencies in response to concerns prompted by PFOA and related materials. To date, PolyFox products have received authorization for manufacture, sale and/or use from regulatory agencies in the United States (USEPA), Europe (UK Health & Safety Executive, Environment Agency), Japan (METI), and most recently Canada (Health Canada and Environment Canada) in June 2006.

[1] Martin et al, Bioconcentration and Tissue Distribution of Perfluorinated Acids in Rainbow Trout (Oncorhynchus mykiss). *Environ.Toxicol. Chem.*, 2003, *22*, 196

[2] Ellis et al, Degradation of Fluorotelomer Alcohols: A Likely Atmospheric Source of Perfluorinated Carboxylic Acids, *Environ. Sci. Technol.* 2004, 38, pp 3316 - 3321

[3] Dinglasan et al, Fluorotelomer Alcohol Biodegradation Yields Poly- and Perfluorinated Acids, *Environ. Sci. Technol.* 2004, 38, pp 2857 - 2864;

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