File No: LTD/1536

April 2015

NATIONAL INDUSTRIAL CHEMICALS NOTIFICATION AND ASSESSMENT SCHEME (NICNAS)

PUBLIC REPORT

Polyfluorinated Polymer ELN101570-1 in Capstone® RCP

This Assessment has been compiled in accordance with the provisions of the *Industrial Chemicals (Notification and Assessment) Act 1989* (Cwlth) (the Act) and Regulations. This legislation is an Act of the Commonwealth of Australia. The National Industrial Chemicals Notification and Assessment Scheme (NICNAS) is administered by the Department of Health, and conducts the risk assessment for public health and occupational health and safety. The assessment of environmental risk is conducted by the Department of the Environment.

For the purposes of subsection 78(1) of the Act, this Public Report may be inspected at our NICNAS office by appointment only at Level 7, 260 Elizabeth Street, Surry Hills NSW 2010.

This Public Report is also available for viewing and downloading from the NICNAS website or available on request, free of charge, by contacting NICNAS. For requests and enquiries please contact the NICNAS Administration Coordinator at:

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Director
NICNAS

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SUMMARY

The following details will be published in the NICNAS *Chemical Gazette:*

ASSESSMENT REFERENCE	APPLICANT(S)	CHEMICAL OR TRADE NAME	HAZARDOUS CHEMICAL	INTRODUCTION VOLUME	USE
LTD/1536	The Chemours Company (Australia) Pty Ltd	Polyfluorinated Polymer ELN101570-1 in Capstone® RCP	Yes	≤ 2 tonnes per annum	Component of stain resistant coatings for carpet and furnishings

CONCLUSIONS AND REGULATORY OBLIGATIONS

Hazard classification
Based on the available information, the notified polymer is recommended for hazard classification according to the *Globally Harmonised System for the Classification and Labelling of Chemicals (GHS),* as adopted for industrial chemicals in Australia. The recommended hazard classification is presented in the table below.

Hazard classification	*Hazard statement*
Acute Toxicity (Category 4)	H332 – Harmful if inhaled

Based on the available information, the notified polymer is recommended for hazard classification according to the *Approved Criteria for Classifying Hazardous Substances* (NOHSC, 2004), with the following risk phrase(s):

R20 Harmful by inhalation

The environmental hazard classification according to the *Globally Harmonised System for the Classification and Labelling of Chemicals (GHS)* is presented below. Environmental classification under the *GHS* is not mandated in Australia and carries no legal status but is presented for information purposes.

Hazard classification	*Hazard statement*
Acute Category 3	H402 - Harmful to aquatic life
Chronic Category 3	H412 - Harmful to aquatic life with long lasting effects

Human health risk assessment
Under the conditions of the occupational settings described, the notified polymer is not considered to pose an unreasonable risk to the health of workers.

When used in the proposed manner, the notified polymer is not considered to pose an unreasonable risk to public health.

However, the notified polymer is a potential precursor for perfluorohexanoic acid (PFHxA) in the environment, and PFHxA is persistent in the environment. Due to the environmental distribution of PFHxA resulting from the use pattern of the notified polymer, secondary human exposure to PFHxA via the environment may occur. The notified polymer is replacing a long chain polyfluoroalkyl polymer, the latter of which will result in secondary human exposures to perfluorooctanoic acid (PFOA) and longer chain perfluorocarboxylic acids (PFCAs). PFOA and longer chain PFCAs are more hazardous to human health and have higher bioaccumulation potential, compared to PFHxA. The overall human health risk posed by the notified polymer is less than that of the substance it replaces.

Environmental risk assessment
On the basis of the PEC/PNEC ratio and the reported use pattern, the notified polymer is not considered to directly pose a risk to the environment, although the safety margin is narrow for this assessed use pattern.

However, degradants of the notified polymer, along with associated impurities and residual monomers of the notified polymer, are potential precursors of the very persistent chemical, PFHxA. The assessed use pattern of the notified polymer does not control the release of breakdown products into the environment during use and after disposal and there are no adequate long-term environmental effects data for PFHxA. Therefore, the long-term environmental implications are unknown. Consequently, the long-term risk cannot be quantified for the notified polymer and its degradation products. In order to inform a more conclusive assessment of long-term environmental risks, further data should be generated. This may include data on longer-term environmental effects, as well as partitioning behaviour and characterisation of the degradation products, for the notified polymer and/or poly- and perfluoroalkyl degradation products (including PFHxA).

The notified polymer is a potential precursor for PFHxA in the environment. PFHxA is an environmentally persistent chemical that has potential to be globally distributed. However, the ecotoxicological profile and bioaccumulation potential of PFHxA is considered to be less problematic when compared with long chain (C8 and above) perfluorocarboxylic acids that PFHxA is expected to replace, noting that current evidence suggests PFHxA was not bioaccumulative in aquatic ecosystems. Nonetheless, the introduction and use of chemicals that degrade to release PFHxA and other very persistent poly- and perfluoroalkyl compounds should be considered a short-term measure until suitable alternatives, with less persistent chemistry, are identified.

Recommendations

REGULATORY CONTROLS
Hazard Classification and Labelling

- The notified polymer should be classified as follows:
  - Acute toxicity (Category 4): H331 – Harmful if inhaled*

  *Classification of products/mixtures containing the notified polymer should be considered based on the concentration of the notified polymer present.

- Aerosol or spray products containing the notified polymer should carry the following safety directions on the label:
  - Avoid breathing of vapours, mists and sprays
  - May be harmful if inhaled
  - Use in well-ventilated areas, where possible
  - In case of insufficient ventilation, wear suitable respiratory equipment

(Material) Safety Data Sheet

- The (M)SDS for products containing the notified polymer should include the following:
  - Avoid breathing of vapours, mists and sprays
  - May be harmful if inhaled
  - Use in well-ventilated areas, where possible
  - In case of insufficient ventilation, wear suitable respiratory equipment

CONTROL MEASURES
Occupational Health and Safety

- A person conducting a business or undertaking at a workplace should implement the following engineering controls to minimise occupational exposure to the notified polymer:
  - Enclosed, automated processes, where possible
  - Airless spray or low pressure spray equipment should be utilised during spray operations, where possible

- A person conducting a business or undertaking at a workplace should implement the following safe work practices to minimise occupational exposure during handling of the notified polymer as introduced or in formulated products:
  - Avoid breathing of vapours, mists and sprays
  - Avoid prolonged spraying
  - Maintain good hygiene practices

- A person conducting a business or undertaking at a workplace should ensure that the following personal protective equipment is used by workers to minimise occupational exposure to the notified polymer as introduced or in formulated products:
  - Respiratory protection when conducting spray operations in areas with insufficient ventilation
  - Gloves
  - Coveralls

  Guidance in selection of personal protective equipment can be obtained from Australian, Australian/New Zealand or other approved standards.

- A copy of the (M)SDS should be easily accessible to employees.

- If products and mixtures containing the notified polymer are classified as hazardous to health in accordance with the *Globally Harmonised System for the Classification and Labelling of Chemicals (GHS)* as adopted for industrial chemicals in Australia, workplace practices and control procedures consistent with provisions of State and Territory hazardous substances legislation should be in operation.

Environment

- The notified polymer should only be introduced as part of a strategy to phase out the use of long chain perfluoroalkyl chemicals.

  - The notifier should seek ways to minimise the level of residual polyfluoroalkyl monomers and impurities in the notified polymer. Such levels should be as low as practicable: where possible, the total weight of these constituents should not exceed the levels attainable utilising international best practice.

- The following control measures should be implemented by users of the notified polymer, or products containing the notified polymer, to minimise exposure of the notified polymer to the environment:
  - Best practice on-site treatment of waste streams should be employed to maximise removal of the notified polymer from wastewaters.

Disposal

- If the notified polymer or products containing the notified polymer cannot feasibly be disposed using a technique that will destroy or irreversibly transform the perfluoroalkyl components of the notified polymer, disposal should be to landfill.

Emergency procedures

- Spills or accidental release of the notified polymer should be handled by physical containment, collection and subsequent safe disposal.

Regulatory Obligations

Secondary Notification
This risk assessment is based on the information available at the time of notification. The Director may call for the reassessment of the chemical under secondary notification provisions based on changes in certain circumstances. Under Section 64 of the *Industrial Chemicals (Notification and Assessment) Act (1989)* the notifier, as well as any other importer or manufacturer of the notified chemical, have post-assessment regulatory obligations to notify NICNAS when any of these circumstances change. These obligations apply even when the notified polymer is listed on the Australian Inventory of Chemical Substances (AICS).

Therefore, the Director of NICNAS must be notified in writing within 28 days by the notifier, other importer or manufacturer:

(1) Under Section 64(1) of the Act; if
  - the importation volume exceeds 2 tonnes per annum notified polymer;

- the polymer has a number-average molecular weight of less than 1000;
- the use changes from a component of stain resistant coatings for carpet and furnishings;
- the notified polymer is intended for use in spray products for consumer use;
- further information on the repeated inhalation toxicity of the notified polymer becomes available;
- additional information has become available to the person as to an adverse effect of the polyfluoroalkyl degradation products of the notified polymer (such as perfluorohexanoic acid);
- additional information has become available to the person as to the environmental fate of the polymer or its polyfluoroalkyl degradation products (such as perfluorohexanoic acid) in relation to degradation or partitioning behaviour, including during water treatment processes;

or

(2) Under Section 64(2) of the Act; if

- the function or use of the polymer has changed from a component of stain resistant coatings for carpet and furnishings, or is likely to change significantly;
- the amount of polymer being introduced has increased, or is likely to increase, significantly;
- the polymer has begun to be manufactured in Australia;
- additional information has become available to the person as to an adverse effect of the polymer on occupational health and safety, public health, or the environment.

The Director will then decide whether a reassessment (i.e. a secondary notification and assessment) is required.

AICS Entry

- When the notified polymer is listed on the Australian Inventory of Chemical Substances (AICS) the entry is proposed to include the following statement(s):
  - This polymer has been assessed by NICNAS and there are specific secondary notification obligations that must be met. Potential introducers should contact NICNAS before introduction.

(Material) Safety Data Sheet

The (M)SDS of the notified polymer provided by the notifier was reviewed by NICNAS. The accuracy of the information on the (M)SDS remains the responsibility of the applicant.

ASSESSMENT DETAILS

This notification has been conducted under the cooperative arrangement with Canada and the United States Environmental Protection Agency (US EPA). The health and environmental hazard assessment components of the Canadian report were provided to NICNAS and, where appropriate, used in this assessment report. Information pertaining to the assessment of the notified polymer by the US EPA was provided to NICNAS and, where appropriate, used in this assessment report. The other elements of the risk assessment and recommendations on safe use of the notified polymer were carried out by NICNAS and the Department of the Environment.

1. APPLICANT AND NOTIFICATION DETAILS

APPLICANT(S)
The Chemours Company (Australia) Pty Ltd (ABN 90 169 142 750)
7 Eden Park Drive
MACQUARIE PARK NSW 2113

NOTIFICATION CATEGORY
Limited: Synthetic polymer with Mn ≥ 1,000 Da.

EXEMPT INFORMATION (SECTION 75 OF THE ACT)
Data items and details claimed exempt from publication: chemical name, other names, CAS number, molecular and structural formulae, analytical data, degree of purity, polymer constituents, residual monomers, impurities, additives/adjuvants, use details and import volume.

VARIATION OF DATA REQUIREMENTS (SECTION 24 OF THE ACT)
Variation to the schedule of data requirements is claimed as follows: all physico-chemical endpoints

PREVIOUS NOTIFICATION IN AUSTRALIA BY APPLICANT(S)
LVC permit

NOTIFICATION IN OTHER COUNTRIES
USA (2007) and Canada (2007)

2. IDENTITY OF CHEMICAL

MARKETING NAME(S)
Capstone® RCP or NRD-626 (up to 25% notified polymer)
ELN101570-1

MOLECULAR WEIGHT
3,400 Da

ANALYTICAL DATA
Reference FTIR spectra were provided.

3. COMPOSITION

The notified polymer contains a polyfluoroalkyl carbon side chain with six perfluorinated carbons.

DEGREE OF PURITY > 90%

HAZARDOUS IMPURITIES/RESIDUAL MONOMERS
None identified

LOSS OF MONOMERS, OTHER REACTANTS, ADDITIVES, IMPURITIES
Not expected to occur under normal conditions of use.

DEGRADATION PRODUCTS
The notified polymer is a potential precursor for PFHxA in the environment (PFHxA: perfluorohexanoic acid - CAS name: Hexanoic acid, 2,2,3,3,4,4,5,5,6,6,6-undecafluoro-; CAS No. 307-24-4).

4. PHYSICAL AND CHEMICAL PROPERTIES

APPEARANCE AT 20 °C AND 101.3 kPa: White translucent waxy solid

Property	Value	Data Source/Justification
Melting Point/Freezing Point	40-75 °C	Measured
Boiling Point	> 300 °C	Estimated
Density	1120 kg/m^3 at 25 °C*	(M)SDS
Vapour Pressure	< 1.3 × 10^{-9} kPa	Estimated based on the NAMW > 1,000 Da (US EPA, 2007).
Water Solubility	< 0.62 mg/g	Measured. The notified polymer is not expected to be water soluble based on the high molecular weight and hydro/lipophobicity of the polymer. However, the notified polymer is expected to be dispersible in water with the aid of surfactants given it is imported as a finished aqueous dispersion product at concentrations up to 30%.
Hydrolysis as a Function of pH	Not determined	The notified polymer does not contain any readily hydrolysable functional groups.
Partition Coefficient (n-octanol/water)	Not determined	On the basis of its hydro/lipophobic tendencies, the notified polymer is expected to partition between the octanol and water phases.
Adsorption/Desorption	Not determined	Generally, polymers of high molecular weight are expected to adsorb to soil, sediments and sludge. However, the notified polymer may have low absorption based on its potential to disperse in water and presence of perfluoroalkyl functionalities which have both hydrophobic and lipophobic tendencies.
Dissociation Constant	Not determined	Not expected to dissociate based on the lack of dissociable functionality.
Flash Point	Does not flash*	(M)SDS. Expected to be high based on the partial fluorination and the low vapour pressure.
Flammability	Not determined	Not expected to be flammable based on the partial fluorination.
Autoignition Temperature	Decomposition expected at > 200 °C*	(M)SDS. Expected to decompose prior to any autoignition.
Explosive Properties	Not expected to be explosive	Contains no explosophores.
Oxidising Properties	Not expected to be oxidising	Estimated based on structure.

* For the product containing the notified polymer at up to 25% concentration.

DISCUSSION OF PROPERTIES

Reactivity

The notified polymer is expected to be stable under normal conditions of use.

Physical hazard classification

Based on the submitted physico-chemical data depicted in the above table, the notified polymer is not recommended for hazard classification according to the *Globally Harmonised System for the Classification and Labelling of Chemicals (GHS),* as adopted for industrial chemicals in Australia.

5. INTRODUCTION AND USE INFORMATION

MODE OF INTRODUCTION OF NOTIFIED CHEMICAL (100%) OVER NEXT 5 YEARS

The notified polymer will not be manufactured in Australia. The notified polymer will be imported into Australia as an aqueous dispersion at concentrations up to 25% in the products Capstone® RCP.

MAXIMUM INTRODUCTION VOLUME OF NOTIFIED CHEMICAL (100%) OVER NEXT 5 YEARS

Year	*1*	*2*	*3*	*4*	*5*
Tonnes	≤ 2	≤ 2	≤ 2	≤ 2	≤ 2

PORT OF ENTRY

Sydney, Melbourne and Brisbane.

TRANSPORTATION AND PACKAGING

The products containing the notified polymer (up to 25% concentration) will be imported by sea in 20 kg or 250 kg steel or high-density polyethylene drums and transported within Australia by road.

USE

The notified polymer is intended to be introduced in order to phase out the use of a partially fluorinated polymer containing fluorinated carbon chain lengths > 6 in various proportions (i.e., existing polymer). The use categories of the notified polymer are identical to those of the existing polymer it replaces, as outlined below.

Carpet and furnishings

The notified polymer will be used as a grease and soil repellent for treatment of carpets before and after selling to consumers, and for treatment of existing furnishing articles at concentrations up to 1%. Consumer use of products containing the notified polymer is not expected.

OPERATION DESCRIPTION

The notified polymer will not be manufactured in Australia. The notified polymer will be imported at up to 25% concentration.

Carpet and furnishings

The notified polymer (up to 25% concentration) will be pumped into a mixing tank where it will be diluted to concentrations up to 1%. It will then be pumped into the spray/dip system, which is an enclosed and automated unit used at the final stage of the carpet production line to apply stain resistant treatments. Low pressure airless spray or an automated dipping system will be used in this unit. Following application, the carpet will travel into a dryer. The notified polymer will be present on the finished carpet at concentrations ranging from 0.15% on residential carpets and 0.4% on commercial carpets.

The notified polymer will also be used for treatment of existing carpet and furnishing articles by professionals. Workers may decant/dilute directly from drums of the notified polymer on the back of their vehicles into application equipment. Following cleaning of carpet, the soil and stain repellent product containing the notified polymer (up to 1% concentration) will be applied by professionals onto the carpet. This may be performed in residential and commercial buildings. Such application may occur by spray (expected to mainly be airless spray).

6. HUMAN HEALTH IMPLICATIONS

6.1. Exposure Assessment

The notified polymer may undergo slow degradation in the environment. As such, most potential exposure to workers and the public is expected to be to the notified polymer itself, rather than to its degradation products. Exposure to the residual polyfluoroalkyl starting constituents and/or impurities of the notified polymer (discrete polyfluoroalkyl chemicals containing perfluoroalkyl carbon chain lengths ranging from four to ten) is also possible. Such exposure is limited by the relatively low concentration of polyfluoroalkyl impurities in the notified polymer in the imported products (up to 1%) or in end-use products (up to 0.01%).

The notified polymer is a potential precursor for perfluorohexanoic acid in the environment. Thisis likely to lead to secondary human exposure to PFHxA. This exposure is unquantifiable.

6.1.1. Occupational Exposure

EXPOSURE DETAILS
Transport and storage workers
Transport and storage workers will only come into contact with the notified polymer (up to 25% concentration) in the unlikely event of an accident.

Carpet and furnishings
Dermal and ocular exposure of workers to the notified polymer (up to 25% concentration) may occur when connecting and disconnecting hoses during the dilution process, and during cleaning and maintenance operations. Inhalation exposures are not expected based on the expected low vapour pressure of the notified polymer and because aerosols are not expected during dilution. The remainder of the dilution process is expected to be mostly automated and exposure is expected to be low.

Exposure of workers to the notified polymer (up to 1% concentration) during application to carpets by the spray/drip system is expected to be negligible due to the enclosed automated nature of the process. Workers required to intervene in the process may undergo dermal, ocular and inhalation exposure but PPE such as aprons, gloves and goggles will be worn. In addition, the use of low-pressure non-atomising spray in the spray application system is not expected to produce respirable particles.

Dermal, ocular and inhalation exposure to the notified polymer (up to 1% concentration) may occur when workers apply products to carpets and textiles by spray. Aerosols of the notified polymer are expected to generate relatively large droplet sizes, given that the target is intended to be well-coated. This exposure may occur on a repeated basis.

6.1.2. Public Exposure
Products containing the notified polymer are not expected to be used by consumers. The public may be exposed to the notified polymer through dermal contact with residues in treated articles, such as carpets and furnishings. The notified polymer is expected to form a cohesive film via adsorption to the substrate fibres. Cleaning of the clothing and fabrics to which the notified polymer is applied is expected to be undertaken and may result in the notified polymer becoming dislodged and available for exposure.

There may also be potential for members of the public to inhale or ingest small quantities of fabric/furnishing fibres or household dust from indoor environments. This may involve the inhalation or ingestion of fibres to which the notified polymer is bound, or perhaps inhalation or ingestion of the notified polymer itself (present in household dust that has been removed from the articles), or polyfluoroalkyl impurities of the notified polymer.

Public exposure may occur on a repeated basis.

6.2. Human Health Effects Assessment

The results from toxicological investigations conducted on formulations of the notified polymer (at up to 25% concentration) are summarised in the following table. Details of studies not referred to in the Canadian assessment can be found in Appendix B.

Endpoint	*Result and Assessment Conclusion*
Rat, acute oral toxicity (2 studies)	LD50 > 11,000 mg/kg bw (equivalent to LD50 > ~2200 mg notified polymer/kg bw) low toxicity
Rat, acute inhalation toxicity (2 studies)	LC50 = 3700 mg/m^3 notified polymer/4 hour; harmful NOAEL = 1.1 mg/m3/4 hours (equivalent to ~0.22 mg/m3/4 hours of the notified polymer)
Rabbit, skin irritation	slightly irritating
Rabbit, eye irritation	slightly irritating
Mouse, skin sensitisation – Local lymph node assay	no evidence of sensitisation
Rat, repeat dose oral toxicity – 15 days	NOAEL = 500 mg/kg bw/day
Rat, repeat dose oral toxicity – 90 days	NOAEL > 1000 mg/kg bw/day
Mutagenicity – bacterial reverse mutation	non mutagenic
Genotoxicity – in vitro mammalian cell gene mutation test	non genotoxic
Rat, developmental toxicity	NOAEL (maternal and foetal) > 1000 mg/kg bw/day
Rat, one-generation reproductive toxicity	NOAEL (parental, reproductive and offspring) > 1000 mg/kg bw/day

Toxicokinetics
The notified polymer is not expected to cross biological membranes (skin or gastrointestinal tract) based on its high molecular weight (> 1,000 Da), the undetectable proportion of low molecular weight species (< 500 Da), and its expected low water solubility. This is supported by the lack of observed systemic toxicity in the acute toxicity studies with the notified polymer. Some accumulation in the respiratory tract may occur from respirable particles (< 10 μm), if present. Alternatively, larger inhalable particles (< 100 μm), if present, are likely to deposit in the nasopharyngeal region and will be coughed or sneezed out of the body or swallowed. Ingestion after swallowing dust or fibres to which the notified polymer is attached is not expected to lead to significant absorption from the GI tract due to the high molecular weight of the notified polymer and its stability to hydrolysis.

Acute toxicity
Two approximate lethal dose studies were conducted with Sprague-Dawley rats. In each study, one male was administered the test substance containing the notified polymer at up to 25% concentration by gavage at doses of 670, 2300, 3400, 5000, 7500 or 11 000 mg/kg bw. No deaths or clinical signs of systemic toxicity were observed during the 14 day observation period. The median lethal dose of the notified polymer (up to 25% concentration) exceeded 2000 mg/kg bw. The absence of any clinical evidence of systemic toxicity at doses up to 11,000 mg/kg bw suggests the notified polymer is likely to exhibit low acute toxicity via the oral route (DuPont, 2006a; DuPont, 2006b).

Inhalation toxicity
Some perfluorinated and polyfluorinated polymers have been known to cause lung injury, which is characterised by respiratory problems ranging from mild to severe effects associated with acute or repeated exposures. These effects are generally considered to be of most concern when the compound has surface activity (Fischer *et al.*, 2012).

In an acute inhalation study with a formulation containing the notified polymer at up to 25% concentration, male and female rats (5/sex/concentration) were exposed to 1600 or 3700 mg/m^3 notified polymer/4 hours. The LC50 was established at 3700 mg/m^3 notified polymer/4 hours based on 5/10 mortalities at this concentration. The notified polymer is therefore harmful by inhalation. One female rat died at 1600 mg/m^3/4 hours exposure concentration. Gross discoloration of the lungs was observed in most rats at both concentrations.

Mortality following acute inhalation exposures to the notified polymer is of concern, based on the above study.

In another acute inhalation toxicity evaluation of the notified polymer (at 20.4% concentration) conducted at the microscopic pathology level, test substance-related slight to moderate degeneration/necrosis of the U-shaped cartilage of the ventral larynx was observed in most male and female rats at dose levels above 47 mg/m^3/4 hours. Slight inflammation of the ventral laryngeal submucosa was also present mostly in males treated with the test substance. Other laryngeal changes noted included slight focal (ventral mucosa) epithelial hyperplasia and

mild ulceration of the ventral laryngeal mucosa in the males treated. Following 14-day recovery period, slight to mild laryngeal degeneration/necrosis of the U-shaped cartilage in the 570 mg/m^3/4 hours persisted. These laryngeal changes were considered by the study authors to be test substance-related and adverse. A No Observed Adverse Effect Level (NOAEL) of acute inhalation exposure to the test substance was determined to be 1.1 mg/m^3/ 4 hours (equivalent to 0.22 mg/m^3/4 hours of the notified polymer) (DuPont, 2013).

No repeated dose inhalation studies with the notified polymer have been submitted and thus uncertainties remain surrounding possible chronic respiratory tract effects following repeated exposures to the notified polymer.

Irritation and sensitisation
The notified polymer (up to 25% concentration) was applied to an intact site on the flank of three male NZW rabbits for a 4 hour period under a semi-occlusive dressing. No deaths or clinical evidence of systemic toxicity were observed. The notified polymer (up to 25% concentration) produced very slight erythema at the treatment site of one animal at 24 and 48 hours after exposure. The notified polymer (up to 25% concentration) is not a significant skin irritant (DuPont, 2006c).

Three male NZW rabbits free from pre-existing ocular defects were selected and 0.1 mL of the notified polymer (up to 25% concentration) was placed into the lower conjunctival sac of the right eye of each animal while the left eye served as the untreated control. Minimal to marked conjunctival redness, up to minimal conjunctival chemosis and up to minimal conjunctival discharge was observed at the 1 and 24 hour observations. All evidence of irritation had resolved by 48 hours. There was no evidence of iridal or corneal injury. The notified polymer (up to 25% concentration) produced ocular irritation graded as minimal (DuPont, 2006d).

The potential for the notified polymer (up to 25% concentration) to cause skin sensitization was determined using the local lymph node assay (LLNA). For three consecutive days, 25 µL of the notified polymer (up to 25% concentration) was applied to the dorsal surface of both ears of female CBA mice (5/group) at concentrations of 0% (vehicle), 5%, 25%, 50% or 100%, or 25% α-hexacinnamaldehyde (positive control). Five days after the first application, all mice received an injection of 20 µCi ^{3}H-methyl thymidine. Five hours later, all mice were euthanized, the draining auricular lymph nodes were excised and the extent of ^{3}HTdR incorporation was determined by autoradiography. No deaths or clinical evidence of systemic toxicity occurred. No evidence of a positive lymphoproliferative response (relative stimulation index exceeding 3) was observed at any concentration. The notified polymer (up to 25% concentration) is unlikely to cause delayed contact hypersensitivity (DuPont, 2006e). This result was supported by a more recent LLNA on the notified polymer at 20.8% concentration, which showed no evidence of sensitisation under the conditions of the assay (DuPont, 2008).

Repeated-dose toxicity
The notified polymer (up to 25% concentration) was administered daily to groups of five SD rats per sex for 15 days at doses of 0 (water), 25, 100, 500 or 1000 mg/kg bw/day in a preliminary limited range finding study. Animals were examined for mortality, clinical observations, bodyweight, food consumption, kidney, liver and thyroid weights and gross pathology only. There were no deaths or clinical evidence of systemic toxicity. Females administered 500 or 1000 mg/kg bw/day had slightly reduced mean total bodyweight gain compared with control animals; however, the significance of this finding is difficult to interpret given the short study duration. Food efficiency was also reduced in female animals administered the highest two doses. An increase in mean thyroid weight (19-31%) was observed among males and females in the 1000 mg/kg bw/day group. Based on these findings, the NOAEL under the study conditions appeared to be 500 mg/kg bw/day, but the limited extent of observation precluded a more concrete determination (DuPont, 2006f).

In a 90-day oral subchronic study in rats with recovery periods of 30 and 90 days, there were no treatment related effects when the notified polymer (up to 25% concentration) was administered at up to 1000 mg/kg bw/day (DuPont, 2007b).

Mutagenicity/Genotoxicity
A bacterial reverse mutation assay was conducted according to the plate incorporation method in two independent experiments. The notified polymer (up to 25% concentration) did not induce a toxicologically significant increase in the number of revertant colonies of *Salmonella typhimurium* (TA1535, TA1537, TA98, TA100) or *Escherichia coli* WP2uvrA, in the presence or absence of metabolic activation (Aroclor 1254 induced rat liver S9 fraction, 10% in standard cofactors) at concentrations ranging from 33.3 to 5000 µg/plate in acetone. The standard positive control substances induced clear increases in the number of revertant colonies, confirming the sensitivity of the test system to known mutagens and the activity of the S9 fraction. The notified polymer (up

to 25% concentration) was not mutagenic under the conditions of this *in vitro* assay (DuPont, 2006g).

The above result was supported by a more recent bacterial reverse mutation test conducted on the notified polymer at a concentration of 20.8% using pre-incubation protocols either with or without metabolic activation. The newer test did not reveal evidence of mutagenicity for the notified polymer (BML, 2008).

The notified polymer (up to 25% concentration) was negative in an *in vitro* mammalian cell gene mutation test (BioReliance, 2008).

Developmental and reproductive toxicity
Twenty-two timed pregnant SD rats per group were administered the notified polymer (up to 25% concentration) at doses of 0 (water), 50, 250 or 1000 mg/kg bw/day from gestation day 6-20. Animals were euthanized on day 21 and both the dams and fetuses were subjected to a gross examination. There were no treatment-related deaths or clinical evidence of systemic toxicity. There were also no treatment-related effects on bodyweight, net bodyweight gain or food consumption and there were no treatment-related maternal gross postmortem findings. When compared with the control group, treatment groups exhibited no significant differences in the number of corpora lutea, implantations, early and late resorptions, live and dead fetuses and in the fetal sex ratio and fetal bodyweight. Four fetuses with malformations were observed (1 with sternoschisis in control group, 1 with protruding tongue, craniorachischisis, absent eye bulge and cleft lip and palate at 50 mg/kg/day, 1 with malrotated rear limbs at 250 mg/kg/ bw/day and 1 with agnathia at 1000 mg/kg bw/day), but these were of such low incidence they are clearly spontaneous in origin. Based on the absence of adverse maternal or fetal effects, the NOAEL for both maternal and fetal toxicity exceeded 1000 mg/kg bw/day, the highest dose tested (DuPont, 2007e).

In a one-generation reproduction study, the parental, reproductive and offspring NOAEL for the notified polymer (up to 25% concentration) was > 1000 mg/kg bw/day, based on the lack of treatment-related effects at all treatment levels (DuPont, 2007b).

Health hazard classification
Based on the available information, the notified polymer is recommended for hazard classification according to the *Globally Harmonised System for the Classification and Labelling of Chemicals (GHS),* as adopted for industrial chemicals in Australia. The recommended hazard classification is presented in the following table.

Hazard classification	***Hazard statement***
Acute Toxicity (Category 4)	H332 – Harmful if inhaled

Based on the available information, the notified polymer is recommended for hazard classification according to the *Approved Criteria for Classifying Hazardous Substances* (NOHSC, 2004), with the following risk phrase(s):

R20 Harmful by inhalation

Toxicology of break down products
The notified polymer contains perfluoroalkylside-chains that are potential precursors of PFHxAin the environment (PFHxA; CAS No. 307-24-4). PFHxA is a perfluorocarboxylic acid consisting of 5 perfluorinated carbons (a short chain perfluorinated chemical). The polymer that is proposed for replacement by the notified polymer is expected to break down to perfluorooctanoic acid (PFOA; CAS No. 335-67-1) (consisting of 7 perfluorinated carbons) and other per- and polyfluorocarboxylic substances with longer perfluoroalkyl carbon chain lengths. The toxicokinetic and toxicological properties of the long chain break down products are generally less favourable compared to the short chain break down products, with properties becoming less favourable with increasing perfluoroalkyl carbon chain length. In addition, it has been established that the bioaccumulation potential of perfluorocarboxylic acids increases with perfluoroalkyl carbon chain length (Conder, 2008; Giesy 2010).

A review of the literature indicates that PFHxA has a less hazardous human health profile, compared to PFOA (refer to Appendix D for details). It is therefore inferred that the human health hazards associated with the expected break down product of the notified polymer (PFHxA) are likely to be similar or less than the human health hazards associated with the expected break down products (PFOA and longer chain perfluorocarboxylic acids) of many per- and polyfluoroalkyl chemicals currently on the market and that are intended for replacement by the notified polymer.

6.3. Human Health Risk Characterisation

6.3.1. Occupational Health and Safety

The notified polymer is harmful by inhalation, with all other toxicology studies indicating low hazard. Acute inhalation toxicity is not of concern to workers during dilution as aerosols are not expected to be generated, but may be of concern when spraying the diluted notified polymer (up to 1% concentration). However, this is expected to be a mostly automated and enclosed process and the use of low-pressure spray is expected to further minimise exposure. Additionally, the low concentration of the notified polymer is expected to further minimise the risk of acute inhalation toxicity. Based on the automated and enclosed nature of the process, the use of low-pressure spray and the low concentration, the risk of acute inhalation toxicity to workers during application to carpets and furnishings is not considered to be unreasonable.

Slight skin and eye irritation may occur during dilution of the notified polymer (up to 25% concentration) but automated processes are expected to be in place and PPE (clothing, gloves and goggles) will be worn, which will further minimise exposure. The risk of slight skin and eye irritation is not considered to be unreasonable.

Repeated dermal exposure of workers to the notified polymer may occur during pre- and post-sale treatment to carpets and furnishings. The repeated dermal toxicity of the notified polymer has not been investigated, however, repeat dose oral toxicity studies indicate that the notified polymer is of low hazard by repeated exposures. Additionally, systemic exposure to the notified polymer is expected to be low based on the high molecular weight (> 1,000 Da) of the notified polymer and the low proportion (< 1%) of low molecular weight species < 1000 Da. Systemic exposure of workers to break down products (e.g., PFHxA) is not expected based on the stability of the notified polymer. Worker exposure to impurities of the notified polymer is not expected to be significant. In addition, the use of engineering controls and PPE are expected to further lower exposure to the notified polymer, its breakdown products and impurities. Overall, the risk of repeat dose toxicity to workers resulting from repeated dermal exposure is not considered to be unreasonable.

Repeated inhalation exposure to the notified polymer may occur during spray operations. The lack of repeat dose inhalation toxicity data is considered to be a data deficiency given the potential for lung injury. This is of particular concern for workers who may use products containing the notified polymer every day. Based on the uncertainties surrounding repeated inhalation exposure to the notified polymer, measures should be taken to minimise exposure. The risk of inhalation toxicity resulting from repeated exposure to the notified polymer is not considered to be unreasonable provided that users minimise inhalation of the notified polymer.

The risk to professionals of acute inhalation toxicity from the notified polymer is not considered to be unreasonable, as the controls used to minimise exposure to prevent repeated toxicity from inhalation are expected to also be protective of acute inhalation toxicity.

Workers may also be exposed to perfluoroalkyl impurities of the notified polymer at relatively low concentrations (< 1%). It is expected that the engineering controls and personal protective equipment utilised during these operations (as outlined above) will act to mitigate any risk associated with such exposure.

6.3.2. Public Health

The public may be exposed to the notified polymer and relatively low levels of perfluoroalkyl impurities through dermal contact with treated articles, such as carpets and furnishings. This exposure may be on a long term repeated basis. Repeated dose toxicity studies with the notified polymer were indicative of low hazard and the high molecular weight (> 1,000 Da) of the notified polymer is expected to prevent any significant dermal absorption. The risk to public health from repeated dermal contact with the notified polymer is not considered to be unreasonable. Additionally, the risk to public health from exposures to perfluoroalkyl impurities is not considered to be unreasonable based on their low concentration (< 0.01%) in end-use products.

The public may inhale or ingest small quantities of carpet/furnishing fibres to which the notified polymer is bound or household dust containing the notified polymer that has been removed from the carpets/furnishings. This may also involve the incidental ingestion or inhalation of low molecular weight polyfluorinated impurities of the notified polymer. Given the low water solubility and high molecular weight of the fibres and the notified polymer itself, inhalation is not expected to result in significant absorption of the notified polymer from the respiratory tract. A small amount of accumulation of fibres or dust in the respiratory tract may occur if particle size is small. Alternatively, for larger particles, the particles may deposit in the nasopharyngeal region and coughed or sneezed out of the body or swallowed. Ingestion after swallowing dust or fibres is not expected to lead to significant absorption from the gastrointestinal tract. In addition, inhalation exposure to impurities is

expected to be low due to the relatively low concentration of impurities in the notified polymer and in end use products. Breakdown of the polymer to PFHxA is not expected during the time of residence in the body. Thus the risk to public health from inhalation or ingestion of fibres or dust containing the notified polymer and/or impurities of the notified polymer is not considered to be unreasonable.

The public may be exposed indirectly to PFHxA, formed by degradation of the notified polymer in the environment. Such exposure may increase over time due to the persistence of PFHxA in the environment. A quantitative risk assessment for this exposure was not conducted. However, the available data indicates that PFHxA has a more favourable toxicological profile and bioaccumulation potential than the long chain perfluoroalkyl substances that are the ultimate break down products of the majority of perfluoroalkyl polymers currently in Australian commerce (such as PFOA). In particular, it is noted that the polymer being replaced contains perfluoroalkyl carbon chain lengths > 6. It is concluded that the risks to human health from indirect exposure to breakdown products of perfluoroalkyl substances will decrease following introduction of the notified polymer, on the basis that the notified polymer is intended to replace a currently available "long" chain perfluoroalkyl polymer.

It should also be noted that the notified polymer has been approved for the same uses in the US and Canada for manufacture/import volumes greater than what is under consideration in Australia.

7. ENVIRONMENTAL IMPLICATIONS

7.1. Environmental Exposure & Fate Assessment

7.1.1. Environmental Exposure

RELEASE OF CHEMICAL AT SITE

The notified polymer will be imported as a component of a finished product for use as a grease and soil repellent in stain repellents for carpet and upholstery treatment. No reformulation in Australia is expected.

RELEASE OF CHEMICAL FROM USE

Based on the ratio for use volumes between the product in pre- and post-sale sectors that was provided by the notifier, most of the notified polymer is expected to be used pre-sale for carpet, and a smaller proportion of the imported notified polymer is expected to be used in the post-sale sector for application to carpet and furniture. The product containing the notified polymer will be applied pre-sale to carpets using a spray/drip system. The spray/dip process is an enclosed system to limit any loss of notified polymer. Following application, the carpet will travel into a dryer to fix the notified polymer to the fibres. The releases from small mill spray application for Australia specifications are estimated by the notifier to be less than 38 kg over an operation period of 27 days per annum. These releases are expected to be mainly from overspray and splashes, which are expected to be collected and drained back into the product for reapplication. The spray unit is serviced twice a year. The waste generated is expected to be less than 3 kg, which is expected to be sent to the retention tanks with the cleaning water for water purification before disposal into the sewer. The liquid waste in the retention tanks is indicated to be coagulated to form solid filter cakes that are expected to be collected for disposal to landfill.

The notified polymer used for post-sale treatment of carpet and upholstery will be applied by the professionals onto the carpet in residential and commercial buildings. Such application may occur by spray (expected to mainly be airless low pressure spray). The releases from this application are estimated by the notifier to be less than 2 kg per annum which may be released to sewer for the worst case scenario.

RELEASE OF CHEMICAL FROM DISPOSAL

The notified polymer is expected to be applied predominantly to carpets. The notified polymer may become dissociated from treated fabrics during vacuuming and cleaning activities. According to a test conducted by the notifier, the majority of the notified polymer is expected to end up in landfill at the end of the carpet's lifetime. Small amounts were indicated to be removed by hot water extraction cleaning and be released to sewer (up to 10%, or up to 200 kg) or to be disposed of to landfill as solid waste from regular vacuuming. Abrasion of the floor surface by foot traffic is expected to result in some relocation of the notified polymer. Estimates for losses due to abrasion from these uses are not available. The above estimated level of releases to sewer from cleaning provided by the notifier is significantly less than the available data from a previous risk assessment for similar application scenario described below. Therefore, these data are not used for risk assessment.

According to the Technical Guidance Document (European Commission, 2003), for indoor articles, including

carpet, subject to cleaning, a total release of the applied chemicals to water can be assumed. This assumption may be suitable for a scenario where the articles are cleaned/washed frequently, which is not the case for carpet. Available data indicates that carpet can have a lifetime of up to 12 years, during which periodic steam cleaning is assumed to occur every three years. From this data, the total amount of the applied notified polymer (to carpet) that can be removed via steam cleaning over the 12 year lifetime is estimated to be 30% of the amount of polymer applied. The rest of the notified polymer is expected to be disposed of to landfill as solid waste from regular vacuuming, or together with the carpet at the end of its useful life. These data are considered acceptable as a representative scenario since carpet is not expected to be cleaned with water frequently. Thus this release scenario will be used for risk assessment purposes.

7.1.2. Environmental Fate

No environmental fate data were submitted.

The majority (about 70%) of the notified polymer applied to carpet is expected to be ultimately disposed of to landfill in form of waste solid from carpet vacuuming or with the used carpet. When associated with the article to which the product containing the notified polymer has been applied, the notified polymer is not likely to be mobile or bioavailable in landfill.

About 30% of the notified polymer is expected to be released to sewer in washing water from carpet cleaning processes. In general, non-ionic polymers with a molecular weight of more than 1000 Da are considered to be efficiently removed in sewage treatment plant (STP) processes through adsorption to sludge. Predictions of the environmental partitioning behaviour of polyfluoroalkyl compounds such as the notified polymer remain uncertain based on current knowledge because of limited data and their unique properties. In particular, the usual predictive models for partitioning during sewage treatment are inapplicable for chemicals containing perfluoroalkyl functionality as they assume lipophilicity for hydrophobic functionality, whereas the perfluoroalkyl functionality is both hydrophobic and lipophobic. The assumption that surface activity and/or high molecular weight results in efficient removal by sorption to sludge during conventional wastewater treatment has not been verified by supporting data for this class of polymer. Thus, noting its potential of being both hydrophobic and lipophobic, the notified polymer, and any associated degradation products and/or impurities/residual monomers of poly- or perfluoroalkyl compounds, may remain in the aqueous phase following wastewater treatment. As such, the notified polymer, its degradation products and the poly- or perfluoroalkyl impurities/residual monomers in wastewater have the potential to be released in STP effluent directly to surface waters or reused in the irrigation of agricultural soils throughout Australia.

The notified polymer may have the potential to disperse in water but it is not expected to hydrolyse under environmental conditions (pH 4 to 9, 25 ºC) based on structural considerations. No data regarding biodegradation of the notified polymer is available. Degradation of the notified polymer is expected to be very slow. The notified polymer is not expected to completely mineralise and degradation products may include more stable lower molecular weight polymer with poly- or perfluoroalkyl functionality or the very persistent perfluorocarboxylic acid, PFHxA. Therefore, the notified polymer has the potential to release PFHxA.

In surface waters, agricultural soils and landfill, the notified polymer is expected to eventually degrade to form water, oxides of carbon and nitrogen and degradation products containing polyfluoroalkyl functionality. The expected initial polyfluoroalkyl degradation products are assumed to undergo further degradation to form, among other compounds, the very persistent perfluorocarboxylic acid degradation product, PFHxA. It is noted that some volatile degradation intermediates have the potential to undergo long range atmospheric transport and thus may result in translocation of PFHxA in the environment. The notified polymer also contains relatively low levels of impurities that may degrade to form perfluorooctanoic acid (PFOA) and other long-chain perfluorocarboxylic acids.

PFHxA is expected to be recalcitrant in the environment, and potentially undergo long range transport while mainly staying in the water column. In water, it is expected to be very persistent and will not hydrolyse, photolyse or biodegrade.

High-temperature incineration is the preferred method of disposal of poly- and perfluoroalkyl compounds due to the environmental persistence characteristics, when it results in mineralisation of the perfluoroalkyl functionality to oxides of carbon and hydrofluoric acid. Incomplete combustion of perfluoroalkyl functionality may produce an array of partially oxidised fluorocompounds. Therefore, disposal of the notified polymer and its degradation products by incineration should only take place at facilities that demonstrate complete combustion of the perfluoroalkyl functionality and have adequate measures in place to control release of hydrofluoric acid.

Due to its high molecular weight which limits the ability to cross biological membranes, the notified polymer is not expected to bioaccumulate. The available laboratory (Higgins *et al*., 2007; Martin *et al*., 2003ab; Woodcroft *et al*., 2010) and field (Falandysz *et al*., 2006; Falandysz *et al*., 2007, Furdui *et al*., 2007) evidence indicates that PFHxA is expected to be less bioaccumulative than PFOA and other long chain perfluoroalkylated compounds, which PFHxA- chemistry is replacing (although PFHxA and PFOA are not considered bioaccumulative). However, both are bioavailable and can be detected in wildlife as demonstrated by monitoring studies (Kumar *et al*., 2009; Ye *et al*., 2008a; Ye *et al*., 2008b; Wang *et al*., 2008). In general, the available evidence indicates that the bioaccumulation potential of perfluoroalkyl compounds is correlated with increasing carbon chain length (Giesy *et al*., 2010). Therefore, PFHxA has a lower bioaccumulation potential than PFOA and other long chain perfluoroalkyl substances

7.1.3. Predicted Environmental Concentration (PEC)

The notified polymer may be released to the aquatic compartment through the disposal of the releases generated from the pre- or post-sale application, or through the disposal of wastewater generated during the carpet cleaning. The following predicted environmental concentrations (PECs) were calculated assuming that there is no removal of the notified polymer during STP processes.

The notified polymer that may be released to sewer from the use can be estimated to be 41 kg (38 kg + 3 kg) per annum, which will occur in NSW and Queensland as indicated by the notifier. The PEC has been calculated assuming 50% (21 kg) of the pre-sale application will occur in QLD, where the STP has a lower daily flow (115 million litres) than in NSW. The release of the notified polymer will occur over 27 days per annum based on the information provided by the notifier. The concentration of the notified polymer in STP effluent from point-source release is estimated as follows:

Predicted Environmental Concentration (PEC) for the Aquatic Compartment		
Total Release Volume to Sewer from Pre Sale Application	21	kg/year
Proportion expected to be released to sewer	100%	
Annual quantity of chemical released to sewer	21	kg/year
Days per year where release occurs	27	days/year
Daily chemical release:	0.778	kg/day
Individual Sewage Treatment Plant Average Daily Flow:	115	ML/day
Removal within STP	0%	
Effluent concentration	6.76	µg/L

On average, the release to sewer from carpet cleaning has been estimated to be 30% over a carpet's life time. As the majority of the import volume will be used to treat carpets, it is assumed that all use goes to treat carpets and that 30% of the total volume will be released to the sewer. Carpet treatment is expected to keep occurring year after year on the same scale. As a worst case, the PEC in sewerage effluent from the annual release of the notified polymer from carpet cleaning has therefore been calculated assuming that up to 30% of the annual import volume will be released to sewer each year. Treated carpets are likely to be used across Australia and releases due to the cleaning of carpets in dispersed locations are expected to occur 365 days per year. The resulting concentration in sewerage effluent on a nationwide basis is estimated as follows:

Predicted Environmental Concentration (PEC) for the Aquatic Compartment		
Total Annual Volume Used	1959	kg/year
Proportion expected to be released to sewer	30%	
Annual quantity of chemical released to sewer	587.7	kg/year
Days per year where release occurs	365	days/year
Daily chemical release:	1.61	kg/day
Water use	200	L/person/day
Population of Australia (Millions)	22.613	million
Removal within STP	0%	
Daily effluent production:	4,523	ML
Effluent concentration	0.36	µg/L

Based on the above calculations, the worst-case concentration for the notified polymer in effluent due to the combined releases to STP from use and cleaning is 7.12 µg/L. Therefore, the PEC for the aquatic compartments

are calculated as follows:

Predicted Environmental Concentration (PEC) for release to the aquatic compartment during use		
Combined effluent concentration	7.1	µg/L
Dilution Factor – River	1	
Dilution Factor – Ocean	10	
PEC – River	7.12	µg/L
PEC – Ocean	0.712	µg/L

STP effluent re-use for irrigation occurs throughout Australia. The agricultural irrigation application rate is assumed to be 1000 L/m^2/year (10 ML/ha/year). The notified chemical in this volume is assumed to infiltrate and accumulate in the top 10 cm of soil (density 1500 kg/m^3). Using these assumptions, irrigation with a concentration of 7.12 µg/L may potentially result in a soil concentration of approximately 47.1 µg/kg. Assuming accumulation of the notified chemical in soil for 5 and 10 years under repeated irrigation, the concentration of notified chemical in the applied soil in 5 and 10 years may be approximately 0.24 mg/kg and 0.47 mg/kg, respectively.

PEC for PFHxA and long chain perfluoroalkyl substances
The notified polymer is assumed to degrade and ultimately form the persistent degradant, PFHxA. However, the yield and rate of conversion of the notified polymer to PFHxA has not been established. Environmental monitoring data shows that PFHxA, and PFOA which PFHxA-chemistry is replacing, is widely found in the environment, particularly in fresh water close to industrial sources, but also in some biota. Water appears to be the main compartment where PFHxA is found. High measured concentrations of both PFHxA and PFOA in surface waters in Germany have been associated with the legal application of waste materials to agricultural soils (Skutlarek *et al*., 2006) indicating that these chemicals have the potential to enter the aquatic compartment following initial release into the soil compartment.

Some larger available data sets from the literature (McLachlan *et al*., 2007; Skutlarek *et al*., 2006; Nakayama *et al*., 2007; So *et al*., 2007; Ahrens *et al*., 2009) include monitoring from a range of rivers in Europe, the USA and China, along with data from the Atlantic Ocean. Using these data (n ≥60), the 10th, 50th and 90th percentile concentrations for PFHxA are 1.0, 6.15 and 22.5 ng/L respectively, while those for PFOA are 2.94, 11.85 and 231.9 ng/L respectively. The use of chemicals that degrade to form PFHxA increases levels of PFHxA and may build up further in the environment.

PFHxA and other poly- and perfluoroalkyl compounds have also been found in landfill leachate, with concentrations of PFHxA ranging from 270 – 790 ng/L (Huset *et al*., 2011). As landfills are reservoirs of solid waste, and receive waste water treatment plant sludge, which may contain poly- and perfluoroalkyl substances, landfills have the potential to continue to release PFHxA and homologues well into the future.

Historically, release of poly- and perfluoroalkyl substances into the environment has been linked to direct releases of low molecular weight poly- and perfluoroalkyl substances, such as poly- and perfluoroalkyl monomers during polymer manufacture and reformulation processes, rather than breakdown of the polymers themselves. In order to limit the extent of direct release of potential PFHxA precursors to the environment, it is recommended that control measures be implemented to minimise the residual weight percentage of unreacted poly- and perfluoroalkyl monomer constituents and impurities in the notified polymer to the extent practicable. Zhao *et al*. (2013) report that fluorotelomer alcohol (FTOH) residual raw material content in FTOH-based polymeric products is generally less than 0.1%. Efforts have also been made globally to control releases of perfluoroalkyl acids, such as PFOA and potential precursors, by reducing the presence of residual poly- and perfluoroalkyl monomers and impurities in polymers. It is recommended that the total weight of residual monomers and impurities in the notified polymer containing polyfluoroalkyl functionality should not exceed the levels attainable utilising international best practice and the levels are further reduced using available technological advances, to the extent practicable

By reducing the presence of residual poly- and perfluoroalkyl monomers and impurities in polymers, it is expected that indirect releases from the degradation of polyfluoroalkyl substances will become a significant source of persistent poly- and perfluoroalkyl substances in the environment in the future. PFHxA is already being detected in the environment and as the long chain poly- and perfluoroalkyl substances are phased out in preference for short-chain polyfluoroalkyl chemistry containing a six-carbon perfluorohexyl moiety, the environmental levels of PFHxA are expected to increase.

Half-lives of polyfluoroalkyl polymers in aerobic soil have been found to be indeterminate with calculated half-lives ranging from decades to millennia (Russell *et al*., 2008; Russell *et al*., 2010; Washington *et al*, 2009). The half-lives of PFHxA in various environmental media are also unknown and its partitioning behaviour is uncertain. Further, degradation products of the notified polymer are unknown as no biodegradation study is available. Therefore, a PEC for indirect releases of PFHxA arising from proposed use and disposal of the notified polymer in Australia cannot be determined.

7.2. Environmental Effects Assessment

The results from ecotoxicological investigations conducted on the notified polymer are summarised in the table below. Details of these studies can be found in Appendix C. Two ecotoxicity studies for daphnia were provided for the notified polymer at concentrations 20.4% and 66.33 respectively.. The study conducted on the notified polymer at a concentration of 66.33% had no significant deviations from the test guidelines and all validity criteria were satisfied and contained a higher percentage of the notified polymer (> 66.33% compared to only 20.4% for the second study).

Endpoint	*Result*	*Assessment Conclusion*
Fish Toxicity	96 h LC50 > 20.4 mg/L	Potentially harmful to fish
Daphnia Toxicity	48 h EC50 = 79.6 mg/L	Potentially harmful to aquatic invertebrate
Algal Toxicity	72 h EC50 > 20.4 mg/L 72 h NOEC = 20.4 mg/L	Potentially harmful to algae

The notified polymer is considered potentially harmful to aquatic life on an acute basis based on the endpoint for daphnids. The notified polymer is formally classified under the Globally Harmonised System of Classification of Chemicals (GHS; United Nations, 2009) as “Acute Category 3: Harmful to aquatic life”. Based on its acute toxicity and potential to persist in the environment, the notified polymer has been formally classified under GHS as Chronic Category 3; Harmful to aquatic life with long lasting effects.

Effects of PFHxA and long chain perfluorocarboxylic acids: There are only limited available toxicity data for PFHxA to organisms, and these are limited to aquatic organisms. Based on the available literature, the most sensitive trophic level is algae. Latala *et al*., (2009) reported the 72-hour median effect concentrations (72 h EC50) for three marine species as follows: 1.0 mg/L for blue green algae (Geitlerinema amphibium); 1.4 mg/L for diatom (Skeletonema marinoi); and, 4.0 mg/L for green algae (Chlorella vulgaris). The data indicates that PFHxA is toxic to algae on an acute basis. The study also investigated the toxicity of PFOA to the three marine species: 0.25 mg/L for blue green algae; 0.37 mg/L for diatom; and, 0.98 mg/L for green algae. The data indicates that PFOA is very toxic to algae on an acute basis and demonstrate decreased toxicity of PFHxA compared with PFOA to three species tested.

Other data indicate that PFOA is not harmful to fish and aquatic invertebrates on an acute basis with median lethal or effect concentrations (L(E)C50) of greater than 100 mg/L (US FDA, 2009). The majority of the available data for the ammonium salt of PFOA (US EPA, 2002) show this substance is largely expected to be not harmful to fish and aquatic invertebrates, although one reported endpoint (fathead minnow 96 h LC50 = 70 mg/L) is below 100 mg/L.

Giesy *et al*. (2010) reported the relationship between increasing carbon chain length and increasing toxicity. Therefore, PFHxA is expected to have a less problematic ecotoxicological profile than PFOA and other long chain perfluorocarboxylic acids it is expected to replace. Long-term effects data that reflect or model the periods over which perfluorocarboxylic acids are present in the environment are not available for PFHxA or long chain perfluorocarboxylic acids. Therefore, the long-term hazard to aquatic organisms has not been adequately established and is unknown.

7.2.1. Predicted No-Effect Concentration

The predicted no-effect concentration (PNEC) was calculated using the most sensitive endpoint for fish/algae. A safety factor of 100 was used since the endpoints for fish, daphnia and algae are available.

Predicted No-Effect Concentration (PNEC) for the Aquatic Compartment		
EC50 (Invertebrates)	20.4	mg/L
Assessment Factor	100	
PNEC:	204	µg/L

7.3. Environmental Risk Assessment

The predicted no-effect concentration (PNEC) was calculated using the most sensitive endpoint for fish/algae. A safety factor of 100 was used since the endpoints for fish, daphnia and algae are available.

Risk Assessment	*PEC µg/L*	*PNEC µg/L*	*Q*
Q - River:	7.12	204	0.035
Q - Ocean:	0.712	204	0.0035

Based on a worst-case scenario, the risk quotients (Q) for river and marine waters are less than 1, indicating the notified polymer will not be present at ecotoxicologically significant concentrations in surface waters. The available data indicates that the notified polymer is harmful to aquatic organisms. The polymer itself is not expected to be readily degradable. Further, the notified polymer is assumed to eventually degrade to form PFHxA which may be delocalised from points of release.

Perfluoroalkyl substances are expected to be very persistent in the environment (for example, PFOA: t½ (hydrolysis) > 200 years; US EPA 2002) but PFHxA is considered to have low potential for bioaccumulation. There is limited evidence in the published literature of PFHxA toxicity to aquatic organisms on an acute basis, although it is reported to be toxic to marine algae. There is no available data on the long-term aquatic effects of PFHxA.

The main environmental risks associated with polyfluoroalkyl polymers relate to the release of perfluoroalkyl degradation products such as PFHxA. However, it is not possible to quantify the long-term risks of PFHxA to the environment due to knowledge gaps both in predicting environmental concentrations from indirect sources of release and its long-term environmental effects. The latter point is considered a critical data gap as aquatic organisms are expected to have long-term exposure to PFHxA due to its persistence in the water compartment.

PFHxA is already wide-spread in surface waters and biota. Continuing release of PFHxA which has no known breakdown mechanism (at least in soil and water) could result in increasing environmental concentrations over time. Hence, there is potential for ecotoxicologically significant concentrations to eventually be reached following its accumulation in the environment. In this eventuality, precursors of PFHxA such as the notified polymer cannot be recalled after release and are a potential source of PFHxA in the environment even long after their use ceases. Thus, use and disposal of the notified polymer increases the environmental risk profile of PFHxA. The notified polymer also contains impurities which are assumed to degrade to form PFHxA and longer chain perfluorocarboxylic acids. Therefore, considering the dispersive use pattern of the notified polymer, it is recommended to reduce the impurities in the notified polymer that breakdown to form PFHxA and longer chain perfluorocarboxylic acids, to the extent possible.

Conclusions

On the basis of the PEC/PNEC ratio, the notified polymer itself is not considered to directly pose an unreasonable short-term risk to the aquatic environment.

However, degradants of the notified polymer, along with associated impurities and residual monomers of the notified polymer, are potential precursors of the very persistent chemical, perfluorohexanoic acid (PFHxA). The assessed use pattern of the notified polymer does not control the release of breakdown products into the environment during use and after disposal and there are no adequate long-term environmental effects data for PFHxA. Therefore, the long-term environmental implications are unknown. Consequently, the long-term risk cannot be quantified for the notified polymer and its degradation products. In order to inform a more conclusive assessment of long-term environmental risks, further data should be generated. This may include data on longer-term environmental effects, as well as partitioning behaviour and characterisation of the degradation products, for the notified polymer and/or poly- and perfluoroalkyl degradation products (including PFHxA).

The assumed major degradation product, PFHxA, is environmentally persistent and has potential to be globally distributed. However, the ecotoxicological profile and bioaccumulation potential of PFHxA is considered to be less problematic when compared with long chain (C8 and above) perfluoroalkyl acids that PFHxA is expected to replace. Nonetheless, the introduction and use of chemicals that degrade to release PFHxA and other very persistent poly- and perfluoroalkyl compounds should be considered a short-term measure until suitable alternatives, with less persistent chemistry, are identified.

In order to limit the extent of direct release of potential PFHxA and long chain perfluorocarboxylic acid precursors to the environment, it is recommended that control measures be implemented to minimise the residual

weight percentage of unreacted polyfluoroalkyl monomer constituents and impurities in the notified polymer to the extent practicable. Where possible, the total weight of residual monomers and impurities in the notified polymer containing polyfluoroalkyl functionality should not exceed the levels attainable utilising international best practice. It is recommended that the levels remain within this range and are further reduced using available technological advances, to the extent practicable.

APPENDIX A: PHYSICAL AND CHEMICAL PROPERTIES

Water Extractivity < 0.62 mg/g at 20 °C for the test substance containing 13% the notified polymer

Method	OECD TG 120 Solution/Extraction Behaviour of Polymer in Water.
Remarks	Flask Method was used. The samples for extractivity analysis were prepared by agitation of the notified polymer/water mixtures (10 g/L) for 24 hours at 20°C, followed by centrifugation. The analysis was conducted using total fluorine analysis. The amount of fluorine present in solutions was below the detection limit of the method (3 mg/L). This suggested that the mean level of the test substance in the water extract was <6.2 mg/L. Based on the initially prepared test mixture of 10 g/L, the mean extractable fraction of the test substance was < 0.62 mg/g (6.2 mg/L ÷ 10 g/L). Therefore, the extractivity of the notified polymer was determined to be < 0.62 mg/g, which corresponds to the detection limit.
Test Facility	DuPont (2007a)

APPENDIX B: TOXICOLOGICAL INVESTIGATIONS

B.1. Acute toxicity – inhalation

TEST SUBSTANCE	Notified polymer (up to 25% concentration)
METHOD	OECD TG 403 Acute Inhalation Toxicity
Species/Strain	Rat/Crl:CD(SD)
Vehicle	None – administered as supplied
Method of Exposure	Nose-only exposure.
Exposure Period	4 hours
Physical Form	Liquid aerosol
Remarks - Method	No significant protocol deviations.

RESULTS

Group	*Number and Sex of Animals*	*Concentration (mg/m^3)*		*Mortality*
		Nominal	*Dry aerosol[1]*	
1	5M + 5F	2600*	1600	1/10
2	5M + 5F	5600**	3700	5/10

* MMAD±GSD: 4.5±3.2 µm (74% particles by mass < 10 µm)
** MMAD±GSD: 3.9±3.0 µm (81% particles by mass < 10 µm)
[1]corresponding to the concentration of the notified polymer

LC50	3700 mg/m^3/4 hours notified polymer/m^3/4 hours
Signs of Toxicity	One female exposed to 1600 mg/m^3/4 hours was found dead on day 3. One female exposed to 3700 mg/m^3/4 hours was found dead on day 2 with another two females at this concentration found dead on day 3. Two males exposed to 3700 mg/m^3/4 hours were found dead by day 1. Body weight losses were observed in both sexes from days 1 to 3 post exposure. Surviving animals continued to gain weight over the remainder of the observation period. Laboured breathing, lethargy, high posture, and hunched posture was observed in one female exposed to 1600 mg/m^3/4 hours (later found dead). Similar clinical signs were observed in animals treated at 3700 mg/m^3/4 hours (one male rat and four female rats). The male and three of the females were subsequently found dead.
Effects in Organs	Gross discolouration of the lungs was observed in most rats from both exposure concentrations. Three females in the 3700 mg/m^3/4 hours exposure group had fluid in the lungs.
Remarks - Results	The MMAD was for the 1600 mg/m^3/4 hours exposure concentration was measured slightly outside the 4 µm recommended by the test guideline. The test substance was still considered to be respirable based on the proportion of particles < 10 µm.
CONCLUSION	The notified polymer is harmful by inhalation.
TEST FACILITY	DuPont (2011)

B.2. Acute toxicity – inhalation (microscopic pathology)

TEST SUBSTANCE	Notified polymer at 20.4% concentration
METHOD	In-house protocol. The objective of the study was to determine the No Observed Adverse

	Effect Level (NOAEL) of the test substance at the microscopic histopathological level of evaluation on the respiratory tract following inhalation exposure. The test substance was administered as an aerosol for a single, 4-hour, nose-only exposure to groups consisting of 10 rats/sex at target concentrations of 0 (air control), 1.0, 50, and 500 mg/m³. For all exposure groups, 5 rats/sex were sacrificed one day following the exposure and the remaining 5 rats/sex were sacrificed 14 days following the exposure. All test animals were subject to gross pathological evaluation, and microscopic histopathological evaluation of the respiratory tract tissues. All test animals were observed each day for mortality and were weighed and observed for clinical signs of toxicity at least once a week.
Species/Strain	Rat/Crl:CD(SD) albino
Vehicle	Air
Method of Exposure	Nose-only exposure.
Exposure Period	4 hours
Physical Form	Liquid aerosol
Remarks - Method	For exposure doses targeted at 1.0 mg/m^3, the test substance was diluted 1:5 (v/v) with Milli-Q water before administration to facilitate the aerosol generation.

RESULTS

Group	*Number and Sex of Animals*	*Concentration (mg/m³)*		*Mortality*
		Nominal	*Actual*	
1	20 (10 M/10 F)	0	0	0/20
2	20 (10 M/10 F)	1.0	1.1 ± 0.26	0/20
3	20 (10 M/10 F)	50	47 ± 12	0/20
4	20 (10 M/10 F)	500	570 ± 45	0/20

LC50 > 570 mg/m^3/4 hours

Mortality and Time to Death

All animals survived the exposures in the study.

Clinical Observations

All animals displayed normal startle responses during the exposure. Sporadic and slight (< 4%) body weight changes were observed in exposure groups and the vehicle control group. One male and one female in the vehicle control group and two males from 47 mg/m³ exposure group had red discharge from the eyes. One day after the exposure, one female from the 1.1 mg/m^3 exposure group displayed hair loss.

Effects in Organs

There were no gross pathology findings for all animals at the scheduled necropsy.

In microscopic examinations, at Day 1 post the exposure, test substance-related degeneration/necrosis of the U-shaped cartilage of the ventral larynx was observed in most male and female rats in the actual 47 and 570 mg/m^3 exposure groups. In the 47 mg/m^3 group the lesions were mainly slight, while in the 570 mg/m^3 group the lesions were mild to moderate. Slight inflammation of the ventral laryngeal submucosa was also present mostly in males in these two exposure groups. Other laryngeal changes were limited to the 570 mg/m^3 group and included slight focal (ventral mucosa) epithelial hyperplasia in 3 of the 5 males and mild ulceration of the ventral laryngeal mucosa in 1 of the 5 males.

Following the 14-day recovery period, laryngeal changes were limited to degeneration/necrosis of the U-shaped cartilage (usually slight to mild) in the 570 mg/m^3 group. Laryngeal changes were considered to be test substance-related and adverse.

Microscopic changes in the trachea were limited to a minimal increase in density and/or size of hyaline droplets in the tracheal mucosa of 1 of 5 and 3 of 5 male rats in the 47 and 570 mg/m^3 groups, respectively, one day following the exposure. A similar finding was also observed in one male in the 47 mg/m^3 recovery group and

was considered by the study authors to be unlikely test substance-related. The minimal increase of hyaline droplets observed in the treatment groups was not associated with other changes in the trachea, such as cell injury; thus, was not considered by the study authors to be adverse.

Retention of enamel, characterized by the presence of amorphous, basophilic material in the enamel space of the distal incisor tooth, was present in male and female rats in the 47 and 570 mg/m^3 recovery groups. This observation was not associated with any other changes in the tooth structure or the enamel organ, and therefore was not considered by the study authors to be an adverse finding.

There were no test substance-related microscopic findings in respiratory tract tissues in the rats in the 1.1 mg/m^3 group.

Remarks – Results

Discharge from the eyes was considered by the study authors as commonly observed following acute nose only exposures and not to be test substance-related.

CONCLUSION The No Observed Adverse Effect Level (NOAEL) of the acute inhalation exposure to the test substance was determined as 1.1 mg/m^3/ 4 hours (equivalent to 0.22 mg/m^3/4 hours of the notified polymer) based on the microscopic histopathological changes observed in the test animals treated at higher dose levels.

TEST FACILITY DuPont (2013)

B.3. Skin sensitisation – mouse local lymph node assay (LLNA)

TEST SUBSTANCE Notified polymer at 20.8% concentration

METHOD OECD TG 429 Skin Sensitisation: Local Lymph Node Assay

Species/Strain Mouse/CBA/JHsd

Vehicle DMSO

Remarks - Method No significant protocol deviations were noted.

Dose concentrations in the study referred to the concentrations of the test substance containing 20.8% of the notified polymer.

Positive control: 25% hexylcinnamaldehyde (HCA) in DMSO

RESULTS

Dose concentration (% w/w)	*Concentration of the Notified polymer (% w/w)*	*Proliferative response (DPM/lymph node)*	*Stimulation Index (Test/Control Ratio)*
Test Substance			
0 (vehicle control)	0	703	1.00
5	1.04	482	0.68
25	5.2	730	1.04
50	10.4	433	0.62
100	20.8	277	0.39
Positive Control			
25	-	5173	7.35

Remarks - Results No statistically significant differences in mean body weights and body weight gains compared to the vehicle control group were observed at any test concentration. No clinical signs of toxicity were observed in the study.

Due to high DPM values for the vehicle control and high variability in the DPM values for several test concentration groups, additional groups of 5 animals dosed at the same concentrations were added by amendment and the LLNA was repeated. Results from the first assay were provided but

not used for interpretation of the results.

CONCLUSION — There was no evidence of induction of a lymphocyte proliferative response indicative of skin sensitisation to the notified polymer under the conditions of the test.

TEST FACILITY — DuPont (2008)

B.4. Subchronic Toxicity 90-Day Gavage Study with One Generation Reproductive Evaluation

TEST SUBSTANCE — Notified polymer (up to 25% concentration)

METHOD — US EPA, OPPTS 870.3100: 90-Day Oral Toxicity in Rodents; Health Effects Test Guidelines (1998)

Species/Strain — Crl:CD(SD) rats

Route of Administration — Oral – gavage

Exposure Information — For evaluation of sub-chronic toxicity
Exposure period: Females 96 days; Males 95 days

For evaluation of recovery from sub-chronic toxicity (one month and three month recovery)
Exposure period: 91-days

For evaluation of reproductive toxicity
Exposure period: Approximately 77 days premating, 14 days during mating, then during lactation and until weaning

Vehicle — None – administered as supplied

Remarks – Method — *Sub-chronic toxicity*
Following dosing, 10 males and 10 females from each group were sacrificed and necropsied. Of the remaining animals in each group, 10 males and 10 females from Groups I and IV were sacrificed and necropsied approximately one month after the last exposure. The remaining test animals (5 males and 5 females from each group) were sacrificed and necropsied 3 months after the last exposure.

Reproductive toxicity
Test animals were dosed daily for 77 days prior to mating then daily during the 14 day mating period. The P_1 male rats and female rats with no evidence of copulation or that did not deliver a litter, continued to be dosed following cohabitation period until the day before sacrifice. Pregnant females were dosed during the 3-week gestation period, but not if in the process of delivery or showing signs of delivery. Lactating females were dosed until the day before pups were weaned on postpartum day 21. The F_1 offspring were not dosed.

P1 parental females were sacrificed after weaning their litters (days 123-136). Non-pregnant females were sacrificed at the same time. P1 males were sacrificed approximately 2 weeks before the females (days 116-117).

Biochemical analysis
Following 10 or approximately 90 days of test substance administration, 5 animals per group were examined for hepatic peroxisomal β-oxidation activity.

RESULTS

Group	*Number and Sex of Animals*				*Dose (mg/kg bw/day)*	*Mortality*
	Recovery	*Sub-chronic*	*Repro*	*Biochem analysis*		
I	15 per sex	10 per sex	20 per sex	5 per sex	0	0

II	5 per sex	10 per sex	20 per sex	5 per sex	50	0
III	5 per sex	10 per sex	20 per sex	5 per sex	250	1
IV	15 per sex	10 per sex	20 per sex	5 per sex	1000	0

Subchronic toxicity study

No test substance-related adverse effects were observed in any of the dosed animals throughout either the sub-chronic toxicity or recovery periods of the study.

Effects on Parental (P) animals:

There were no test substance related systemic or reproductive effects on P generation rats.

Effects on 1st Filial Generation (F1)

There were no test substance effects that were attributed to treatment in the F1 generation.

No mortality or clinical signs in F1 test animals throughout post-weaning, except for one female from the 1000 mg/kg bw/day dose group that was accidentally killed on F1 test day 39. Six F1 pups of each sex died during the lactation period and were found to have lungs that were not expanded and to have a lack of a milk spot in the stomach. The study authors determined that the deaths were not test substance-related as there were one or two dead pups in each male or female dose group.

Microscopic findings

There were no microscopic evaluations of collected tissues from the F_1 adults. Microscopic examination of tissue from P1 adults was limited to the reproductive organs of mated pairs that failed to produce a litter. 19 of the 80 P1 adult pairs failed to produce a litter, but this was not considered by the test authors to be test substance-related. A morphological explanation of their infertility was found for 11 P1 rats pairs, but the cause of infertility in 8 pairs was not determined. Decreased ovarian corpora lutea and testicular degeneration were suggested causes and were said by the test authors to not be suggestive of a test substance-related effect.

Biochemical analysis findings

The test substance did not induce hepatic peroxisomal β-oxidation activity in male or female rats at any dose level.

CONCLUSION

The study authors reported that there were no adverse effects on reproductive endpoints in P_1 or F_1 (exposed to the test substance during gestation and lactation) test animals dosed up to 1000 mg/kg/day.

A no-observed-adverse-effect level (NOAEL) for subchronic toxicity endpoints and for reproductive endpoints in male and female rats were both 1000 mg/kg/day based on a lack of adverse, test substance-related effects on any main study or reproductive parameters.

TEST FACILITY DuPont (2007b)

B.5. Genotoxicity – bacteria

TEST SUBSTANCE Notified polymer at 20.4% concentration

METHOD Ministry of Labour, Japan: Standards for Mutagenicity Tests using Microorganisms; similar to OECD TG 471 Bacterial Reverse Mutation Test.

	Pre incubation procedure
Species/Strain	*S. typhimurium*: TA1535, TA1537, TA98, TA100 *E. coli*: WP2uvrA
Metabolic Activation System	Enzymatic fraction of phenobarbital and 5,6-benzoflavone induced rat liver homogenate.
Concentration Range in Main Test	a) With metabolic activation: 39 to 5,000 µg/plate b) Without metabolic activation: 0.61 to 313 µg/plate
Vehicle	Water
Remarks - Method	The purity of the notified chemical was considered in the preparation of the treatment. All dose levels were adjusted to 100% pure notified

polymer in the test.

Strain specific positive controls were used.

RESULTS

Metabolic Activation	*Test Substance Concentration (µg/plate) Resulting in:*			
	Cytotoxicity in Preliminary Test	*Cytotoxicity in Main Test*	*Precipitation*	*Genotoxic Effect*
Absent				
Test 1	≥ 20	-	> 5,000	Negative
Test 2	-	≥ 20	> 5,000	Negative
Present				
Test 1	≥ 1,250	-	> 5,000	Negative
Test 2	-	≥ 1,250	> 5,000	Negative

Remarks - Results

The test substance caused a visible reduction in the growth of the bacterial lawn to all of the bacterial tester strains without metabolic activation and all but WP2uvrA with metabolic activation. The test substance was tested up to 5000 µg/plate.

No significant increases in the frequency of revertant colonies were recorded for any of the bacterial strains, with any dose of the test substance, either with or without metabolic activation.

All the positive control chemicals used in the test induced marked increases in the frequency of revertant colonies thus confirming the activity of the S9-mix and the sensitivity of the bacterial strains.

CONCLUSION

The test substance was not mutagenic to bacteria under the conditions of the test.

TEST FACILITY

BML (2008)

B.6. Genotoxicity – in vitro

TEST SUBSTANCE

Notified polymer at 20.4% concentration

METHOD

OECD TG 476 In vitro Mammalian Cell Gene Mutation Test.

Species/Strain: Mouse

Cell Type/Cell Line: L5178Y/TK$^{+/-}$ Lymphoma

Metabolic Activation System: Rat S9 fraction from Aroclor 1254 induced rat liver

Vehicle: Distilled water

Remarks - Method

A preliminary toxicity assay was undertaken at concentrations of 0.5 to 5000 µg/mL in both the presence and absence of S9 activation with a 4 hour exposure and also without activation with a 24 hour exposure.
The concentration range chosen for the main test did not include a concentration exhibiting maximum toxicity.
An extended treatment assay in the presence of metabolic activation was not undertaken because no unique metabolic requirements were known for the notified polymer.

Metabolic Activation	*Test Substance Concentration (µg/mL)*	*Exposure Period*	*Harvest Time*
Absent			
Test 1	100, 250*, 500*, 750*, 1000*, 1500*, 2000	4 h	24/48
Test 2	100, 500*, 750*, 1000*, 1500*, 2000*	24 h	48/72
Present			
Test 1	100, 250*, 500*, 750*, 1000*, 1500*, 2000	4 h	24/48

*Cultures selected for metaphase analysis.

RESULTS

Metabolic Activation	*Test Substance Concentration (µg/mL) Resulting in:*			
	Cytotoxicity in Preliminary Test	*Cytotoxicity in Main Test*	*Precipitation*	*Genotoxic Effect*
Absent				
Test 1	5000	> 2000	≥ 1500	negative
Test 2	5000	≥ 1500	≥ 1500	negative
Present				
Test 1	5000	> 2000	≥ 1500	negative

Remarks - Results

Preliminary toxicity assay
Precipitation was observed at concentrations ≥ 1500 µg/mL.
Substantial toxicity was observed at 5000 µg/mL with and without S9 activation and with a 4-hour exposure, and without activation with a 24-hour exposure.

Main study
There was an absence of a concentration-related increase in mutant frequency.

CONCLUSION

The notified polymer was not clastogenic to mouse lymphocytes treated in vitro under the conditions of the test.

TEST FACILITY

BioReliance (2008)

APPENDIX C: ENVIRONMENTAL FATE AND ECOTOXICOLOGICAL INVESTIGATIONS

C.1. Environmental Fate

C.2. Ecotoxicological Investigations

C.2.1. Acute toxicity to fish

TEST SUBSTANCE	Test substance containing 20.4% the notified polymer and a surfactant at 1.44% active solids
METHOD	Static acute test - test guideline not provided
Species	*Oncorhynchus mykiss*
Exposure Period	96 hours
Auxiliary Solvent	Not applied
Water Hardness	100 -140 mg/L as $CaCO_3$, adjusted, filtered well water used
Analytical Monitoring	The actual concentrations were not measured
Remarks – Method	Test substance was added directly to well water for dilution to concentrations of 0.1, 1.0, 10, and 100 mg/L for the test substance, corresponding to nominal concentrations of 0.0204, 0.204, 2.04, and 20.4 mg/L for the notified polymer. One replicate, each with 5 fish, was used for each concentration level including the blank control. The test was conducted at 12.4-12.5°C using 16 hours light (220-336 lux) and 8 hours darkness scheme. For all the control and test groups, the oxygen level were maintain at 8.4 – 10.1 mg/L and the pH level was maintained at 7.3-7.8.

RESULTS

Concentration mg/L test substance	*Number of Fish*	*Mortality*			
Nominal		*24 h*	*48 h*	*72 h*	*96 h*
0	5	0	0	0	0
0.1	5	0	0	0	0
1	5	0	0	0	0
10	5	0	0	0	0
100	5	0	0	0	0

LC50	>100 mg/L test substance, or > 20.4 mg/L notified polymer at 96 hours.
NOEC	100 mg/L test substance, or 20.4 mg/L notified polymer at 96 hours.
Remarks – Results	The test did not follow a standard test guideline (e.g. OECD TG 203). It did not meet the validity criteria and requirements of OECD TG 203 (e.g. ≥ 7 fish each vessel, ≥ 5 test concentrations, two replicates, etc.). However, considering no mortality was observed in all of the control and test groups, this is considered acceptable. Based on the determined LC50 for the test substance, the LC50 for the notified polymer is expected to be > 20.4 mg/L. As it has not been demonstrated that the median effect concentration is > 100 mg/L, the notified polymer is considered potentially harmful to fish.
CONCLUSION	The notified polymer is considered potentially harmful to fish
TEST FACILITY	E.I. du Pont de Nemours and Company (2006a)

C.2.2. Acute toxicity to aquatic invertebrates

TEST SUBSTANCE	Test substance containing 20.4% the notified polymer and a surfactant at 1.44% active solids
METHOD	Static acute test - test guideline not provided

Species	*Daphnia magna*
Exposure Period	48 hours
Auxiliary Solvent	Not applied
Water Hardness	100 -140 mg/L as $CaCO_3$, adjusted, filtered well water used
Analytical Monitoring	The actual concentrations were not measured
Remarks - Method	The test substance was added directly to well water for dilution to concentrations of 0.1, 1.0, 10, and 100 mg/L for the test substance, corresponding to nominal concentrations of 0.0204, 0.204, 2.04, and 20.4 mg/L for the notified polymer. One replicate, each with 10 animals, was used for each concentration level including the blank control. The test was conducted at 20.1-20.3°C using 16 hours light (220-271 lux) and 8 hours darkness scheme. For all the control and test groups, the oxygen level were maintain at 8.0 – 8.3 mg/L and the pH level was maintained at 7.1-7.8. The EC50 was determined using method from Peltier, W. H. and Weber, C.I., Eds. (1985).

RESULTS

Concentration mg/L test substance Nominal	*Number of D. magna*	*Number Immobilised*	
		24 h	*48 h*
0	10	0	0
0.1	10	0	0
1	10	0	6
10	10	0	5
100	10	0	7

EC50	4.3 (95% CL 0.96 – 24.1) mg/L test substance, or 0.88 mg/L notified polymer at 48 hours.
Remarks - Results	The test did not follow a standard test guideline (e.g. OECD TG 202). It did not meet the requirements from OECD TG 202 (e.g. ≥ 20 animals). Therefore, the test results need to be taken with caution. The EC50 for the test substance was determined to be 4.3 (95% CL 0.96 – 24.1) mg/L. The EC50 is equivalent to a value of 0.88 mg/L for the notified polymer. In lack of any data for the potential effects from the surfactant (at low level of 1.44% of active solids), the notified polymer is conservatively considered to be very toxic to daphnids based on the determined EC50 value.

CONCLUSION The notified polymer is considered to be very toxic to daphnids

TEST FACILITY E.I. du Pont de Nemours and Company (2006b)

C.2.3. Acute toxicity to aquatic invertebrates

TEST SUBSTANCE Test substance containing 66.33% the notified polymer

METHOD OECD TG 202 *Daphnia* sp. Acute Immobilisation Test – Static Test

Species	*Daphnia magna*
Exposure Period	48 hours
Auxiliary Solvent	Not applied
Water Hardness	100 -140 mg/L as $CaCO_3$, adjusted, filtered well water used
Analytical Monitoring	The actual concentrations were not measured
Remarks - Method	The test was conducted according to the guidelines above and good laboratory practice (GLP) principles. No significant deviations from the test guidelines were reported. Predetermined amounts of the test substance were added directly to appropriate volumes of well water and stirring for approximately 30

minutes. The treatment solutions were clear and colourless with no visible precipitate.

RESULTS

Concentration mg/L test substance Nominal	*Number of D. magna*	*Number Immobilised*	
		24 h	*48 h*
7.5	20	0	0
15	20	0	0
30	20	0	1
60	20	0	0
120	20	0	0

EC50	> 120 mg/L test substance, or > 79.6 mg/L notified polymer at 48 hours
NOEC	120 mg/L
Remarks - Results	All validity criteria for the test were satisfied. The endpoint values were not calculated because immobility was less than 50% in all treatment solutions. EC50 and NOEC values were assessed by visual observations based on nominal concentrations. It was noticed that 20% of the test organisms in controls showed sublethal effect such as floating at the surface of the treatment solution. Based on the determined LC50 for the test substance, the EC50 for the notified polymer is expected to be < 100 mg/L. As it has not been demonstrated that the median effect concentration is > 100 mg/L, the notified polymer is considered potentially harmful to aquatic invertebrates.
CONCLUSION	The notified polymer is considered potentially harmful to aquatic invertebrates
TEST FACILITY	E.I. du Pont de Nemours and Company (2008)

C.2.4. Algal growth inhibition test

TEST SUBSTANCE	Test substance containing 20.4% the notified polymer and a surfactant at 1.44% active solids
METHOD	Static acute test - test guideline not provided
Species	*Pseudokirchneriella subcapitata*
Exposure Period	72 hours
Concentration Range	0.01, 0.1, 1.0, 10, and 100 mg/L for the test substance
Auxiliary Solvent	Not applied
Water Hardness	A synthetic algal-assay-procedure (AAP) nutrient medium was used as test medium
Analytical Monitoring	The actual concentrations were not measured
Remarks - Method	The test substance was added directly to AAP medium for dilution to concentrations of 0.01, 0.1, 1.0, 10, and 100 mg/L for the test substance, corresponding to nominal concentrations of 0.00204, 0.0204, 0.204, 2.04, and 20.4 mg/L for the notified polymer. Two replicates, each with algae at 10,000 cells/mL, were used for each concentration level including the blank control. The test was conducted under 23.6-23.7°C and 6860 - 7380 lux (mean value of 7212 lux) conditions. For all the control and test groups, the pH level was maintained at 7.55-7.98.

RESULTS

Biomass		*Growth*	
EC50	*NOEC*	*EC50*	*NOEC*

mg/L at 72 h	*mg/L*	*mg/L at 72 h*	*mg/L*
> 100	100	> 100	100

Remarks - Results

The test did not follow a standard test guideline (e.g. OECD TG 201). It meets the validity criteria for OECD TG 201. However, it did not meet all the requirements from OECD TG 201 (e.g. minimum of 3 replicates). This is considered acceptable considering no inhibition was observed at test levels no higher than 10 mg/L test substance, and 2% inhibition compared to the control was observed at the top test level of 100 mg/L test substance.

The EC50 values for both mass and growth for the test substance were determined to be > 100 mg/L, which is equivalent to a value of 20.4 mg/L for the notified polymer. The 72 h NOEC was determined to be 100 mg/L the test substance or 20.4 mg/L notified polymer.

As it has not been demonstrated that the median effect concentration is > 100 mg/L, the notified polymer is considered to potentially harmful to algae based on the determined EC50 value.

CONCLUSION The notified polymer is potentially harmful to algae

TEST FACILITY E.I. du Pont de Nemours and Company (2006c)

APPENDIX D: TOXICOLOGY OF PERFLUOROHEXANOIC ACID (PFHXA)

The following conclusions can be drawn from the data on PFHxA to assess health effects:

1. Absorption of PFHxA in mice and rats was rapid, with C_{max} achieved within 1 hour. Systemic exposure (AUC) was higher in males than in females in both mice and rats, probably as a result of the more rapid clearance in females than in males. Low levels of PFHxA were found in various rat tissues; these decreased rapidly and could not be detected in most tissues by 24 hours. Excretion of unchanged PFHxA was rapid and was largely via the urine. Most of the PFHxA was excreted via the urine within 24 hours, indicating almost 100% bioavailability. There was no evidence of bioaccumulation following repeat exposure in rats. Similar kinetics were observed in monkeys, with rapid absorption, similar exposure for males and females, and rapid and comprehensive urinary excretion of unchanged PFHxA. The volume of distribution in rats and monkeys indicates distribution mainly to extracellular fluid. The serum half-lives were 2.4/5.3 hours (male/female) in monkeys and 1/0.42 hours (male/female) in rats (Chengelis, 2009a; Gannon, 2011).
2. In a study comparing the toxicokinetics of PFHxA to PFOA following repeated oral exposure for 10 days, results indicate that the AUC was 9 times lower for PFHxA, which is attributed to the more rapid excretion of PFHxA. The half-life for PFHxA was 3 times lower than PFOA and persistence in the liver was much lower for PFHxA than PFOA (DuPont, 2003).
3. During seasonal use of ski wax, PFHxA levels in the blood of workers increased during the ski season, then decreased to below the detection limit following cessation of exposure. PFOA levels in blood were also monitored and were found at mostly stable concentrations before, during and after the ski season (elevated compared to the general population). These data suggest that clearance of PFHxA from blood occurs soon after cessation of exposure (Nilsson, 2010).
4. The acute toxicity of PFHxA was low, with an LD_{50} value of > 1750 mg/kg bw and < 5000 mg/kg bw in female rats. Males are expected to be more sensitive to PFHxA based on higher exposure (AUC) and an expected lower LD_{50} for males (Loveless, 2009). No information was available to assess acute dermal toxicity or acute inhalation toxicity.
5. In repeat dose oral toxicity studies in rats (14 days, 90 days), there was evidence of effects on the liver and decreased haematological parameters at 500 mg/kg bw/day, with liver effects in males at 100 mg/kg bw/day. Nasal lesions (degeneration and atrophy of the olfactory epithelium) were observed at 100 mg/kg bw/day and above in the 90-day study and the NOAEL was 20 mg/kg bw/day in both sexes (DuPont, 2006k; DuPont, 2007c, Chengelis, 2009b).
6. In a 2-year chronic toxicity/carcinogenicity study in rats, there were treatment-related systemic effects (increased incidence of struggling, and papillary necrosis and tubular degeneration of the kidneys) at 100/200 mg/kg bw/day (male/female). The NOAEL for non-neoplastic effects was 15/30 mg/kg bw/day (male/female). There was no evidence of carcinogenicity in either male or female rats (AGC Chemicals, 2010).
7. NaPFHx showed no effect on fertility parameters in a one-generation reproduction study in rats. The NOAEL for maternal systemic toxicity in the P1 animals was 100 mg/kg bw/day based on excessive body weight gain during lactation. There were no biologically significant adverse effects on pups (DuPont, 2007c).
8. In a developmental toxicity study with NaPFHx in rats, there was evidence of maternal (reduced body weight and body weight gain) and foetal toxicity (reduced neonatal bodyweight) at 500 mg/kg bw/day (DuPont, 2007d). In a second developmental toxicity study in mice with ammonium PFHx, foetal toxicity (increased incidence of still births, perinatal death, and microphthalmia and corneal opacity) was noted at 175 mg/kg bw/day in the absence of maternal toxicity. There was no toxicity in pups post-weaning. The NOAEL was 35 mg/kg bw/day (Daikin Industries, 2011).
9. No evidence of genotoxicity was observed in an *in vitro* mutagenicity assay in bacteria (DuPont, 2006i) or in a test for chromosome aberrations in human peripheral blood lymphocytes (DuPont 2006j).

The toxicology of PFOA has been characterised previously (Environment Canada, 2012; Chemical Safety Report, 2009). Comparative analysis of the toxicokinetics of PFHxA and PFOA indicated the following:

- Bioavailability of PFHxA and PFOA after oral administration was high.

- In repeat oral exposure studies, PFHxA showed no evidence of bioaccumulation, whereas PFOA showed some evidence of bioaccumulation.
- Excretion of PFHxA via the urine was rapid and virtually complete over 24 hours, whereas excretion of PFOA was slower, with only 20% excreted over 24 hours.
- Half-lives of excretion of PFHxA after oral exposure were 2–3 hours, whereas the excretion half-life of PFOA was 4.8 days.

Comparative analysis of the toxicity of PFHxA and PFOA indicated the following:

- The acute toxicities of PFHxA and PFOA were low.
- No data were available to compare eye and skin irritation or sensitisation.
- In 90-day repeat dose studies in rats, the LOAEL for PFHxA (100 mg/kg bw/day) occurred at higher doses than for PFOA (0.64 mg/kg bw/day).
- In chronic toxicity studies in rats, the LOAEL for PFHxA (100/200 mg/kg bw/day [m/f]) was higher than for PFOA (14.2/16.1 mg/kg bw/day [m/f]).
- Reproduction studies with PFHxA produced no effect on reproductive parameters with a NOAEL of 500 mg/kg bw/day, whereas PFOA produced increased mortality, decreased bodyweight and delayed sexual maturity in the F1 generation with a NOAEL of 10 mg/kg bw/day in females.
- The LOAEL was 175 mg/kg bw/day for developmental effects in a rat study with ammonium PFHx. The NOEL for developmental effects for PFOA was 150 mg/kg bw/day in a rat study.
- There was no evidence of genotoxicity for PFHxA or PFOA.
- A carcinogenicity study in rats with PFHxA produced no evidence of a treatment-related increase in tumours, whereas a study in rats with PFOA produced an increased tumour incidence in males. The US EPA considers PFOA is “likely to be carcinogenic to humans” (US EPA, 2012).

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