DuPont Surface Protection Solutions

DUPONT™ CAPSTONE® REPELLENTS AND SURFACTANTS

PRODUCT STEWARDSHIP DETAIL

DUPONT®

The miracles of science™

www.capstone.dupont.com

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1. DuPont — A Global Leader in Sustainability

At DuPont, sustainability is not just about reducing our impact on the environment. It is also about protecting people and the environment. The need for truly sustainable options for 21st century life remains one of the most critical challenges facing the global community. DuPont has a history of taking actions that address important societal challenges and market needs.

The DuPont vision is to be the world's most dynamic science company creating sustainable solutions essential to a better, safer, healthier life for people everywhere. For over 20 years, DuPont has been reducing the environmental footprint of its own operations. Today, footprint reduction is expected of all companies. The challenge—and the opportunity—is to create products and services that provide the performance required, are cost effective and reduce the environmental impact along the entire value chain.

As an ingredient supplier, DuPont has an impact on virtually every major industry in the world — from agriculture to construction, transportation and communications. That impact is why DuPont is building sustainability into products, how they perform for our customers and final consumers, as well as how the Company makes them. The DuPont 2015 Sustainability Goals span footprint reduction, R&D investment and revenue growth commitments. These goals are aligned with customers and the markets that these customers serve.

DuPont strives to put science to work to help customers, and their customers grow businesses while contributing to social and environmental progress worldwide.

For DuPont, sustainable growth is the creation of shareholder and societal value while we reduce the environmental *footprint* along the value chains in which we operate. DuPont defines *"footprint"* as all injuries, illnesses, incidents, waste, emissions, use of water and depletable forms of raw materials and energy.

Today, a comprehensive sustainable growth approach is integrated in to the DuPont business model. DuPont is listed on the Dow Jones Sustainability North America Index, is on the 2010 list of 100 Best Corporate Citizens, is on the Leadership Index of the Carbon Disclosure Project and was a founding member of the World Business Council for Sustainable Development (WBCSD) and the U.S. Climate Action Partnership (USCAP).

www.sustainability.dupont.com

2. DuPont Product Stewardship

DuPont has corporate product stewardship operating standards to guide new product research, as well as evaluation of products before their commercial use.

For new products or for a product to be used in a new application, the product life-cycle is evaluated, including industrial and consumer use, and disposal.

Worker and consumer exposure and environmental emissions undergo evaluations and comparisons to hazard data from toxicology studies.

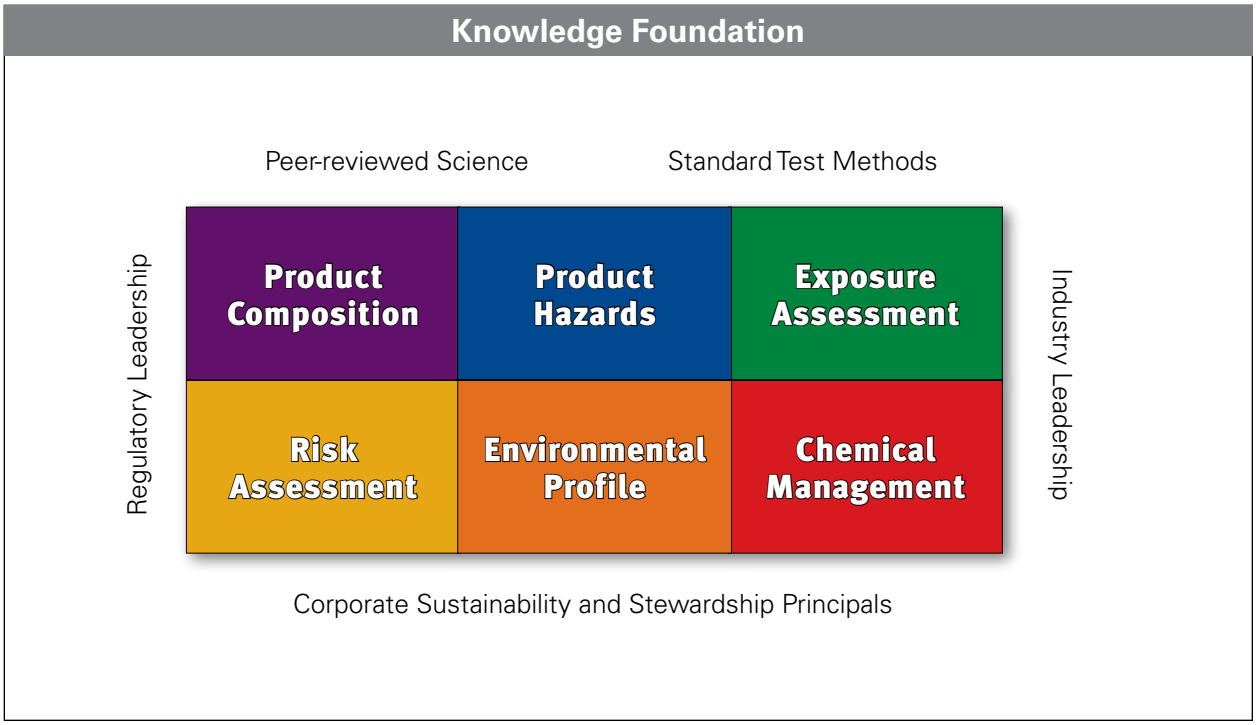
Product stewardship reviews foster a comprehensive analysis of the use, exposure and hazards of a product. The hazards, appropriate use and disposal information for a product are documented in the product M/SDS.

3. DuPont™ Capstone® Repellents and Surfactants – Knowledge Foundation

DuPont has developed a new line of surface protection products based on sustainable short-chain technology (six or less fluorinated carbons) that deliver superior performance, supported by extensive environmental, health and safety testing. DuPont™ Capstone® repellent and surfactant products are based on short-chains that cannot break down into PFOA or PFOS in the environment and they are manufactured using patented technology to minimize the presence of residual unreacted raw materials and by-products.

DuPont has developed and continues to develop comprehensive knowledge about DuPont™ Capstone® repellent and surfactant products. Extensive studies show that DuPont™ Capstone® repellent and surfactant products, raw materials such as short-chain alcohol, and potential degradation products including perfluorohexanoic acid (PFHxA) have a favorable environmental, health and safety profile, rapid bioelimination, and are not bioaccumulative. This knowledge foundation is comprised of six knowledge areas framed by principles, leadership and science (Buck, 2009). The knowledge foundation is a comprehensive body of environmental, health and safety data that show DuPont™ Capstone® repellent and surfactant products are safe for workers, consumers and the environment when used as intended.

Figure 3.1 DuPont™ Capstone® Repellents and Surfactants Knowledge Foundation



DuPont™ Capstone® Repellents and Surfactants Knowledge Foundation Summary

Product Composition

DuPont™ Capstone® repellent and surfactant products are based on sustainable short-chain technology*, made with raw materials comprised of six fluorinated carbon functionality or shorter.

Residual raw materials and by-products have been minimized using patented technology.

DuPont manufacturing facilities are ISO 9001-2008 and ISO14001 certified.

Product Hazards

A comprehensive toxicology database on products, raw material(s) and degradation product(s) provides a *knowledge foundation* to show that DuPont™ Capstone® repellent and surfactant products are safe for workers, consumers and the environment.

DuPont™ Capstone® repellent and surfactant products, raw material alcohol and perfluorohexanoate degradation product have rapid bioelimination/clearance.

For specific product hazard information, see the product M/SDS.

Exposure Assessment / Risk Assessment

DuPont™ Capstone® repellent and surfactant products are safe for workers, consumers and the environment when used as intended.

A comprehensive evaluation of the toxicology and potential exposure for products, raw materials, and degradation products provides a *knowledge foundation* for exposure assessment and risk characterization.

Environmental Profile

Studies to date show that DuPont™ Capstone® surfactant and repellent products have favorable* environmental characteristics and are safe for the environment when used as intended.

Degradation products are not expected to be harmful to human health or the environment at relevant environmental concentrations, are rapidly eliminated/cleared and are not bioaccumlative.

Chemical Management

DuPont™ Capstone® repellent and surfactant products are listed on global regulatory inventories.

We will work with customers regarding study data to qualify for specific labeling criteria and to assure proper handling, use and disposal.

Safe storage, handling, use and disposal of DuPont™ Capstone® repellent and surfactant products guidance is given in technical bulletins and product safety data sheets.

** Short-chain molecules that can not break down to PFOA in the environment. DuPont™ Capstone® repellent and surfactant products meet the goals of the U.S. EPA 2010/15 PFOA Stewardship Program.*

4. DuPont™ Capstone® Repellent and Surfactant Products

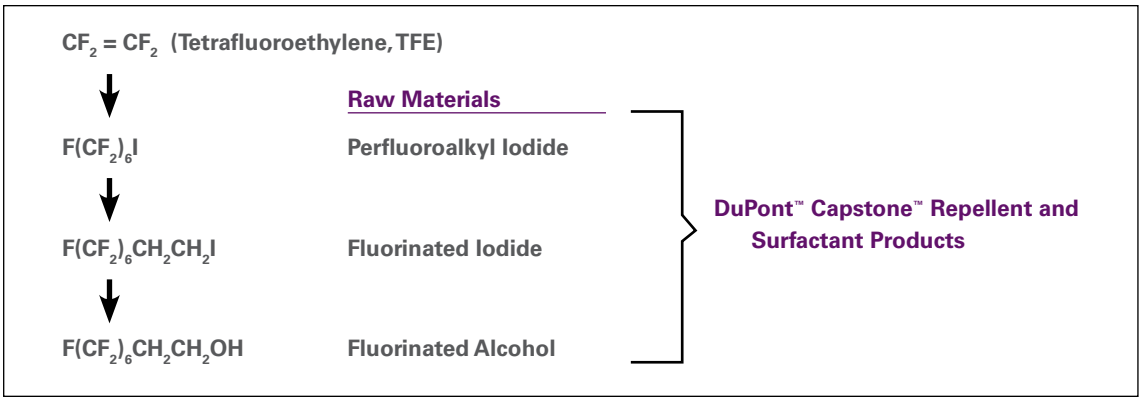
- Designed with chemical architecture that provides maximum fluorine efficiency.
- Excellent performance and favorable* environmental, safety and health properties.
- Stand upon a comprehensive environmental, health and safety *knowledge foundation*.

4.1 Product Composition

Product Composition

- DuPont™ Capstone® repellent and surfactant products are based on sustainable short-chain technology.*
- All are made with short-chain raw materials comprised of six fluorinated carbon functionality, $F(CF_2)_nCH_2CH_2^-$, where n = 6 or shorter.
- Residual raw materials and by-products have been minimized using patented technology.
- DuPont™ Capstone® manufacturing facilities are ISO 9001-2008 and ISO14001-2004 certified.

Figure 4.1.1 Products are based on short-chain chemistry



Product composition is an important consideration. The identity and quantity of residual raw materials and by-product impurities need to be understood.

DuPont uses proprietary LX Platform products technology to minimize the levels of residual raw materials and impurities present to ensure that the environmental footprint of DuPont™ Capstone® repellent and surfactant products is favorable.* The LX Platform products technology removes trace levels (parts-per-million, ppm) of the by-product impurity perfluorohexanoic acid (PFHxA) that may be formed during manufacturing.

The level of PFHxA in products is expected to be below the limit of detection (LOD) or less than 0.5 parts-per-million (ppm) as determined by a published, peer-reviewed and validated method (Larsen, 2006).

** Short-chain molecules that can not break down to PFOA in the environment.*
DuPont™ Capstone® repellent and surfactant products meet the goals of the U.S. EPA 2010/15 PFOA Stewardship Program.

5. Product Safety — We have data about our products

Product Hazards

- A comprehensive toxicology database on products, raw material(s) and degradation product(s) provides a *knowledge foundation* to show that DuPont™ Capstone® repellent and surfactant products are safe for workers, consumers and the environment.
- The database includes acute and repeated-dose studies.
- DuPont™ Capstone® repellent and surfactant products, raw material alcohol and perfluorohexanoate degradation product have rapid bioelimination/clearance.
- For specific product hazard information, see the product M/SDS.

5.1 Toxicology Studies and Hazard Assessment — An Introduction

Toxicology studies are used to identify the potential hazards of a substance by a specific exposure route (e.g., oral, dermal or inhalation). The studies are designed to find a dose (e.g., milligrams per kilogram of body weight per day, mg/kg/day) or concentration (e.g., mg/liter/day inhaled) at which toxic effects are observed and a dose at which no adverse effects are observed. Hazard assessment is the evaluation and ranking of potential hazards by their estimated frequency and intensity, and determination of an acceptable margin of safety. This is a margin that provides adequate distance between the dose at which toxic effects are observed and the expected potential exposure range.

The dose at which effects are observed in a toxicology study may be significantly greater than the amount to which any person or creature may ever be exposed. All substances are toxic at some dose level. It is essential that the hazards (or toxicity) of a substance *always* be compared to exposure in order to assess potential risk (Paustenbach, 2002). Simply put, it is not sufficient to say that a substance is "toxic". One must also determine at what dose effects are observed and by what exposure route the "toxic" effects are observed. Further, a comparison to expected potential exposure must made be in order to adequately characterize the safety of a product for its intended use.

5.2 Comprehensive Toxicology Knowledge

A comprehensive toxicology database on products, raw material(s) and degradation product(s) provides a *knowledge foundation* to show that DuPont™ Capstone® repellent and surfactant products are safe for workers, consumers and the environment. The database includes acute and repeated-dose studies **(Figure 5.2.1)**. The results of these studies are used to define safe use and disposal practices for foreseeable worker, consumer and environmental exposures.

For each DuPont™ Capstone® repellent or surfactant product, the chemical structure, properties and intended use(s) are evaluated to determine what hazard data are needed. In general, acute and genetic toxicity studies are conducted on most products or a representative equivalent. Repeated dose mammalian studies are conducted on at least one representative member of a group of common polymeric or surfactant substances. Likewise, repeated dose aquatic studies are conducted on a surfactant representative of a group. Regulatory bodies such as the U.S. Environmental Protection Agency, (EPA) provide guidance on selecting representative compounds for testing.

Figure 5.2.1 Toxicology studies overview

Mammalian

Acute

- Oral, Inhalation
- Eye, Skin Irritation
- Skin Sensitization

Genetic

- In-vitro, In-vivo

Repeated Dose

- Oral, Dermal, Inhalation
- Developmental Toxicity
- Reproductive Toxicity
- Pharmacokinetics

Aquatic Toxicity

Acute

- Fish
- Daphnia (invertebrate)
- Algae

Repeated Dose

- Fish 90-Day Early-life Stage
- Bioconcentration/Bioaccumulation

5.3 DuPont™ Capstone® Repellent Product Profile

Product

The hazards section of the M/SDS for each DuPont™ Capstone® repellent or surfactant product contains a summary of the toxicology testing results for the product or a representative equivalent. An example of the toxicology study data for a DuPont™ Capstone® repellent product is shown below.

Mammalian

Acute

- Oral LD50 (rat): >11,000 mg/kg
- Eye Irritation (rabbit): mild irritant, reversible within 48 hours
- Skin Irritation (rabbit): non-irritating
- Local Lymph Node Assay (LLNA) (mouse): negative for skin sensitization

Genetic Toxicity

- Bacterial Reverse Mutation (Ames): negative
- Chromosome Aberrations in Mammalian Cells: negative
- Not genotoxic

Aquatic Toxicity

Acute

- Fish: 96 hr LC50: >100 mg/L
- Daphnia: 48 hr EC50: >4.3 mg/L
- Algae 72 hr EC50: >100 mg/L

Repeated-Dose Mammalian

- Oral 90-day sub-chronic: NOAEL† 1000 mg/kg/day
- Reproduction, One-Generation: NOAEL 1000 mg/kg/day; no effects on reproductive parameters
- Development: NOAEL 1000 mg/kg/day; no effects on developmental parameters

†NOAEL = no observed adverse effect level

Product Toxicology Summary

- Very low acute oral and dermal toxicity. Low acute aquatic toxicity.
- Very low repeated-dose toxicity.
- Not a selective developmental or reproductive toxicant.
- Not damaging to DNA, not genotoxic.
- Rapid bioelimination and not bioaccumulative.
- Not expected to be harmful to human health or the environment at environmentally relevant concentrations.

5.4 Raw Material Profile: Short-Chain Alcohol

Raw Material

Numerous toxicology studies have been completed on short-chain alcohol raw material, $F(CF_2)_6CH_2CH_2OH$, used to manufacture DuPont™ Capstone® repellent and surfactant products (Serex, 2009). A data summary is shown below. DuPont uses proprietary LX Platform products technology to minimize the levels of residual raw materials and impurities present in products.

Mammalian

Acute

- Oral LD50 (rat): 1,750 mg/kg
- Eye Irritation (rabbit): mild irritant, reversible within 48 hours
- Skin Irritation (rabbit): non-irritating
- Dermal LD50: 5,000 mg/kg
- Local Lymph Node Assay (LLNA) (mouse): negative for skin sensitization

Genetic Toxicity

- Bacterial Reverse Mutation (Ames): negative
- Chromosome Aberrations in Mammalian Cells: negative
- Not genotoxic

Aquatic Toxicity

Acute

- Fish: 96 hr LC50: 4.84 mg/L
- Daphnia: 48 hr EC50: 7.84 mg/L
- Algae: 72 hr EC50: 4.52 mg/L

Repeated-Dose Mammalian

- Oral 90-day sub-chronic: NOAEL† 5 mg/kg/day
- Reproduction, One-generation: NOAEL 25 mg/kg/day
- Development: NOAEL 25 mg/kg/day
- Pharmacokinetics: Rapid bioelimination. Single and repeated dose studies completed.

†NOAEL = no observed adverse effect level

Raw Material Toxicology Summary

- Low acute oral and dermal toxicity. Moderate aquatic toxicity.
- Repeated-dose toxicology similar to published results for other fluorotelomer alcohols. (Serex, 2009).
- Not a selective developmental or reproductive toxicant.
- Not damaging to DNA, not genotoxic.
- Rapid bioelimination and not bioaccumulative.
- Not expected to be harmful to human health or the environment at environmentally relevant concentrations. The results of these studies support no C, M or R classification under the Globally Harmonized System (GHS) for classification and labeling or under the EC Classification, Labeling and Packaging Legislation (CLP).

5.5 Degradation Product Profile: Perfluorohexanoic Acid

Degradation Product

Toxicology study data is available for a degradation product, perfluorohexanoic acid (PFHxA) and its sodium salt (Loveless, 2009; Chengelis, 2009a). A data summary is shown below.

Mammalian

Acute

- Oral LD50 1,750 mg/kg

Genetic Toxicity

- Bacterial Reverse Mutation (Ames): negative
- Chromosome Aberrations in Mammalian Cells: negative
- Not genotoxic

Aquatic Toxicity

Acute

- Fish: 96 hr LC50: >100 mg/L
- Daphnia: 48 hr EC50: >100 mg/L
- Algae: 72 hr NOEC: 50 mg/L

Repeated-Dose Mammalian

- Oral 90-day sub-chronic: NOAEL† 20 mg/kg/day
- Reproduction, One-Generation: NOAEL 100 mg/kg/day; no effects on reproductive parameters
- Development: NOAEL 100 mg/kg/day; no effects on developmental parameters
- Pharmacokinetics: Rapid bioelimination. Single and repeated dose studies completed.

†NOAEL = no observed adverse effect level

Degradation Product Toxicology Summary

- Low acute oral toxicity. Low aquatic toxicity.
- Low repeated dose toxicity.
- Not a selective developmental or reproductive toxicant.
- Not damaging to DNA, not genotoxic.
- Rapid bioelimination and not bioaccumulative.
- Not expected to be harmful to human health or the environment at environmentally relevant concentrations.

6. Persistence, Biopersistence and Bioaccumulation

6.1 Persistence

"Persistence" generally refers to environmental persistence: the length of time a chemical stays in the environment, once introduced. Persistent substances do not break down easily in the environment. (Environment Canada, 2008).

- In general, DuPont™ Capstone® repellent and surfactant products are designed to be stable and not break down or degrade. This property makes their performance last. It is therefore important to consider the environmental profile of the product.
- As an example, the potential degradation product PFHxA is a persistent substance. It does not readily degrade via biotic or abiotic mechanisms in the environment. It is stable. However, PFHxA has rapid bioelimination/clearance, low toxicity, does not bioconcentrate and is not bioaccumulative according to global regulatory criteria.

6.2 Biopersistence, Bioelimination and Clearance

"Biopersistence" is a measure of the tendency of a chemical substance to stay in a living system for an extended period of time, as typically measured by half-life ($t_{½}$) or clearance/elimination time. Rapid bioelimination/clearance is desirable and indicates that the chemical does not persist in living systems.

Studies show that DuPont™ Capstone® repellent and surfactant products, raw material alcohol and perfluorohexanoate degradation product have rapid bioelimination/clearance.

Screening Studies

Biopersistence, a measure of how long a chemical substance remains in a living organism, was determined in male rats, a mammalian model **(Figure 6.2.1)**. PFHxA and short-chain fluorotelomer alcohol are rapidly bioeliminated. The concentration in rat blood, as area-under the curve to infinity (AUCINF), of perfluorohexanoate (PFHxA) and short-chain fluorotelomer alcohol are dramatically less than longer carbon-chain homologues (Serex 2008; **Figure 6.2.2**).

Figure 6.2.1 Biopersistence Screening Study

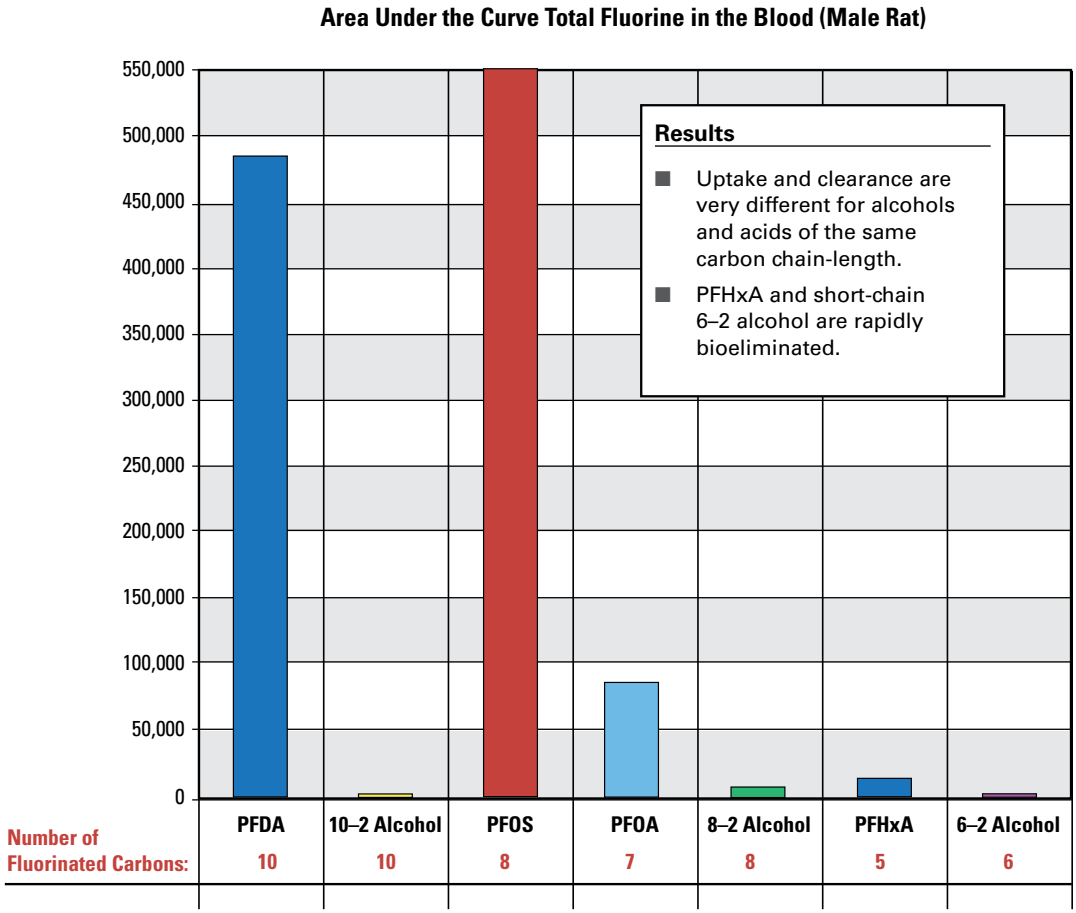
Purpose: To compare bio-uptake and bioelimination in rat blood for a series of fluorinated acids and fluorotelomer raw materials, surfactants and polymeric products.

Study: 10 consecutive days dosing via oral gavage, 84 day recovery period with analysis of total blood, liver and fat fluorine on selected days (3 during dosing, 4 during recovery).

Analysis: Using fluorine data to compare internal exposure to fluoro-organic materials on a dose normalized to micromolar (µmol) Fluorine basis.

Figure 6.2.2 Biopersistence Screening Study

Area under the curve (AUCINF/D) in blood for a homologous series of perfluorocarboxylic acids, fluorotelomer alcohols, and PFOS. (Serex 2008).



PFOS: perfluorooctane sulfonate
PFDA: perfluorodecanoic acid
PFOA: perfluorooctanoic acid
PFHxA: perfluorohexanoic acid

10–2 Alcohol: $C_{10}F_{21}CH_2CH_2OH$
8–2 Alcohol: $C_8F_{17}CH_2CH_2OH$
6–2 Alcohol: $C_6F_{13}CH_2CH_2OH$

Pharmacokinetic Studies

Pharmacokinetics refers to the movement of a substance into, through, and out of the body—the time course of its absorption, bioavailability, distribution, metabolism, and excretion.

Pharmacokinetic studies show the sodium salt of perfluorohexanoic acid (NaPFHx) is rapidly bioeliminated in male and female rats and mice, with blood concentration decreasing to below the level of detection (LOD) after 12 hours (Gannon, 2009; **Figure 6.2.3**). Another recent study showed that perfluorohexanoate was rapidly bioeliminated in both monkeys and rats, more rapidly than perfluorobutane sulfonate (PFBS) (Chengelis, 2009b; **Figure 6.2.4**).

Figure 6.2.3 Perfluorohexanoic acid, sodium salt (NaPFHx) is rapidly eliminated in rats. (Gannon, 2009)

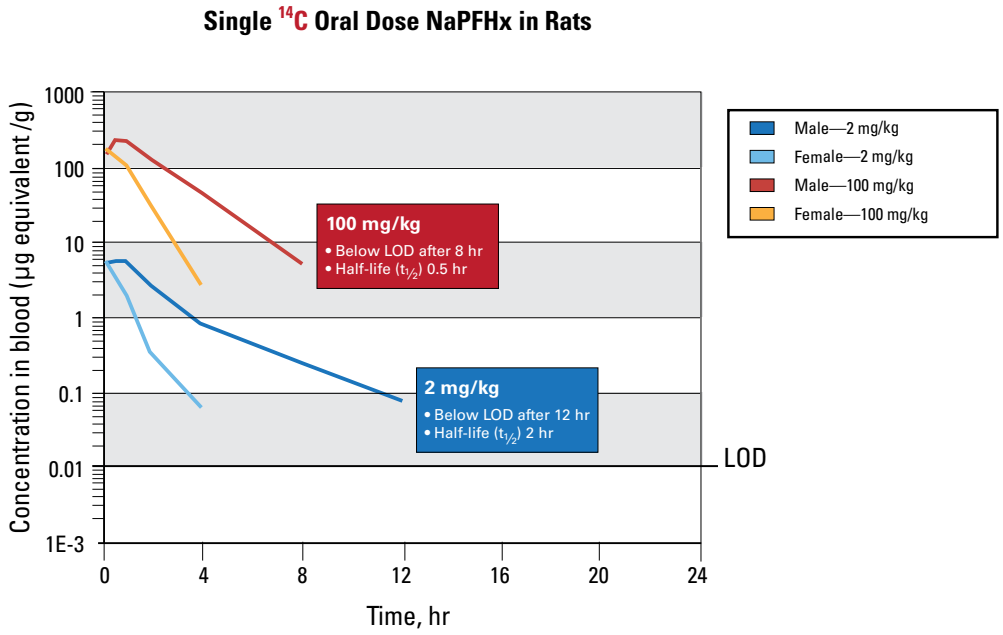
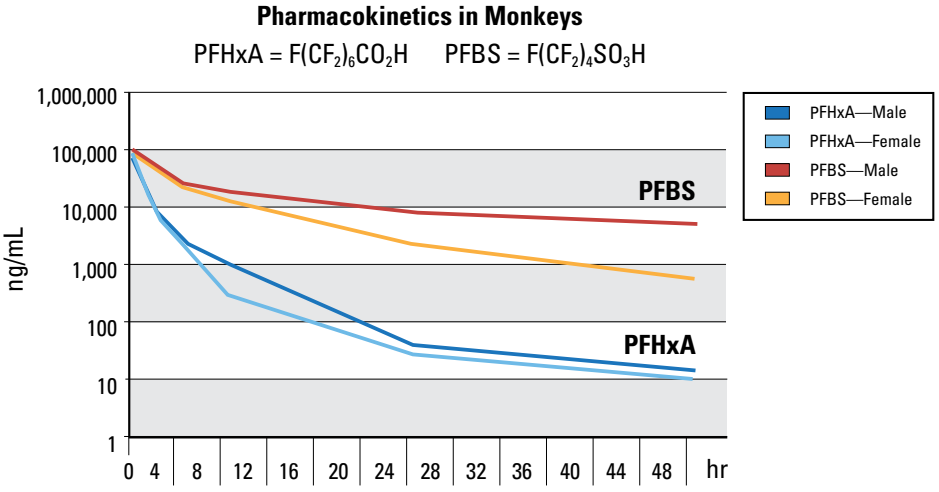


Figure 6.2.4 PFHxA and PFBS pharmacokinetics in monkeys. (Chengelis, 2009b)



6.3 Bioaccumulation

"Bioaccumulation" is the process by which, via all potential exposure routes (e.g., food, air), a chemical builds up or accumulates in a living system. Bioaccumulation is often determined in fish according to standard test protocols and the results compared to regulatory criteria (Schwarzenbach, 2003).

DuPont™ Capstone® repellent and surfactant products are not expected to bioaccumulate, based on their physical properties, the results of biopersistence (biouptake and bioelimination) screening and repeated-dose toxicology studies.

Published, peer-reviewed scientific studies (Martin, 2003a, 2003b), including a recent critical review (Conder, 2008), concluded that perfluorinated carboxylic acids (PFCAs) with less than eight total carbons, including perfluorohexanoate, are not bioaccumulative according to global regulatory criteria.

In addition, DuPont recently completed a bioconcentration/bioaccumulation study on a short-chain sulfonate, $F(CF_2)_6CH_2CH_2SO_3^-$ (6:2 FTS) a degradation product of some DuPont™ Capstone® surfactant products (DuPont, 2009). The study showed 6:2 FTS does not bioconcentrate and is not bioaccumulative.

In Summary

- DuPont™ Capstone® repellent and surfactant products, raw material such as short-chain alcohol and potential degradation products do not persist in living systems.
- Degradation products, such as PFHxA and short-chain fluorotelomer sulfonate (6:2 FTS), do not bioconcentrate and are not bioaccumulative according to global regulatory criteria.
- These results confirm that DuPont™ Capstone® repellent and surfactant products show favorable environmental, health and safety characteristics.

7. Exposure Assessment and Risk Characterization

- DuPont™ Capstone® repellent and surfactant products are safe for workers, consumers and the environment when used as intended.
- A comprehensive evaluation of the toxicology and potential exposure for products, raw material(s), and degradation product(s) provides a *knowledge foundation* for exposure assessment and risk characterization.

7.1 Hazard Assessment

Hazard assessment is the process of determining under what exposure conditions a substance can cause adverse health effects in a living system. Toxicology studies are used to identify the potential hazards of a substance by a specific exposure route (e.g., oral, dermal or inhalation). The studies are designed to find a dose (e.g., milligrams per kilogram of body weight per day, mg/kg/day) or concentration (e.g., mg/liter/day inhaled) at which toxic effects are observed and a dose at which no adverse effects are observed.

The dose or concentration at which effects are observed in a toxicology study may be vastly higher than the amount any person or creature may ever be exposed to. All substances are toxic at some dose level. It is essential that the hazards (or toxicity) of a substance *always* be compared to exposure in order to assess potential risk (Paustenbach, 2002). Simply put, it is not sufficient to say that a substance is "toxic". One must also talk about how much, (the dose at which effects are observed), and by what exposure route the "toxic" effects are observed.

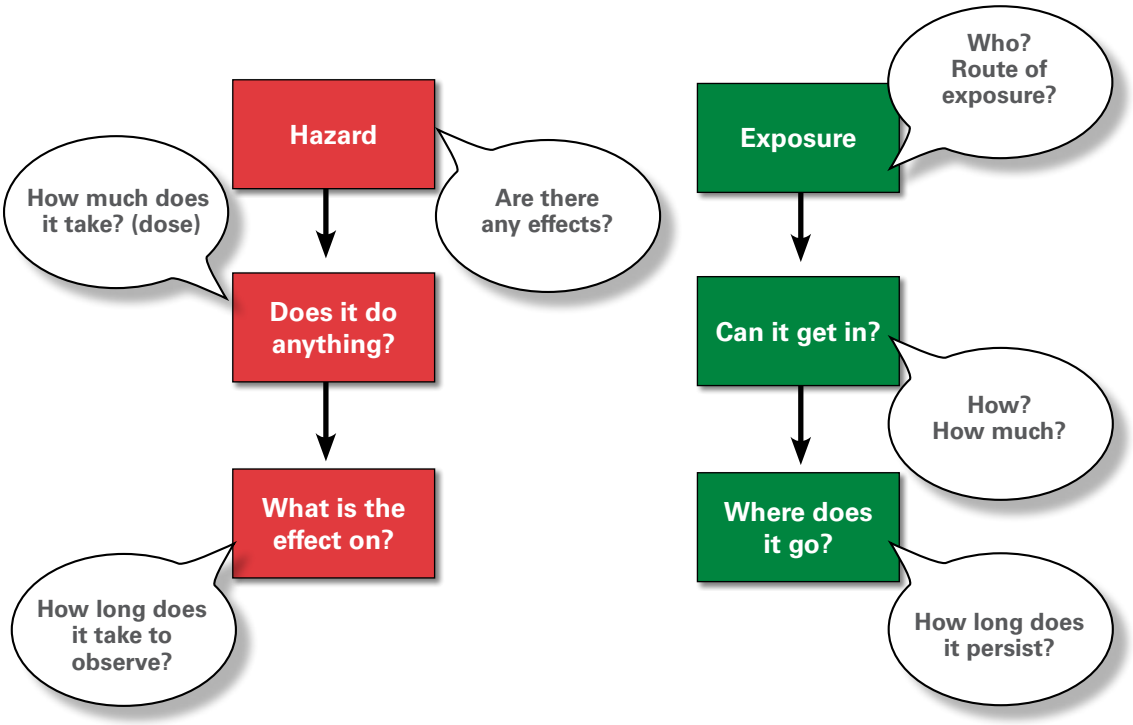
> Paracelsus wrote in 1567, "*All substances are poisons, there is none which is not a poison. The right dose differentiates a poison from a remedy.*" Paracelsus was one of the first people to recognize that a chemical can be harmless or even beneficial at low concentrations but poisonous at higher ones. It is easy to assume that a toxic chemical must also have a very high risk, but this is not necessarily true. (Trautmann, 2001)

7.2 Exposure Assessment

Exposure assessment quantifies the media (e.g., air, water), amount, and pathway (oral, dermal or inhalation) for substance intake into a living system (e.g., human, fish).

In order to put to practical use the hazard assessment from toxicology studies, an exposure assessment must be undertaken to quantify actual potential exposure in appropriate units (e.g., mg/kg/day). Both assessments begin with asking the right questions **(Figure 7.2.1)**. The assessment attempts to incorporate all potential human exposure pathways (Washburn, 2005)

Figure 7.2.1 Hazard and Exposure — Ask the right questions.

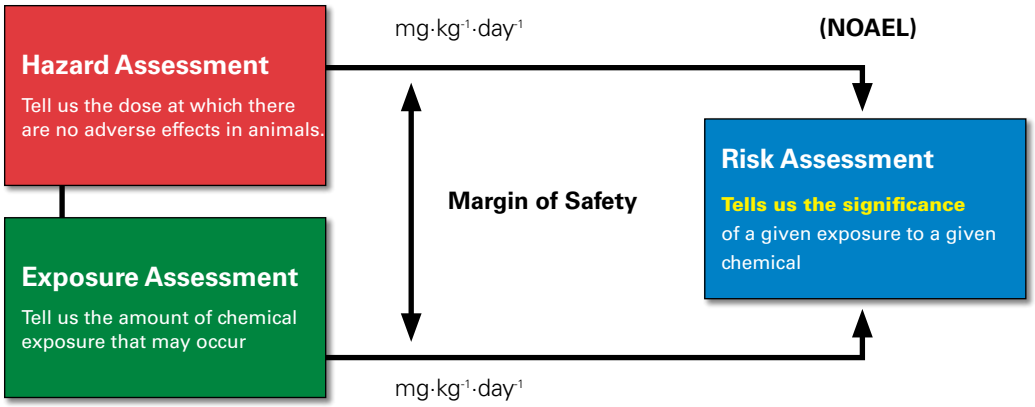


A quantitative human exposure assessment includes consideration of oral, dermal and inhalation exposure pathways -- for worker and consumer contact with a DuPont™ Capstone® repellent or surfactant product or article containing the product. Exposure may be determined by actual measurements (e.g., in workplace air, extraction of a treated textile) or by estimation using published methodologies (Paustenbach, 2002; Washburn, 2005).

7.3 Risk Assessment — DuPont™ Capstone® repellent and surfactant products are safe for their intended uses.

The exposure assessment value (mg/kg/day) is compared to the hazard assessment value (mg/kg/day), the NOAEL (no observed adverse effect level) derived from toxicology studies. Their ratio is called the "margin of safety" **(Figure 7.3.1)**. A potential exposure is generally deemed to be safe for well-studied substances like DuPont™ Capstone® repellent and surfactant products when the margin of safety is greater than one thousand (>1000).

Figure 7.3.1 Risk Assessment — Integrating Hazard and Exposure, Margin of Safety



Margins of Safety of greater than 1000 are considered of low to no concern for industrial chemicals.

The presence of trace levels (e.g., ppm, ppb or ppt) of a chemical in a consumer article by no means indicates that a consumer article is unsafe.

Models have been developed to be able to quantify potential worker and consumer exposure. The methodology has been published in a peer-reviewed scientific journal as a consumer article exposure and risk characterization (Washburn, 2005). This methodology has been used to evaluate DuPont™ Capstone® repellent and surfactant products. For example, the margin of safety for PFHxA (perfluorohexanoic acid) on a textile fabric following this methodology is greater than one million, meaning that the potential exposure is more than one million times lower than the NOAEL for PFHxA.

Please contact your local DuPont representative to discuss specific DuPont™ Capstone® repellent and surfactant products.

8. DuPont™ Capstone® Repellent and Surfactant Products Show Favorable Environmental Characteristics

Environmental Profile

- Studies to date show that DuPont™ Capstone® surfactant and repellent products have favorable environmental* characteristics and are safe for the environment when used as intended.
- Degradation products are 1) not expected to be harmful to human health or the environment at relevant environmental concentrations, 2) have rapid bioelimination and 3) are not bioaccumulative according to global regulatory criteria.

8.1 Environmental Overview

The environmental profile of DuPont™ Capstone® repellent and surfactant products is very important. DuPont scientists evaluate how each product is used and its disposition in the environment, including the active ingredient polymer or surfactant, raw material(s) and degradation product(s). Results from studies to date show that DuPont™ Capstone® repellent and surfactant products have favorable environmental characteristics.

Residual raw materials and by-products, such as PFHxA, have been minimized using patented LX Platform products technology. The removal of residual raw materials and by-products minimizes the environmental footprint of DuPont™ Capstone® repellent and surfactant products. As a result, the environmental emissions of residual raw materials and by-products are minimal.

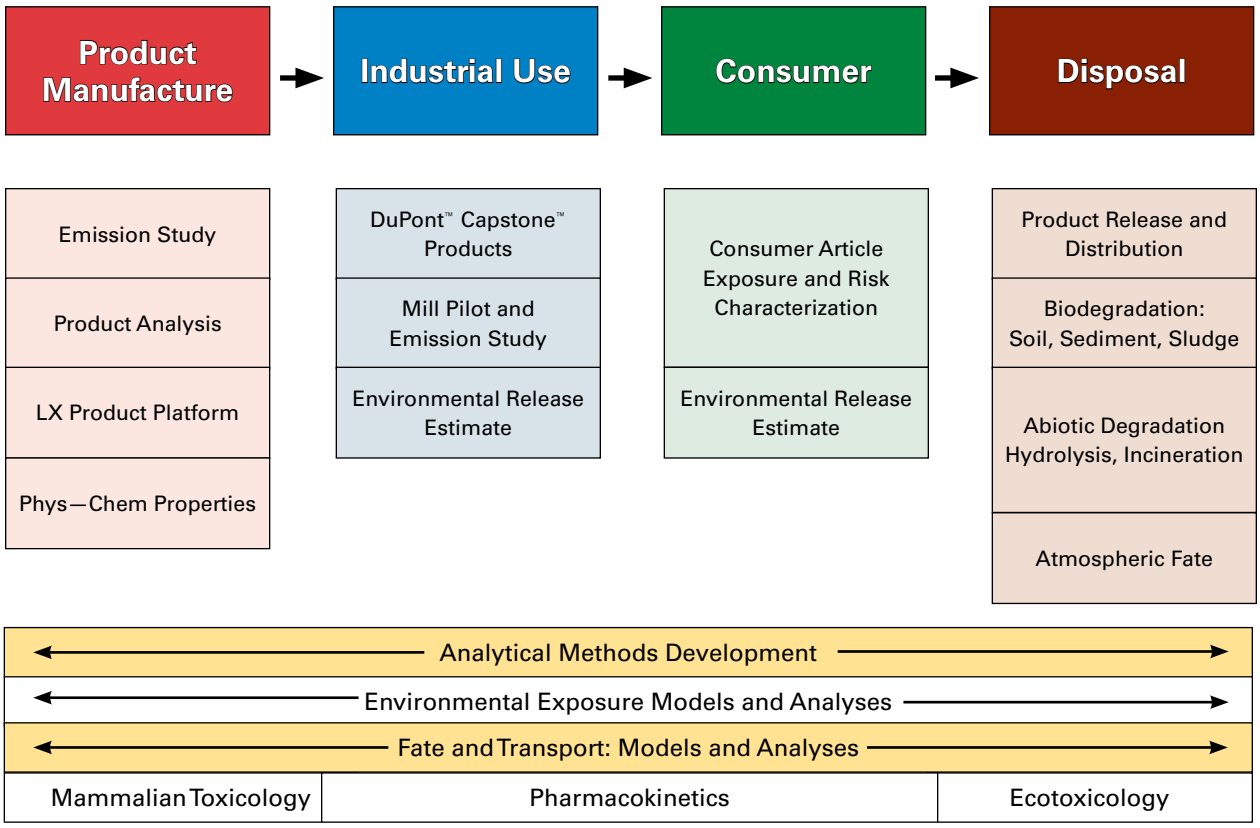
DuPont has studied the environmental profile of products, raw materials and potential degradation products. The studies include physical-chemical properties, environmental transport modeling, exposure modeling, and abiotic and biotic degradation studies. Many of the studies have been published in peer-reviewed scientific journals and presented at international scientific meetings. Also, mammalian and aquatic toxicity studies have been conducted on products, raw materials and degradation products **(see Section 5. Product Safety)**. These studies provide a *knowledge foundation* for DuPont™ Capstone® repellent and surfactant products regarding their environmental profile from industrial and consumer use and disposal.

8.2 Environmental Studies

The available scientific data to date shows that DuPont™ Capstone® repellent and surfactant products are safe for workers, people and the environment when used as intended. DuPont™ Capstone® repellent and surfactant products are expected to be stable. They may potentially degrade to form perfluorinated carboxylic acids, including PFHxA. Additional environmental studies are ongoing (e.g., long-term landfill simulation) and will be conducted on existing and new products in the future.

- A product life-cycle study of North America including emissions from the manufacture, use and disposal concluded that the life cycle was only a minor (~1%) contributor to total historic environmental emissions of perfluorocarboxylic acids (Yarwood, 2007).
- Environmental fate studies, including biodegradation studies on an acrylate polymer (Russell, 2008), urethane polymer (Russell, 2010) and alcohol raw materials (Wang, 2005a, 2005b, 2009; Liu, 2010), atmospheric fate of residual raw materials (Yarwood, 2007) and incineration of treated textiles (Yamada, 2005) have been published. In general, the studies show that products are stable and degradation results in only small amounts of perfluorinated carboxylic acids (PFCAs).
- Residual raw materials and by-products, such as PFHxA, have been minimized using patented LX Platform products technology. The types of data available are shown below **(Figure 8.2.1)**.

Figure 8.2.1 Overview of life-cycle product stewardship data



8.3 Degradation Products

DuPont™ Capstone® repellent and surfactant products are based on short-chain molecules that cannot degrade to PFOA, PFOS (perfluorooctane sulfonate) or PFHxS (perfluorohexane sulfonate) in the environment. Studies have been conducted to determine what the potential degradation products are from short-chain alcohol (Liu, 2010). Additional environmental studies are ongoing and will be conducted on existing and new products in the future. Two degradation products that may be formed at low concentrations are PFHxA and 6:2 FTS.

Perfluorohexanoic acid (PFHxA) is a degradation product that may be formed at low concentrations. PFHxA has rapid bioelimination, low toxicity, does not bioconcentrate and is not bioaccumulative according to global regulatory criteria (Conder, 2008).

6:2 Sulfonate (6:2 FTS), $F(CF_2)_6CH_2CH_2SO_3^-$, is a degradation product that may be formed at low concentrations from some DuPont™ Capstone® surfactant products. 6:2 FTS has rapid bioelimination, low toxicity, does not bioconcentrate and is not bioaccumulative according to global regulatory criteria. (DuPont 2007, DuPont, 2009).

8.4 Environmental profile comparisons

8.4.1 The Facts about Short-Chain Chemistry — C4 and C6

DuPont™ Capstone® repellents and surfactants, raw material and PFHxA, a degradation product, have Environmental, Health and Safety (EHS) characteristics that are as good as or better than comparable C4 materials.

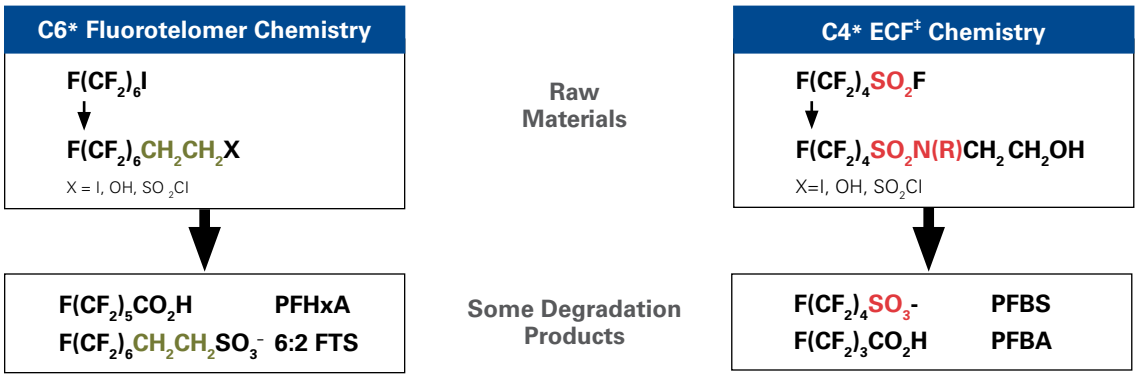
- Short-chains that do not degrade to PFOA or PFOS
- Low absorption and rapid bioelimination
- Do not bioconcentrate or bioaccumulate,
- Low mammalian and environmental toxicity

C4 or C6? It's not about the numbers. It's about having data on the product a customer purchases, the raw material used to make it and what the product may degrade to in the environment.

- For example, the scientific data shows that PFHxA, a degradation product from C6 chemistry, is eliminated faster in mammals than perfluorobutane sulfonate (PFBS), an ultimate degradation product from commercial C4 chemistry. (Chengelis, 2009b)

There are fundamental chemical, physical and biological property differences between products made from fluorotelomer chemistry and electrochemical fluorination (ECF) chemistry.

Figure 8.4.1 C6 Fluorotelomer and C4 ECF Chemistry are fundamentally different



*Number of fluorinated carbons

‡ECF = electrochemical fluorination

8.4.2 Not All "C6" are the Same

A very general, non-specific term for chemicals that contain six carbons is "C6" chemistry. When it comes to fluorinated substances, C6 chemicals are not "all the same."

The physical-chemical, bioelimination and toxicological properties of DuPont™ Capstone® repellent and surfactant products and raw materials are unique and different from other "C6" products such as perfluorohexane sulfonyl products [e.g., $C_6F_{13}SO_2N(R)$-] made by electrochemical fluorination (ECF).

- PFHxA and PFHxS both have six fluorinated carbons. The similarity ends there. These two substances are clearly very different from one another **(Table 8.4.2)**.

Table 8.4.2 Not all "C6" are the same. A Comparison: PFHxA and PFHxS

	PFHxA $F(CF_2)_5CO_2H$	**PFHxS** $F(CF_2)_6SO_3^-$
pKa (acidity)	2–3	Less than -1
Blood $t_{½}$ in Rats	0.05–0.2 days	1.5–30 days
Blood $t_{½}$ in Monkey	1 day	87–144 days
Bioaccumulation	Not Bioaccumulative	Bioaccumulative
Acute Oral LD50 (Male Rat)	2,000 mg/kg	No Data
One-Gen Repro/Developmental Toxicity NOAEL	M/F 100 mg/kg/day No effects on developmental or reproductive endpoints	M <0.3 mg/kg/day F >10 mg/kg/day No effects on developmental or reproductive endpoints at 10 mg/kg/day
Oral Repeated Dose (Male Rat) NOAEL	20 mg/kg/day 90 days	<10 mg/kg/day 28 days

- **Different physical-chemical properties:** The pKa (acidity) of PFHxA, a carboxylic acid, is three orders of magnitude (1000x) greater, therefore less acidic, than PFHxS, a sulfonic acid.

- **Different biological properties:** Perfluorohexanoic acid (PFHxA) has rapid bioelimination, low toxicity, does not bioconcentrate and is not bioaccumulative according to global regulatory criteria. PFHxA is significantly less toxic when repeatedly dosed to animals (Loveless, 2009) and has a half-life ($t_{½}$) in the blood of monkeys of less than 24-hours while the half-life for PFHxS is 100-days (Lieder, 2006).

In Summary

"C6" perfluorinated acids are not the same. Perfluorohexanoic acid (PFHxA) and perfluorohexane sulfonate (PFHxS), both "C6," are very different in physical, chemical and biological properties.

8.4.3 "C8" Sulfonates are not the same. 6:2 Fluorotelomer Sulfonate (FTS) compared to PFOS

6:2 FTS and PFOS both have eight carbons. 6:2 FTS contains two non-fluorinated carbons. This difference results in dramatic differences in physical-chemical properties and toxicity. These two substances have very different toxicity profiles **(Table 8.4.3)** and are clearly *very different* from one another.

Table 8.4.3 Comparison: 6:2 FTS and PFOS

	6:2 FTS $F(CF_2)_6CH_2CH_2SO_3^-$	**PFOS** $F(CF_2)_8SO_3^-$
pKa (acidity)	2–3	Less than -1
Acute Fish LD50	>107 mg/L	78 mg/L
Daphnia EC50	>109 mg/L	58 mg/L
Algae EC50	>96 mg/L	48.2 mg/L
90-Day Fish Early Life-Stage NOEC	2.62 mg/L	0.29 mg/L
Bioaccumulation	Not Bioaccumulative	Bioaccumulative
Acute Oral LD50 (Male Rat)	2,000 mg/kg	233 mg/kg
28-Day Rat Oral Repeated Dose NOAEL	15 mg/kg/day	1.77 mg/kg/day

In Summary

6:2 FTS is not a strong acid, has rapid bioelimination, and is not bioaccumulative. In stark contrast, PFOS is a strong acid, is biopersistent, and is bioaccumulative (European Union, 2006).

9. Chemical Management

Chemical Management

- DuPont™ Capstone® repellent and surfactant products are listed on global regulatory inventories.
- We work with customers regarding study data to qualify for specific labeling criteria, and to assure proper handling, use and disposal.
- Guidance for safe storage, handling, use and disposal of DuPont™ Capstone® repellent and surfactant products is given in technical bulletins and product safety data sheets

10. Regulatory

- DuPont™ Capstone® repellent and surfactant products are listed on existing global regulatory inventories, including the United States (TSCA) and Europe (REACH).
- The U.S. Environmental Protection Agency, Environment Canada and Health Canada, and NICNAS in Australia have reviewed and approved the manufacture, use and sale of short-chain products.
- DuPont™ Capstone® repellent and surfactant product approvals from regulatory agencies, such as the U.S. Environmental Protection Agency (EPA), U.S. Food & Drug Administration (FDA), Environment Canada and Health Canada, the German Federal Institute for Risk Assessment (BfR), and China Ministry of Health (MOH) include assessment of hazard, exposure, and risk when reviewing new chemicals before their manufacture, sale and use.
- DuPont™ Capstone® repellent and surfactant products meet the goals of the U.S. Environmental Protection Agency 2010/15 PFOA Stewardship Program.

  In January 2006, DuPont committed to participate in the U.S. Environmental Protection Agency 2010/15 PFOA Stewardship Program to significantly reduce manufacturing emissions and product content levels of PFOA, its precursors and related higher homologues by 2010, and to work toward the elimination of those sources by 2015. In February 2007, the company committed to no longer make, buy or use PFOA by 2015, or earlier if possible.

  DuPont™ Capstone® repellents and surfactants have been evaluated through submissions of Pre-Manufacturing Notifications (PMNs), have been evaluated under the EPA New Chemical Program and Consent Orders have been granted. These products are alternatives under the EPA Long-Chain Perfluorinated Chemicals (PFCs) Action Plan.
- REACH: DuPont is ensuring that all DuPont™ Capstone® repellent and surfactant products sold to our EU and EEA customers by DuPont legal entities in Europe are in compliance with REACH regulatory requirements.

  DuPont™ Capstone® repellent and surfactant products to our current knowledge do not contain substances above the legal threshold that are on the Candidate List of Substances of Very High Concern (SCHC) as published on the ECHA website on 28th October 2008. Please contact your local DuPont representative if you have questions regarding the REACH status of DuPont™ Capstone® repellent and surfactant products.
- European Directive 2006/122 provides restrictions on the marketing and use of perfluorooctane sulfonate (PFOS) (amendment of Council Directive 76/769/EEC). PFOS is not used or added in the manufacture of DuPont products. In fact, DuPont products are based upon a different chemistry than that associated with PFOS. Please note that PFOA is not regulated as part of this directive, and there is no European Directive to regulate PFOA to date.

11. Broadly sharing DuPont scientific studies — DuPont continues to share broadly its scientific research.

In addition to product M/SDS and technical documents provided to customers, DuPont scientists have presented study results at international scientific conferences (e.g., Society of Toxicology, Society of Environmental Toxicology and Chemistry, American Chemical Society, and Canadian Chemical Society), trade shows/seminars, and universities around the world, and published scientific work in peer-reviewed scientific journals.

Importantly, DuPont has provided details of the studies conducted on products to regulatory agencies worldwide. These agencies include, but are not limited to, the following: U.S. Environmental Protection Agency (U.S. EPA); Environment & Health Canada; Norway: Norwegian Pollution Control Authority (SFT), Sweden: KEMI; Germany: Umwelt Bundes Amt (German EPA), Federal Institute for Risk Assessment (BfR); UK: Department of the Environment, Food and Rural Affairs, Health & Safety Executive, The Environment Agency; China: Ministry of Health and Ministry of Environment.

11.1 Peer-reviewed science

We have published papers across a broad spectrum of topical areas to openly share the results of our studies and gain reflection on our work from the global scientific community. The papers span topics including physical-chemical properties, analytical methods, toxicology, environmental fate, human exposure and risk assessment. Many of the papers are the product of collaborations with industrial and academic scientists outside DuPont. A number of the papers are highly cited (e.g., Prevedouros, 2006). A bibliography of publications is available upon request.

11.2 Analytical Methods

Reliable, robust, validated analytical methods are fundamental to sound science. We have published numerous papers to share the analytical methods we have developed. The matrices include water, air, consumer articles (Mawn, 2005), soil (Wang, 2009), and sludge (Wang, 2005a,b) as well as methods for accurate determination of physical properties such as vapor pressure, water solubility and partition coefficients.

With the widespread presence in the environment of some fluorinated substances such as PFOS and PFOA, there is interest in making measurements in many matrices. When requesting analysis on, for instance, wastewater, or any other matrix, from a contract laboratory, it is recommended to ask the laboratory for the analytical method and method validation report. The method describes the sample preparation and analysis procedures and the validation report provides documented evidence that the laboratory has validated the method for both the test sample matrix (e.g., wastewater) and the analyte(s) (e.g., PFOS, PFBS, PFOA) within the quantitation range (e.g., ppm, ppb) desired including method blanks, calibration and spiked control samples as well as the use of well characterized analyte standards.

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