Fluoropolymers

Offer High Performance Characteristics or Niche Applications

by Cynthia Challener
JCT CoatingsTech
Contributing Writer

Fluoropolymers are attractive for a broad range of applications in the paint and coatings sector. High molecular weight fluoropolymer resins serve as the basis for extremely durable, high performance coatings used for building products and other demanding applications. Low molecular weight fluoroadditives provide mar/slip and chemical resistance to paint formulations. Fluorotelomers and small chain fluorochemicals act as surfactants, improving both application properties and performance characteristics of the coatings themselves. However, environmental concerns have been raised regarding the biopersistence of the compounds perfluorooctanoic acid (PFOA) and perfluorooctanesulfonic acid (PFOS). The industry is committed to substantial reductions of PFOA/PFOS from all sources.

THE HEAVYWEIGHTS MEAN BUSINESS

High molecular weight materials used as the binder in a paint or coating formulation account for the largest percentage of fluoropolymers sold to this market. Polyvinylidenedifluoride (PVDF) is the dominant compound, while polyfluoroethylene vinyl ether (FEVE) is the second most important fluoropolymer. The market amount in the United States is estimated by research firm Kusumgar, Nerfli and Growney (KNG) to be 3.5 million gallons of paint and coatings sector. High molecular weight fluoropolymer resins serve as the basis for extremely durable, high performance coatings used for building products and other demanding applications. Low molecular weight fluoroadditives provide mar/slip and chemical resistance to paint formulations. Fluorotelomers and small chain fluorochemicals act as surfactants, improving both application properties and performance characteristics of the coatings themselves. However, environmental concerns have been raised regarding the biopersistence of the compounds perfluorooctanoic acid (PFOA) and perfluorooctanesulfonic acid (PFOS). The industry is committed to substantial reductions of PFOA/PFOS from all sources.

The market for these materials is much smaller, though—about 1 million pounds and valued at just $35 million. Demand is actually declining for these fluorinated polymers, which are used primarily in OEM applications, according to KNG.

The greatest growth for fluoropolymer resins lies in the industrial maintenance sector, where an annual rate of increase in sales of 15% has been observed. Unfortunately, the volume is very small. Total sales are just $7-8 million. Interest in fluoropolymers is growing due to the high performance characteristics of these materials, particularly their chemical and oil resistance. For these industrial applications, the high cost of the coatings can be justified.

On a geographic basis, the largest demand for fluoropolymer coatings can be found in the United States. "The U.S. has a greater number of areas within the country that experience high UV exposure, which can be effectively addressed with these coating products," notes George Pilcher, a vice president with consulting firm The ChemQuest Group. He estimates that 80-15% of OEM metal building products with factory applied coatings are painted with fluoropolymer-based products.

In Europe, end-of-life issues have helped limit the demand, and only 4% of building products are coated with fluoropolymers. The high cost of PVDF coatings has kept demand at a much lower level in the Asia-Pacific region. "Pollution continues to be a problem in this part of the world. Buildings look old very quickly, and it is difficult to justify the additional cost of a high performance fluoropolymer-based coating," Pilcher adds. As a result, fluoropolymer coatings account for no more than 1% of all coated building products there.

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Arkesa and Solvay Solexis are the two key manufacturers of PVDF. Both companies allow only approved coating manufacturers to produce coatings based on their fluoropolymers. In fact, potential licensees of Solvay Solexis’ Hylar 5000® coatings must pass a rigorous two-year qualification process.

Qualified formulations must contain a minimum of 70% PVDF based on total resin. To form a finished paint, the PVDF is blended with a compatible acrylic and dispersed into organic solvents along with pigments. They are formulated for architectural coatings as well as factory-applied coil coating and spray applications and can be applied to a broad array of metal substrates including aluminum, aluminized steel, and galvanized steel.

These fluoropolymer coatings have been shown to last more than 35 years without signs of aging. "The PVDF resin provides long life protection against UV radiation, chemical and airborne pollution, severe weather, and environmental conditions such as salt spray or wind-borne sand," states Art Tigera, global segment manager for PVDF coatings with Solvay Solexis. He adds that large commercial buildings involve significant capital investment, and owners desire to protect that investment with the most effective coatings available.

Solvay Solexis continues to see an upward trend in demand on a global basis for architectural coating applications. Tigera estimates the global market for PVDF to be about 12,000-15,000 tonnes/year currently.

The generic description of FEVE coating polymers is that they consist of fluoro-olefin units (namely CTFE or TFE) along with vinyl ether units and pendant functional groups (e.g., hydroxyl groups). One version of FEVE is manufactured by Asahi Glass and sold under the trade name Lumiflon. It differs from PVDF in that it is soluble and can provide a higher gloss. It can also be reacted with melamines, isocyanates, and other groups to incorporate desired performance characteristics, according to Pilcher.

However, the overall lower fluorne content of FEVE systems, as well as the presence of the vinyl ether groups, make them more susceptible to UV degradation when compared with PVDF, according to Tigera.

Pilcher notes that FEVEs are most commonly used to coat aluminum composite panels, which find application in high-end architectural buildings where they provide sound-deadening properties and also make curved structures possible.

One of the biggest challenges that producers of coatings based on fluoropolymer resins face is the high cost of their products. The price of FEVE-based coatings, for example, is at least five times higher than silicone-
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Fluoroplastic coatings offer a wide variety of characteristics for paints and coatings, including reduced anti-stick behavior, and reduced coloration. Photo courtesy of DuPont.

DuPont established fluoropolymers manufacturing capability in China in 2005 to meet this expected growth in demand. The company has also constructed a Chinese facility for the production of high molecular weight fluoropolymers that may be used as fluoro- or fluoro-polymers. DuPont produces low molecular weight fluoropolymers either through direct polymerization or by degradation of high molecular weight fluoropolymers.

Solvay Solexis is also expanding their fluoropolymers manufacturing capabilities with a new facility in China to meet the growing global demand. The new plant complements their existing U.S. microwavable facility in Delaware. The company is vertically integrated in PTFE with a broad portfolio of both high and low molecular weight products and is committed to the fluoro-polymers market, according to Tigera.

New products for the paint and coatings market produced via both suspension and emulsion polymerization processes are being introduced by Solvay Solexis. These new fluoropolymers focus on texture and gloss improvements and offer a variety of properties to meet individual customer needs. Solvay’s patented microwavable process enables effective product customization, allowing us to meet the most stringent requirements of our customers, Tigera adds.

With expertise in PTFE processing, DuPont focuses on fluoropolymers based on PTFE, offering several grades with a wide range of characteristics. High molecular weight PTFE serves as the key feedstock, and fluoropolymers can be based on either suspension or emulsion polymerized PTFE. Some grades contain functionality (typically carbonyl acids) as well as different functional groups, while others do not. Emulsion-based grades are offered in both microwavable and aqueous dispersion forms. While suspension-based grades are available only in micropowder form. These grades are characterized by low and high specific surface area, which differentiates the two types and adds. Competition from lower-cost producers who are now entering the market must also be addressed. The quality of these products is not yet comparable, but is expected to only improve over time.

**Market Update**

Fluoropolymers

Fluoropolymers are highly valued for their performance properties, including high temperature resistance, high extensibility, and high heat resistance. They are used in a variety of applications, including coatings, adhesives, and sealants. DuPont established fluoropolymers manufacturing capability in China in 2005 to meet this expected growth in demand. The company has also constructed a Chinese facility for the production of high molecular weight fluoropolymers that may be used as fluoro- or fluoro-polymers. DuPont produces low molecular weight fluoropolymers either through direct polymerization or by degradation of high molecular weight fluoropolymers.

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**Fluoropolymers**

The major fluoropolymer used as an additive in paints and coatings is PTFE. In the United States, about 2 million pounds of these low molecular weight polymers are sold into the paint and coatings market per year at a value of $7.5–8 million, according to KNG. PTFE fluoropolymers provide matrix, abrasion, and chemical resistance, cleanliness, and resistance to mold/mildew and staining in architectural paints. They are also added to various coatings to modify surface frictional (COF) characteristics, provide anti-stick behavior, and impart water repellency. Some NASCAR racing vehicles may incorporate fluoropolymers containing coatings on the wheel hubs to reduce drag, for example.

Coatings containing fluoropolymers are also used to reduce shipping damage on stacked metal sheet stock—they can then serve as a processing aid during metal stamping before being stripped away. One of the largest applications for these fluoropolymers is in printing inks, where they provide excellent gloss and anti-blocking properties while allowing the use of more quickly evaporating solvents to enable increased production efficiency. According to Barry Campbell, marketing manager for the DuPont Zonyl® PTFE Florolucids business, the largest potential for growth is in ink applications, as emerging markets such as China and India upgrade their print materials to higher quality products. Sales in mature regions such as the U.S. and Western Europe remain relatively flat.

Another potential growth area is in coatings for coil stock used on appliances. The rapidly increasing mid-tier class population in emerging markets is becoming able to afford more consumer goods and also to demanding better quality products. Fluoropolymers will likely benefit from this situation. Demand for chemical-resistant architectural coatings may experience growth in these markets as well. The co-deposition of PTFE and metal (e.g., electrodos nickel) represents another growth opportunity.
Fluorocarbons offer a wide variety of characteristics for paints and coatings, including reduced anti-blocking, leveling, and reduced cracking. Photo courtesy of DuPont.

expected of high performance fluorcoatings, including dirt removability, excellent abrasive resistance, high weatherability, and good UV transparency. In addition, with appropriate control of the coating viscosity, these coatings can be applied using various methods such as spray, roll, dip, and brush. Other markets are opening up as well. Heat-reflective coatings for metal roofing is at present a nice niche application, but interest is increasing at a rapid pace and this market is expected to grow considerably. "Cool roof coatings are just another example of how green fluropolymer-based coatings are truly useful," Parker believes.

AGC Chemicals is developing functionality that can be included at ambient temperature, water-based one component and two-component coating systems, and fluropolymers that can be cured by UV light. According to Parker, some of the technologies are already available on the market or will be available in the near future. The company is also looking at several technologies that will make the use of fluropolymers more environmentally friendly as well as increase the performance characteristics of these resins. Also of note, AGC Chemicals has commented to expect overall growth in demand. "Due to an increase in interest coupled with substantial sales growth, we are anticipating some expansion of our manufacturing capabilities in the near future," says Parker.

Solvay Solexis has a technical service lab under construction in Asia and is planning to build a new plant in China that is expected to be operational in the 2011 timeframe. This investment reflects the company's expectations that the greatest growth in fluoropolymer coatings in the near term will be in Asia and the Middle East. There is a tremendous amount of infrastructure development occurring in these areas, and we hope to capitalize on that growth," Tigges says.

The key to success with fluoropolymers, according to Tigges, will be to continuously prove to potential customers the advantage of the higher cost fluoropolymer coatings over lower cost alternatives. "We need to prove that our products truly are high performance materials that provide a true benefit to our customers," he adds. Competition from lower-cost producers who are now entering the market will also be addressed. The quality of these products is not yet comparable, but is expected to only improve over time.

DuPont established fluorodifluoriding manufacturing capability in China in 2005 to meet this expanded growth in demand. The company has also constructed a Chinese facility for the production of high molecular weight fluoropolymers that may be used as fluorodifluoride feedstock. DuPont produces low molecular weight fluoropolymers either through direct polymerization or by degradation of high molecular weight fluoropolymers. Solvay Solexis is also expanding their fluoropolymer manufacturing capabilities with a new facility in China in order to meet the growing global demand. The new plant complements their existing U.S. micropowder facility in Delaware. The company is vertically integrated in PTFE with a broad portfolio of both high and low molecular weight products and is committed to the fluoropolymers market, according to Tigera. New products for the paint and coatings markets produced via both suspension and emulsion polymerization processes are being introduced by Solvay Solexis. These new fluoropolymers focus on texture and gloss improvements and offer a variety of properties to meet individual customer needs. Solvay Solexis' patented microsphere process enables effective particle customization, allowing us to meet the most stringent requirements of our customers," Tigera adds.

With expertise in PTFE products, DuPont focuses on fluoropolymers based on PTFE, offering several grades with a wide range of characteristics. High molecular weight PTFE serves as the key feedstock, and fluoropolymers can be based on either suspension or emulsion polymerized PTFE. Some grades contain functionality (typically carbonyl acid) as well as functional groups, while others do not. Emulsion-based grades are also available in both micropowder and aqueous dispersion forms while suspension-based grades are available only in micropowder form. Besides particle size, high and low specific surface area differentiates the two types and
can be used to modify such properties as formulation viscosity.

The newest product in the Zonyl PTFE fluoroad-
tives portfolio from DuPont is based on 70 nm-sized
particles and is available as both a micropowder and
aqueous dispersion. "These products represent the
smallest particle size fluoroaditives on the market,"
notes Campbell.Because of their small size, PTFE
nano-particles can find their way into interstices where
at least one observed benefit is greatly improved
flex life in coated fabrics.

"Educational programs about the variation in be-
behavior and performance of these different grades is
critically important," notes Larry Campbell. For ex-
ample, suspension polymerization-based grades are
manufactured with a well-known particle size and
particle size distribution, and neither is affected by
customer processing. Fluoroaditives prepared via
emulsion polymerization are sub-micron primary
particles with an average agglomerate size and distri-
bution that changes/reduces when processed by the
customer—the degree depending on the incorpora-
tion technique used. The effect can be significant in
a paint formulation.

Fluoroaditives with reactive end groups might be
of more interest for some applications, according to
Campbell. "These end groups could be used to create
multifunctional additives, which are receiving growing
interest in the paint and coatings market today. They
may also serve to anchor the additives in a certain way
within the coating, allowing for targeted surface prop-
erties or perhaps for preventing migration of additives
within the applied coating," he explains.

With so many alternatives, it can be difficult to en-
sure that customers are fully exploring the potential
benefts of unique additives. In addition, despite
their high price, fluoroaditives, like fluoropolymer
resins, can also be very cost-effective in many cases.

Campbell explains that formulators who elect to use
a cheaper additive may nd that it adversely affects
the performance of the overall formulation. Then, those
changes must be compensated through the use of addi-
tional additives, making the composite formulation
more complex. Due to their unique chemical make-up, fluoroaditives
do not typically interact with other ingredients, and
therefore may often be used at an equivalent or lower
cost in a less complex formulation.

Dyron, a 3M Company, manufactures and supplies
a broad range of fluoropolymer dispersions and pow-
ders used in spray, roller, curtain, and other coating
processes, including PTFE, PA, and FEP.

The company introduced a new emulsifier in 2007
for its aqueous fluoropolymer dispersions that are used
in paint and coatings. According to market develop-
ment manager Mike Haley, the new emulsifier technol-
yogy does not rely on the use of ammonium perfluoro-
oc-tane (APFO), a salt derived from perfluorooctanoic acid (PFOA) (see discussion in Fluorosurfactants
section).

"The introduction of this new technology helps our
customers stay competitive in their industry and
further strengthens our commitment to a sustainable
fluoropolymer business," he states.

**Fluorosurfactants**

Fluorosurfactants are generally produced from fluo-
rotelomers or short chain fluorinated compounds that
often include other functionality such as phosphate
groups. KNG estimates the total market for fluorosur-
factants in the U.S. to be $14–15 million and 300,000–400,300 pounds. The majority of fluoro-
surfactants are used in solvent-based coat-
ings, although the greatest value of sales
is attributed to those used in water-
base formulations.

Fluorotroelomer-based or short perfluoralkyl chain-based fluorochemicals used as surfactants in coatings provide enhanced wetting, low and leveling prop-
erties—characteristics that are important for applica-
tions particularly, according to Dr. Rick
Thomas. Polyfox technical manager at OMINOVA Solutions, the superior performance is a di-
edic consequence of the very low
surface tension afforded by these
materials.

Larger fluorotelomer compounds, or
"membranes," actually have the ability
to be integrated into the coatings. These low
molecular weight fluoropolymers can
possess a variety of functionality and
are designed to affect specifc prop-
nerties of the applied coatings, such as
cleanability and anti-
blocking," says Thomas.

Thus, the key driver for growth for these fluorosurfactants is the demand for higher performing coatings that still meet even stricter VOC regulations. Whether a water-
borne, high solids, or low-VOC solvent system, coatings
producers are looking to create products with improved
gloss, appearance, resistance to staining and
dust pickup; increased durability and abrasion resistance;
and the ability to coat difficult substrates.

"These challenges are year after year increasing per-
nance demands on typical hydrocarbon sur-
factants," notes Thomas. "In some cases we have had cus-
tomers report an increase in coating defects like orange
peel and pinholes. The low surface tension and su-
perior flow and leveling characteristics of fluorosur-
factants seem to be particularly effective at reducing these
defects."

"Removing solvent creates numerous formulation
challenges," agrees Thomas H. Samples, global busi-
ness manager for the DuPont Water Protection
Solutions business. "It is much more difficult to find a
direct substitution for additives when switching to a
waterborne formulation, and it can be a combination
of several non-fluorinated ingredients to achieve the
same level of performance. A single fluorosurfactant,
however, can often provide the same or better results."

As with other fluoroaditives and high molecular
weight fluoropolymers, even through the prices
of fluorosurfactants are higher than their
hydrocarbon-based counterparts, they can be
more cost effective overall and also
"greener" because less material can be
used.

"The challenge, of course, is to
get customers to choose a flu-
rosurfactant that mixes and test it
with a base formula rather than
replacing a hydrocarbon sur-
factant in a complicated coat-
ing that contains several differ-
ent additives," Samples
reminds. "The best way for cus-
tomers to realize the true benefit
is to take this approach." DuPont
will often take a customer formula
and redesign it with a fluorosurfac-
tant by balancing with the base compon-
ents. In most cases a more cost-effective
solution that provides the same perform-
ance can be found.

Fluorosurfactants are also highly
effective, which con-
tributes to their cost effectiveness.
Fluorotelomers are incorporated into
colours, coatings at a level of 50–200
ppm. Hydrocarbon-based additives, on the other hand,
are used at a level of 1–2%.
"As a result, much less sur-
factant is required while at the same time eliminating
the need for the use of multiple additives," stresses
Samples. "The coating is thus green from the VOC per-
spective and from the perspective of reduced resource
consumption."

While the switch to low VOCs has been a positive
trend, fluorosurfactant producers have also been con-
tending with environmental concerns associated with
the compounds perfluorooctanoic acid (PFOA) and
perfluorooctanesulfonic acid (PFOA). PFOA and PFOA have demonstrated biopersistent potential and have been
detected in a variety of media worldwide, includ-
ing various floras, fauna, and water.

The source of these compounds is still being investi-
gated, but it may include some of the traditional fluo-
rosurfactants used historically. Production of fluoro-
polymer products by them has been identified as a possi-
ble source of emissions, and manufacturers of these
products are addressing the issue.

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ence and possible consequences of materials such as
PFOA, PFOA, and their degradation products in the en-
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these issues," Thomas states. "They like the properties
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duce the desired characteristics but avoid any of the
environmental concerns associated with PFOA/PFOA.
It is important to note that fluorotelomer products are
not made with, nor do they use, PFOA in the manufac-
turing process. However, PFOA is an unintended re-
action byproduct that is present at trace levels in some
of these products.

OMINOVA Solutions, for example, has developed a family of short fluorosurfactants (C<sub>3</sub>) and low
molecular weight reactive fluoropolymers under the
Poloxone™ trademark that are not capable of produc-
ing PFOA/PFOAs or substances that can degrade to
these problematic chemicals. The company will also be introducing waterborne fluoroso-
factants that have been developed in response to the
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Customers should be able to receive EPA DIE recog-
nition for their products containing this innovation.

In addition, OMINOVA has introduced products
that can be used to modify polymers such as polyesters,
copolymers, and polyurethanes. "We consider this chem-
istry to be in the top tier of fluoropolymers and fluoro-
polymer and providing attributes of both," explains
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can be used to modify such properties as formulation viscosity.

The newest product in the Zonyl PTFE fluorooadditives portfolio is DuPont's Zonyl AF400, which is based on 70 nm-sized particles and is available as both a micropowder and aqueous dispersion. "These products represent the smallest particle size fluorooadditives on the market," notes Campbell. Because of their small size, PTFE nanoparticles can find their way into interstices where at least one observed benefit is greatly improved flex life in coated fabrics.

"Educational programs about the variation in behavior and performance of these different grades is critically important," notes Larry Campbell. For example, suspension polymerization-based grades are manufactured with a well-known particle size and particle size distribution, and neither is affected by customer processing. Fluoroadditives prepared via emulsion polymerization are sub-micron primary particles with an average agglomerate size and distribution that changes/reduces when processed by the customer—the degree depending on the incorporation technique used. The effect can be significant in a paint formulation.

Fluoroadditives with reactive end groups might be of more interest for some applications according to Campbell. "These end groups could be used to create multithermal additives, which are receiving growing interest in the paint and coatings market today. They may also serve to anchor the additives in a certain way within the coating, allowing for targeted surface properties or perhaps for preventing migration of additives within the applied coating," he explains.

With so many alternatives, it can be difficult to ensure that customers are fully exploring the potential benefits of different additives. In addition, despite their high price, fluoroadditives, like fluopolymer resins, can also be very cost effective in many cases.

Campbell explains that formulators who elect to use a cheaper additive may find that it adversely affects the performance of the overall formulation. Then, those changes must be compensated through the use of additional additives, making the formulation more complex.

Due to their unique chemical makeup, fluorooadditives do not typically interact with other ingredients, and therefore may often be used at an equivalent or lower cost in a less complex formulation.

Dyenoyr, a 3M Company, manufactures and supplies a broad range of fluoropolymer dispersions and powders used in spray, roller, curtain, and other coating processes, including PTFE, FEP, and PFA.

The company introduced a new emulsifier in 2007 for its aqueous fluopolymer dispersions that are used in paint and coatings. According to market development manager Mike Haley, the new emulsifier technology does not rely on the use of ammonium perfluorooctanoate (APFO), a salt derived from perfluoroctanoic acid (PFOS) (see discussion in Fluoro surfactants section)."The introduction of this new technology helps our customers stay competitive in their field and further strengthens our commitment to a sustainable fluoropolymer business," he states.

Fluoro surfactants

Fluoro surfactants are generally produced from fluorotelomer or short chain fluorinated compounds that often include other functionality such as phosphate groups. KMG estimates the total market for fluorosurfactants in the U.S. to be $14–15 million and 300,000–400,300 pounds. The majority of fluorosurfactants are used in solvent-based coatings, although the greatest value of sales is attributed to those used in water-borne formulations.

Fluorotelomer-based and short perfluoroalkyl based-fluorochemicals used as surfactants in coatings provide enhanced wetting, flow, and leveling properties—characteristics that are important for application according to Dr. Reid Thomas, Polyflex technical manager at OMMO Solutions, the superior performance is a direct consequence of the very low surface tension afforded by these materials.

Larger fluorotelomer compounds, or "surfactants," actually have the ability to be integrated into the coatings. "These low molecular weight fluoropolymers can possess a variety of functionality and are designed to affect specific properties of the applied coatings, such as cleanness and anti-blocking," says Thomas.

The key driver for growth in these surfactants is the demand for higher performing coatings that still meet ever stricter VOC regulations. Whether a waterborne, high solids, or low-VOC solvent system, coatings producers are looking to create products with improved gloss, appearance, resistance to staining and dirt pickup; increased durability and abrasion resistance; and the ability to coat difficult substrates.

These challenges are faced by ever-increasing performance demands on typical hydrocarbon surfactants," notes Thomas. "In some cases we have had customers report an increase in coating defects like orange peel and pinholles. The low surface tension and superior flow and leveling characteristics of fluorosurfactants seem to be particularly effective at reducing these defects."

"Removing solvent creates numerous formulation challenges," agrees Thomas H. Samples, global business manager for the DuPont Water Protection Solutions business. "It is much more difficult to find a direct substitution for additives when switching to a waterborne formulation, and it can take a combination of several non-fluorinated ingredients to achieve the same level of performance. A single fluorosurfactant, however, can often provide the same or better results."

As with other fluorooadditives and high molecular weight fluoropolymers, even though the prices of fluorosurfactants are higher than their hydrocarbon-based counterparts, they can be more cost effective overall and also "greener" because less material can be used.

"The challenge, of course, is to get customers to choose a fluorosurfactant first and test it with a base formula rather than replacing a hydrocarbon surfactant in a complicated coating that contains several different additives," Samples remarks. "The best way for customers to realize the true benefits is to take this approach." DuPont will often take a customer formula and redesign it with a fluorosurfactant by matching with the base components. In most cases a more cost-effective solution that provides the same performance can be found.

Fluoro surfactants are also highly efficient, which contributes to their cost effectiveness.

Fluorotelomers are incorporated into paints and coatings at a level of 20–200 ppm. Hydrocarbon-based additives, on the other hand, are used at a level of 1–2%. As a result, much less surfactant is required while at the same time eliminating the need for the use of multiple additives," stresses Samples. "The coating is thus green from the VOC perspective and from the perspective of reduced resource consumption."

While the switch to low VOCs has been a positive trend, fluorosurfactant producers have also been confronted with environmental concerns associated with the compounds perfluorooctanoic acid (PFOA) and perfluorooctane sulfonic acid (PFOS). PFOA and PFOS have demonstrated biopersistent potential and have been detected in a variety of media worldwide, including various flora, fauna, and water.

The source of these compounds is still being investigated, but it may include some of the traditional fluoroo surfactants used historically. Production of fluoroo surfactants has by now been identified as a potential source of emissions, and manufacturers of these products are addressing the issue.

"The world community is now sensitized to the presence and possible consequences of materials such as PFOA, PFOS, and their degradation products in the environment. As a result of this recent publicity, coatings users and formulators are now very aware of many of these issues," Thomas states. "They like the properties afforded to coatings by fluoroo surfactants but do not want to have any adverse environmental impact associated with their use."

In January 2006, the U.S. EPA announced its 2010/15 PFOA Stewardship Program. All eight invited companies, including DuPont, 3M, AG Chemicals, Daikin, and Solvay Solexis, have committed to reduce by 95% all sources of PFOS both from facility emissions and their products by 2010 and to eliminating all sources of PFOA from emissions and products by no later than 2015.

Most producers of fluoroo surfactants, including those not directly involved in this program, have responded to this situation by developing new products that provide the desired characteristics but avoid any of the environmental impacts associated with PFOA/PFOs.

It is important to note that fluoroo surfactants are not made with, nor do they use, PFOA in the manufacturing process. However, PFOA is an unintended reagent in the products that are present at trace levels in some of these products.

OMMO Solutions, for example, has developed a family of short chain fluoroo surfactants (<C17) and low molecular weight reactive fluoropolymers under the PolyFlex trade name that are not capable of producing PFOA/PFOs or substances that can degrade to these problematic chemicals. The company will also be introducing fluoroo surfactants that have been developed in response to the EPA's Design for the Environment (DIE) program. Customers should be able to receive EPA DIE recognition for their products containing this innovation.

In addition, OMMO has introduced products that can be used to modify polymers such as polyesters, acrylates, and polyurethanes. "We consider this chemistry to be a step forward in the development of fluoroo surfactant and fluoro polymer and providing attributes of both," explains Thomas.
DuPont's Capstone® repellents and surfactants are designed to deliver maximum performance with a minimal environmental footprint.

For the electronics industry, which Thomas believes will be a key source of growth in the future, OMNOMA has launched a line of electronic grade fluorosurfactants/fluorochemicals for use specifically in semiconductor coatings manufacturing. The company also continues to invest in production capabilities in order to meet the growing demand for its full range of products.

DuPont has also had an active program to address the PFAS issue. The transition has been a two-step process, which began with the introduction in 2006 of the L1 Platform products, which were made via a manufacturing process that removed greater than 97% of trace levels of PFOS, its homologues, and direct precursors from fluorotelomer products. That program was completed in 2007, when at the end of the year the company began introducing its new Capstone™ short chain fluorotelomers that cannot break down in the environment to PFOS.

Capstone F510 and F511 are the newest products in the line and were launched at the end of March 2008. DuPont plans to have several new products for paint and coatings applications on the market by the end of the year, and will be expanding the entire Capstone portfolio over the next 18 months. To that end, the company has recently tripled the capacity for its Capstone products.

"This significant investment demonstrates our commitment to the market and makes clear our intention to be able to provide for the long term and to be able to meet the needs of our customers in the future," Samples states. In particular, DuPont is expecting to see increased demand for fluorotelomers and small-molecule-based surfactants—whether high molecular weight resins, low molecular weight additives, or short chain surfactants—which will present the use of these interesting compounds from commanding a large share of the overall paint and coatings market. However, their unique properties will continue to make them attractive in formulations designed for high performance applications.

The growing interest in "greener" coatings and the regulatory drive toward lower VOC products may create additional opportunities for growth, as will the increasing demand for higher quality products in emerging economies. Manufacturers of fluoropolymers are also addressing concerns about PFOS/PFOA and creating further growth potential through the development of more environmentally friendly products. In the process they may also uncover new technologies that enable wider application of fluoropolymers in paint and coatings.

FACING THE FUTURE

Undoubtedly, the high cost of fluropolymers—whether high molecular weight resins, low molecular weight additives, or short chain surfactants—will prevent the use of these interesting compounds from commanding a large share of the overall paint and coatings market. However, their unique properties will continue to make them attractive in formulations designed for high performance applications.

The growing interest in "greener" coatings and the regulatory drive toward lower VOC products may create additional opportunities for growth, as will the increasing demand for higher quality products in emerging economies. Manufacturers of fluoropolymers are also addressing concerns about PFOS/PFOA and creating further growth potential through the development of more environmentally friendly products. In the process they may also uncover new technologies that enable wider application of fluoropolymers in paint and coatings.