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**NATIONAL INDUSTRIAL CHEMICALS NOTIFICATION AND ASSESSMENT SCHEME
(NICNAS)**

PUBLIC REPORT

Polyfluorinated Polymer in HP Designjet Commercial and Industrial Printer Inks

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
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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/1667	Hewlett-Packard Australia Pty Ltd	Polyfluorinated Polymer in HP Designjet Commercial and Industrial Printer Inks	Yes	≤ 0.3 tonne per annum	Component of industrial and commercial printer ink

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.

<i>Hazard classification</i>	<i>Hazard statement</i>
Acute toxicity (Category 4)	H302 – Harmful if swallowed

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:

R22: Harmful if swallowed

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.

<i>Hazard classification</i>	<i>Hazard statement</i>
Acute Category 3	H402: Harmful to aquatic life

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 of perfluorohexanoic acid (PFHxA), which 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 (Russell *et al*, 2013). 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 and assessed use pattern, the notified polymer itself is not considered to directly pose an unreasonable short-term risk to the 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, 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 the long-term environmental risk profile of PFHxA is currently unknown. Consequently, the long-term risk profile for the notified polymer and its degradation products is unknown. This situation may change if further data on the environmental behaviour of the notified polymer and its poly- and perfluoroalkyl degradation products (including PFHxA) were to become available.

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 shows that PFHxA was not bioaccumulative in aquatic systems or humans (Russell *et al*, 2013). 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): H302 – Harmful if swallowed*

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

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:
 - Local ventilation systems, where possible
 - Enclosed, automated processes, 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:
 - Avoid contact with skin
 - Avoid breathing mists, vapours or sprays
 - 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:
 - Coveralls
 - Impervious gloves
 - Respiratory protection if ventilation is inadequate

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 perfluorinated 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 perfluorinated 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 300 kilograms per annum notified polymer;
 - the function or use of the polymer is changed from a component of inks;
 - the formulation of the product containing the notified polymer is changed;
 - additional information has become available on the repeat dose toxicity of the notified polymer;
 - additional information has become available to the person as to an adverse effect of the poly- or perfluoroalkyl degradation products of the notified polymer (such as PFHxA);
 - additional information has become available to the person as to the environmental fate of the polymer or its poly- or perfluoroalkyl degradation products (such as PFHxA) 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 chemical has changed from a component of paints and coatings, floor care and cleaning products, stone and tile sealants and inks, or is likely to change significantly;
 - the amount of chemical 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 Annotation

- 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

1. APPLICANT AND NOTIFICATION DETAILS

APPLICANT(S)

Hewlett-Packard Australia Pty Ltd (ABN 74 004 394 763)
355 Burwood Highway
Forest Hills VIC 3131

NOTIFICATION CATEGORY

Limited-small volume: Chemical other than polymer (1 tonne or less per year)

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, molecular weight, analytical data, degree of purity, polymer constituents, residual monomers, impurities, and import volume.

PREVIOUS NOTIFICATION IN AUSTRALIA BY APPLICANT(S)

None

NOTIFICATION IN OTHER COUNTRIES

China, Korea, USA, Europe, Taiwan and Japan

2. IDENTITY OF CHEMICAL

MARKETING NAME(S)

Fluorosurfactant in HP Designjet Commercial and Industrial Printer Inks (notified polymer up to 1% concentration)

MOLECULAR WEIGHT

> 500 Da

ANALYTICAL DATA

Reference IR spectra was provided.

3. COMPOSITION

DEGREE OF PURITY > 90%

LOSS OF MONOMERS, OTHER REACTANTS, ADDITIVES, IMPURITIES

Not expected to occur under normal conditions of use.

DEGRADATION PRODUCTS

Over time, the notified polymer is expected to ultimately degrade into perfluorohexanoic acid (PFHxA) - 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: Yellow/tan solid

Property	Value	Data Source/Justification
Melting Point/Freezing Point	40-50 °C	Measured
Density	1,290 kg/m ³	Measured
Vapour Pressure	0.24 kPa at 25.176°C	Measured
Water Solubility	0.168 g/L at 20 °C	Measured.
Hydrolysis as a Function of pH	Not determined	Does not contain hydrolysable functionality
Partition Coefficient (n-octanol/water)	log Pow = 4.39 – 4.89 at 20 °C	Measured. Based on its surface activity, the notified polymer is expected to partition between the

Adsorption/Desorption	$\log K_{oc} < 2.97$	octanol and water phases. Calculated. The notified polymer may have low absorption based on its surface activity and the perfluorinated functionality that has hydro/lipophobic tendencies.
Dissociation Constant	Not determined	Not expected to dissociate based on lack of dissociable functionality.
Flash Point	Not determined	Expected to be high based on the partial fluorination.
Flammability	Not determined	Not expected to be flammable based on the partial fluorination.
Autoignition Temperature	Not determined	Expected to decompose prior to any autoignition.
Explosive Properties	Not expected to be explosive	Contains no explosives.
Oxidising Properties	Not expected to be oxidising	Estimated based on structure.

DISCUSSION OF PROPERTIES

For full details of tests on physical and chemical properties, refer to Appendix A.

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 in printer cartridges or printheads as a component of finished printer ink (up to 1% concentration).

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

Year	1	2	3	4	5
Tonnes	≤ 0.3	≤ 0.3	≤ 0.3	≤ 0.3	≤ 0.3

PORT OF ENTRY

Melbourne and Sydney

TRANSPORTATION AND PACKAGING

The notified polymer (up to 1% concentration) will be imported by sea in printheads (25 mL or 100 mL) or printer cartridges (775 mL or 5000 mL) and transported by road within Australia.

USE

The notified chemical 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 chemical). The use categories of the notified polymer are identical to those of the existing polymer it replaces, as outlined below.

The notified will be used a component of commercial and industrial ink (up to 1% concentration). Printing is expected to occur mostly on canvas, shade cloth, paper and other substrates. Ink products containing the notified polymer will not be sold to the public.

OPERATION DESCRIPTION

The notified polymer will not be manufactured in Australia. The notified polymer will be imported in finished printheads and printer cartridges at up to 1% concentration. Transport workers will handle the packaged printheads and cartridges. Printing processes are expected to be mostly automated, with local exhaust

ventilation in place. Printer operators will manually change printheads and cartridges. Workers are also expected to manually handle printed items.

6. HUMAN HEALTH IMPLICATIONS

6.1. Exposure Assessment

The notified polymer is not expected to undergo significant degradation during use. 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 (up to 1%) and in the imported printer cartridges or printheads (up to 0.01%).

Over time, the notified polymer will break down and release PFHxA into the environment, which is likely to lead to secondary human exposure to PFHxA. This exposure is unquantifiable.

6.1.1. Occupational Exposure

CATEGORY OF WORKERS

<i>Category of Worker</i>	<i>Exposure Duration (hours/day)</i>	<i>Exposure Frequency (days/year)</i>
Transport and storage	4 – 8	200
Service technicians	8	200
Printer operators	0.5	5

EXPOSURE DETAILS

Transport and storage workers

Transport and storage workers will only come into contact with the notified polymer (up to 100% concentration) in the unlikely event of an accident.

Use in inks

Exposure of workers to the notified polymer (up to 1% concentration) during the use of ink products containing it is expected to be low due to the enclosed automated nature of the processes. Workers required to intervene in the process may undergo dermal, ocular and inhalation exposure. Service technicians are expected to wear disposable gloves. Systemic exposures may result from dermal contact with substrates to which ink containing the notified polymer has been applied, however, based on the relatively low concentration in the end-use products and the fact that the majority of the polymer will remain bound to the substrate to which it was applied, exposure is expected to be low.

6.1.2. Public Exposure

The public may make dermal contact with surfaces that have had inks containing the notified polymer applied to them. This exposure may be on a long term repeated basis. However, once applied the notified polymer will adhere to the substrate and is not expected to be available for exposure in significant quantities.

6.2. Human Health Effects Assessment

The results from toxicological investigations conducted on the notified polymer and an analogue are summarised in the table below. Details of these studies can be found in Appendix B.

<i>Endpoint</i>	<i>Test substance</i>	<i>Result and Assessment Conclusion</i>
Rat, acute oral toxicity	Notified polymer – variation 2	LD50 = 1,030 mg/kg bw; harmful
Rat, acute oral toxicity	Notified polymer – variation 1	LD50 = 550 mg/kg bw; harmful
Rat, acute oral toxicity	Notified polymer – variation 3	LD50 = 1,030 mg/kg bw; harmful
Rat, acute dermal toxicity	Notified polymer – variation 3	LD50 > 5,000 mg/kg bw; low toxicity
Rat, acute dermal toxicity	Notified polymer – variation 1	LD50 > 5,000 mg/kg bw; low toxicity
Rat, acute inhalation toxicity	Notified polymer – variation 1	LC50 > 5.9 mg/L/4 hour; low toxicity
Rabbit, skin irritation	Notified polymer – variation 3	non-irritating
Rabbit, skin irritation	Notified polymer – variation 1	non-irritating

Rabbit, skin irritation	Notified polymer – variation 2	non-irritating
Rabbit, eye irritation	Notified polymer – variation 1	slightly irritating
Rabbit, eye irritation	Notified polymer – variation 2	slightly irritating
Mouse, skin sensitisation – Local lymph node assay	Notified polymer – variation 1	no evidence of sensitisation
Mouse, skin sensitisation – Local lymph node assay	Notified polymer – variation 3	no evidence of sensitisation
Mutagenicity – bacterial reverse mutation	Notified polymer – variation 1	non mutagenic
Rat, Repeated dose toxicity – 90 day oral toxicity study with a one generation reproductive and developmental study	Analogue chemical	NOAEL (systemic) = 25 mg/kg bw/day NOAEL (reproductive and developmental) not established
Rat, one-generation reproductive toxicity study	Analogue chemical	NOAEL (systemic) > 25 mg/kg bw/day NOAEL (reproductive and developmental) > 25 mg/kg bw/day

Toxicokinetics, metabolism and distribution.

The notified polymer has a molecular weight of ~500 – 1,000 Da and has between 1 and 6% of low molecular weight species, which would suggest low to moderate dermal absorption. A moderate water solubility of 0.168 g/L at 20 °C favours dermal absorption but the relatively high partition coefficient (log Pow = 4.39 – 4.89 at 20 °C) suggests the rate of dermal penetration may be limited by the rate of transfer between the stratum corneum and the epidermis. The toxicity studies suggest that the notified polymer is absorbed both dermally and orally with systemic effects seen in the acute oral and reproductive studies following oral exposure to rats and also in the LLNA following dermal exposure to mice.

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 where some will be coughed or sneezed out with the balance swallowed.

Acute toxicity.

In three acute oral toxicity studies on different variations of the notified polymer it was found to be harmful, with LD50 values between 550 and 1,030 mg/kg bw.

There were no deaths or adverse test substance related effects in either of two acute dermal toxicity studies where the notified polymer was applied at a concentration of 5,000 mg/kg bw. In an LLNA study with the notified polymer, mice treated with a concentration of 100% lost 17-21% of their bodyweight by day 2 with clinical signs at lower concentrations including wet fur, dehydration and decreased faeces.

Inhalation toxicity

Perfluoroalkyl chemicals have been known to cause acute lung injury. Acute lung injury is characterised by respiratory problems ranging from mild to severe effects, including mortality, associated with acute or repeated exposures. Acute lung injury is generally considered to be of most concern when the compound has surface activity (Fischer et al., 2012).

In an acute inhalation toxicity study on the notified polymer no deaths occurred with the LD50 > 5.9 mg/L/4 hour and hence it is considered to be of low toxicity. At the high dose a number of clinical signs were noted, all of which had cleared by four days after dosing.

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 was non-irritating to the skin of rabbits in three separate tests on different variations of the polymer. In two separate eye irritation studies on two different variations of the notified polymer it was found to be slightly irritating to the eyes of rabbits with effects resolving in one study within 72 hours and in the other study within four days.

The potential for the notified polymer (up to 100% concentration) to cause skin sensitization was determined using two local lymph node assays. In one of the studies reductions in body weight and signs of toxicity necessitated euthanizing the animals treated with a concentration of 100% on day 2; however, in the other study at the same concentration signs of toxicity were not as severe and the animals could complete the study. No evidence of a positive lymphoproliferative response (relative stimulation index exceeding 3) was observed at any concentration in either of the studies. The notified polymer (up to 100% concentration) is unlikely to cause delayed contact hypersensitivity.

Repeated Dose Toxicity

In an oral repeated dose toxicity study combined with a one generation reproductive study, analogue 1 was administered to rats at doses of 0 (water), 25, 100 or 500 mg/kg bw/day for 90 days. Exposure to the test substance at doses of 100 or 500 mg/kg bw/day resulted in adverse treatment related effects. Adverse effects included changes in body weight and organ weight parameters, food efficiency, thyroid follicular hypertrophy, chronic progressive nephropathy, clinical signs, liver enzyme and red blood cell parameters. There were no adverse systemic effects on the parental animals at the lowest dose of 25 mg/kg bw/day, which was therefore the NOAEL for the study.

A second one generation reproductive study with analogue 1 was conducted on rats at doses of 0 (water), 1, 10 or 25 mg/kg bw/day to investigate the effects seen in the above study. In this study statistically significant test substance related increases in the liver weight relative to body weight were seen in both male and female animals dosed with 25 mg/kg bw/day of the test substance. Compared to the control group, the increase in the liver weight relative to body weight was 110 and 114% for male and female rats in the 25 mg/kg bw/day group, respectively. In the absence of histopathological or clinical chemical changes indicative of liver injury the study authors considered the liver weight increases to be a physiologic response to metabolism of a xenobiotic and not toxicologically adverse. Therefore, the NOAEL for systemic effects in both male and female animals was set at the highest dose tested of 25 mg/kg bw/day.

Mutagenicity

A bacterial reverse mutation assay was conducted according to the plate incorporation method. The notified polymer 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), at concentrations ranging from 33.3 to 5000 µg/plate in dimethyl sulfoxide. 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 was not mutagenic under the conditions of this in vitro assay.

Toxicity for reproduction

In an oral repeated dose toxicity study combined with a one generation reproductive study, analogue 1 was administered to rats at doses of 0 (water), 25, 100 or 500 mg/kg bw/day. Reproductive effects included a significant reduction in the number of implantation sites in the 500 mg/kg bw/day dose group in comparison to the control group and a reduction in the fertility index at all doses in comparison to the control group. Adverse effects in the F1 generation were seen in the 100 and 500 mg/kg bw/day dose groups and consisted of reductions in the mean litter size, number of pups born and born alive, pup survival and pup weight. Based on the presence of adverse reproductive effects at all of the doses tested in this study a NOAEL for reproductive and neonatal toxicity could not be set.

A second one generation reproductive study with the analogue chemical was conducted on rats at doses of 0 (water), 1, 10 or 25 mg/kg bw/day to investigate the effects seen in the above study. Based on the absence of adverse effects on any reproductive parameters or on the F1 offspring the NOAEL for reproductive and neonatal toxicity in this study was 25 mg/kg bw/day, which was also the NOAEL for systemic toxicity in the parental animals.

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 table below.

<i>Hazard classification</i>	<i>Hazard statement</i>
Acute toxicity (Category 4)	H302 – Harmful if swallowed

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:

R22: Harmful if swallowed

Toxicology of break down products

The notified polymer contains perfluoroalkyl side-chains that are potential precursors of PFHxA in the environment (PFHxA; CAS No. 307-24-4), a perfluorinated chemical 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 if swallowed, with all other toxicology studies on the notified polymer indicating low hazard. An analogue of the notified polymer was shown to have a NOAEL of 25 mg/kg bw/day after repeated oral exposure.

The notified polymer is expected to be absorbed dermally and therefore workers exposed to the polymer at up to a 1% concentration during use of printing inks containing it could be at risk of systemic toxicity. However, printing processes are expected to be predominantly automated and enclosed with local exhaust ventilation in place. In addition, service technicians are expected to use disposable gloves, thereby reducing dermal exposure. Based on the automated and enclosed nature of the processes, the relatively low concentration of the notified polymer in the end use products, and the use of PPE the risk of systemic toxicity to workers is not considered to be unreasonable.

Workers may also be exposed to per- and polyfluoroalkyl impurities of the notified polymer at relatively low concentrations (< 0.01%). 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 also be exposed to the notified polymer and low levels of per- and polyfluoroalkyl impurities from direct dermal contact with articles that have been printed with inks containing the notified polymer. This exposure may be on a long term repeated basis. However, dermal transfer from the treated article is expected to be low as the notified polymer will be present at low concentrations and will predominantly remain absorbed to the substrate to which it was applied. Thus the risk to public health from repeated dermal exposure to the notified polymer from treated articles is not considered to be unreasonable. The risk to public health from long term repeated dermal exposure to per- and polyfluoroalkyl impurities of the notified polymer from treated articles may be mitigated by the relatively low concentrations at which they are present in end use

products.

The public may be exposed indirectly to the ultimate break down product of the notified polymer, PFHxA, via 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 perfluorinated chemicals that are the ultimate break down products of the majority of perfluorinated polymers currently in Australian commerce (such as PFOA). In particular, it is noted that the polymer being replaced contains perfluorinated carbon chain lengths > 6. It is concluded that the risks to human health from indirect exposure to breakdown products of perfluorinated chemicals will decrease following introduction of the notified polymer, on the basis that the notified polymer is intended to replace a currently available “long” chain perfluorinated polymer.

It should also be noted that the notified polymer has been approved for the same uses in the USA for a manufacture/import volume greater than the volume 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 not be manufactured, reformulated or repackaged in Australia. Therefore, releases to the environment are not expected from this activity. Releases to the environment may occur following accidental spills during import, transport or storage. Any notified polymer that is spilled is expected to be adsorbed onto a suitable material and collected for disposal in accordance with local regulations.

RELEASE OF CHEMICAL FROM USE

The majority of the notified polymer is expected to be printed onto canvas, shade cloth and a variety of other substrates. Up to 3% of the notified polymer is expected to be used for printing on paper. Limited release to the sewer is expected during use. Once applied to the substrates, the notified polymer is expected to remain bound the substrates. Release of the notified polymer may occur as a result of equipment cleaning activities or accidental spills (up to 0.3% of the total import volume). Any notified polymer that is spilled is expected to be adsorbed onto a suitable material and collected for disposal in accordance with local regulations.

RELEASE OF CHEMICAL FROM DISPOSAL

Residues in empty cartridges are expected to account for up to 2 % of the total import volume of the notified polymer and these residues are expected to be disposed of to landfill along with the empty cartridge.

For the notified polymer that will be in ink printed onto paper, it is assumed that 50% of the printed paper will end up in landfill and the rest will undergo paper recycling processes. During recycling processes, waste paper will be repulped using a variety of chemical agents, which, amongst other things, enhance detachment of inks from the fibres. Therefore, up to 1.5% of the total import volume of the notified polymer is expected to be released to sewer as a result of paper recycling.

For other surfaces to which ink is applied, the majority of the notified polymer is expected to adhere to the printed surface. Printed articles and other dried residues containing the notified polymer are expected to ultimately be disposed of to landfill.

7.1.2. Environmental Fate

For details of the environmental fate studies please refer to Appendix C.

The majority of the notified polymer is expected to adhere to the printed surface to which it is applied. Printed articles and other dried residues containing the notified polymer are expected to ultimately be disposed of to landfill. 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.

Some of the notified polymer may be released to sewer from paper recycling. In general, surfactants have the potential to be removed from wastewater and influent in sewage treatment plants (STP) via partitioning to phase

boundaries. Predictions of the environmental partitioning behaviour of polyfluoroalkyl surfactants 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 perfluorinated functionality as they assume lipophilicity for hydrophobic functionality, whereas the perfluorinated 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 chemical. Thus, noting its potential to disperse in water, a significant proportion of the notified polymer, and any associated impurities/residual monomers of poly- and perfluoroalkyl compounds, may well remain in the aqueous phase following wastewater treatment. As such, the notified polymer and the poly- and 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.

Over time, the notified polymer is expected to become dissociated from the printed articles. The notified polymer has the potential to disperse in water but it is not expected to hydrolyse under environmental conditions (pH 4 to 9, 25 °C) based on structural considerations. A test study indicates that the notified polymer is rapidly degradable, achieving 62% degradation in 28 days but failing the 10-day window criteria. Degradation products are not known for certain as no characterisation of the degradation products was undertaken in the biodegradation test. A recent paper found that close analogues of the notified polymer undergo rapid biotransformation via a chain shortening mechanism (see Exempt Information). However, the notified polymer is not expected to completely mineralise and degradation products may include more stable lower molecular weight polymers with per- and polyfluoroalkyl functionality or the very persistent perfluorinated degradation product PFHxA. Therefore, the notified polymer has the potential to release the PFHxA after only a short period of time.

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 per- and polyfluoroalkyl functionality. The expected initial per- and polyfluoroalkyl degradation products are assumed to undergo further degradation to form, among other compounds, the very persistent perfluorinated 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 impurities that may degrade to form perfluorooctanoic acid (PFOA) and other long-chain per- and polyfluorocarboxylic 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 such as perfluoroacetic acid, fluorinated dioxins and furans. 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.

The notified polymer has the potential to bioaccumulate based on its molecular weight and n-octanol/water partition coefficient. Generally, a log Pow of > 4.2 indicates a potential for bioaccumulation as high values indicate a tendency to partition to lipids while a low value indicates a tendency to partition to water. However, this also assumes lipophilicity of the hydrophobic functionality which does not apply to perfluoroalkyl functionality. Certain perfluoroalkyl compounds are known to accumulate in the blood and liver rather than lipids in biological systems (Danish EPA, 2008). As perfluoroalkyl compounds do not follow the usual mechanism for bioaccumulation and are not expected to bioaccumulate in lipids, and because of the notified polymer's surface-active properties, the n-octanol-water partition coefficient is not considered to be a reliable indicator of bioaccumulation potential for the notified polymer. Further, the notified polymer has the potential to undergo degradation and biotransformation in the environment, reducing its potential 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 perfluoroalkyl 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.*, 2008ab; Wang *et al.*, 2008). In aquatic biota, there is little evidence of increased bioconcentration of PFOA compared with PFHxA although PFOA may generally be expected to be found in aquatic organisms more often than PFHxA. In general, the available evidence indicates that the bioaccumulation potential of perfluorinated compounds is correlated with increasing fluorinated carbon chain length (Giesy *et al.*, 2010). Therefore, PFHxA has a lower bioaccumulation potential than PFOA and other long chain perfluorinated compounds, which PFHxA-based chemistry is replacing.

7.1.3. Predicted Environmental Concentration (PEC)

The predicted environmental concentration (PEC) is outlined in the table below. Assuming the entire import volume of the notified polymer will be used in ink printed on paper under a worst-case scenario, up to 50% of the notified polymer is expected to be released to sewer from recycling of printed paper products. Release from this activity is expected to occur nationwide over 260 days per year. Assuming no removal during sewage treatment plant (STP) processes, the PEC is calculated as follows:

<i>Predicted Environmental Concentration (PEC) for the Aquatic Compartment</i>		
Total Annual Import	300	kg/year
Proportion expected to be released to sewer	50%	
Annual quantity of chemical released to sewer	150	kg/year
Days per year where release occurs	260	days/year
Daily chemical release:	0.58	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
Dilution Factor - River	1	
Dilution Factor - Ocean	10	
PEC - River:	0.13	µg/
PEC - Ocean:	0.013	µg/L

STP effluent re-use for irrigation occurs throughout Australia. The agricultural irrigation application rate is assumed to be 1000 L/m²/year (10 ML/ha/year). The notified polymer in this volume is assumed to infiltrate and accumulate in the top 10 cm of soil (density 1500 kg/m³). Using these assumptions, irrigation with a concentration of 0.128 µg/L may potentially result in a soil concentration of approximately 0.85 µg/kg. Assuming accumulation of the notified polymer in soil for 5 and 10 years under repeated irrigation, the concentration of notified polymer in the applied soil in 5 and 10 years may be approximately 4.2 µg/kg and 8.5 µg/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 as characterisation of the degradation products was not undertaken in the biodegradation study. 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. As use of chemicals that degrade to form PFHxA increases, levels of PFHxA may build up further in the environment.

PFHxA and other poly- and perfluoroalkyl substances 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 compounds, 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 so far been found to be indeterminate (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 characterisation was not undertaken in the biodegradation study. 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

Ecotoxicological data for the notified polymer are summarised in the table below. Details of the studies can be found in Appendix C.

<i>Endpoint</i>	<i>Result</i>	<i>Assessment Conclusion</i>
Fish Toxicity		
Rainbow trout	96 h LC50 = 36.7 mg/L	Harmful to fish
Rainbow trout	96 h LC50 = 33.5 mg/L	
Invertebrate Toxicity		
<i>Daphnia magna</i>	48 h EC50 = 28.8 mg/L	Harmful to aquatic organisms
Algal Toxicity		
Green algae	72 h EC50 = 88.3 mg/L 72 h NOEC = 27.5 mg/L	Harmful to algae

Based on the measured data, the notified polymer is considered harmful to fish, aquatic invertebrates and algae on an acute basis. 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”. The long-term hazard has not been measured for the notified polymer, therefore the notified polymer is not formally classified under the GHS. Based on the rapid degradability of the notified polymer, it is not classified under the GHS for long term hazard.

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 most sensitive ecotoxicological endpoint for the notified polymer was the 48-hour median effect concentration (48 h EC50) for daphnia. This endpoint was used to calculate the predicted no-effect concentration (PNEC). An assessment factor of 100 was used as measured data was available for three trophic levels.

Predicted No-Effect Concentration (PNEC) for the Aquatic Compartment			
EC50 (<i>Daphnia</i> ; 48 h)	28.8	mg/L	
Assessment Factor	100		
PNEC:	288	µg/L	

7.3. Environmental Risk Assessment

Risk assessment	PEC µg/L	PNEC µg/L	Q
Q - River	0.13	288	<< 0.01
Q - Ocean	0.013	288	<< 0.01

Based on a worst-case scenario where 50% of the total import volume of the notified polymer is released to sewer from paper recycling, the risk quotients (Q) for river and marine waters are much less than 1, indicating the notified polymer will not be present at ecotoxicologically significant concentrations in surface waters. The polymer itself is rapidly degradable. It is not expected to persist in the environment therefore reducing its potential to bioaccumulate. However, the notified polymer is assumed to 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: $t_{1/2}$ (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. . To date, the available data on environmental concentrations of PFHxA indicate a low risk of environmental toxicity. However, the long-term environmental risk profile of PFHxA is currently unknown, and further long term research should ideally be undertaken to characterise this risk.

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. 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, to the extent possible.

Conclusions

On the basis of the PEC/PNEC ratio and assessed use pattern, 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, 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 the long-term environmental risk profile of PFHxA is currently unknown. Consequently, the long-term risk profile of the notified polymer and its degradation products is unknown. This situation may change if further data on the environmental behaviour of the notified polymer and its poly- and perfluoroalkylated degradation products (including PFHxA) were to become available.

The notified polymer is a potential precursor for PFHxA in the environment, 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, it is recommended that 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**Vapour Pressure** 0.24 kPa at 25.176 °C

Method	In house method
Remarks	A sample was loaded into a static cell which was degassed at 0 °C before being heated to 150 °C whilst measuring the pressure.
Test Facility	Not specified

Water Solubility 0.168 g/L at 20 °C
0.142 g/L at 12 °C

Method	In-house method
Remarks	Six separate 100 – 104 mg samples of test substance were added to 200 mL of Haskell Well Water (HWW) and stirred for 25 hours at 12 and 20 °C. The samples were centrifuged and aliquots of the supernatant were analysed by LC/MS resulting in well-resolved peaks. The initial study produced a higher than expected solubility of the test substance at 12 °C, likely due to the difficulty separating the solution and test substance after centrifuging. An additional solubility study was performed at 12 °C by adding approximately 35 mg of test substance to 200 mL of HWW in triplicate. The resulting solubility from the additional study was determined to be more representative of the solubility of the test substance.
Test Facility	DuPont (2012)

Partition Coefficient (n-octanol/water) log Pow = 4.39 to 4.89 at 20 °C

Method	OECD TG 117 Partition Coefficient (n-octanol/water).
Remarks	HPLC Method. The test substance was eluted as a series of peaks. Minimal peak tailing was observed at the end of the series.
Test Facility	DuPont (Unspecified date)

Adsorption/Desorption log K_{oc} < 2.97

Method	Calculated using the Chiou equation and Kenaga equation
Remarks	The Chiou equation is used for halogenated molecules and the Kenaga equation is used for a variety of organic molecules. Both equations rely on knowledge of the solubility of the molecule. The equations are as follows: Chiou equation: $\log K_{oc} = -0.557 \times \log S + 4.277$ (where S = solubility in $\mu\text{mol/L}$) Kenaga equation: $\log K_{oc} = -0.55 \times \log S + 3.64$ (where S = solubility in mg/L)
Test Facility	Calculated by DuPont

Stability Stable up to 96 hours at 6 °C and 20 °C

Method	In-house method
Remarks	25.3 mg of the test substance was added to 500 mL of Haskell Well Water (HWW). After stirring the solution, stability solutions were prepared in HWW up to nominal concentrations of 1.00 mg test substance/L. One solution was refrigerated at 6 °C for 96 hours and the other was kept at a temperature of 20 °C for 96 hours.
Test Facility	DuPont (2012)

APPENDIX B: TOXICOLOGICAL INVESTIGATIONS

B.1. Acute toxicity – oral

TEST SUBSTANCE	Notified polymer – variation 2
METHOD	OECD TG 425 Acute Oral Toxicity: Up-and-Down Procedure
Species/Strain	Rat/Sprague-Dawley
Vehicle	None
Remarks - Method	No significant protocol deviations.

RESULTS

<i>Group</i>	<i>Number and Sex of Animals</i>	<i>Dose mg/kg bw</i>	<i>Mortality</i>
1	1 female	5000	1/1
2	1 female	175	0/1
3	1 female	550	0/1
4	1 female	1750	1/1
5	1 female	550	0/1
6	1 female	1750	1/1
7	1 female	550	0/1
8	1 female	1750	1/1

LD50 1030 mg/kg bw

Signs of Toxicity No signs of toxicity were observed in the animal treated at 175 mg/kg bw. Hypoactivity and piloerection were observed on the first day in animals treated at 550 and 1750 mg/kg bw, with abnormal gait observed in animals treated at 1750 mg/kg bw. The 550 mg/kg bw animals appeared healthy for the remainder of the study period and a weight gain was observed. Mortalities occurred within 3 days for the animals treated at 1750 mg/kg bw and on day 1 for the 5000 mg/kg bw animal.

Effects in Organs Red intestines were observed in animals treated at 1750 and 5000 mg/kg bw.

CONCLUSION The notified polymer is harmful via the oral route.

TEST FACILITY Eurofins (2010a)

B.2. Acute toxicity – oral

TEST SUBSTANCE	Notified polymer – variation 1
METHOD	OECD TG 425 Acute Oral Toxicity: Up-and-Down Procedure.
Species/Strain	Rat/Sprague-Dawley
Vehicle	Administered as received
Remarks - Method	No significant protocol deviations.

RESULTS

<i>Group</i>	<i>Number and Sex of Animals</i>	<i>Dose mg/kg bw</i>	<i>Mortality</i>
1	1 female	5,000	1/1
2	2 female	175	0/2
3	4 female	550	1/4
4	3 female	1,750	3/3

LD50 550 mg/kg bw

Signs of Toxicity In the animals treated at 175 mg/kg bw, hypoactivity, hunched posture

Effects in Organs	and reduced faecal volume were observed. In the 550 mg/kg bw dose group one animal died on the first day with hypoactivity and piloerection noted prior to death. Clinical signs noted in the surviving rats in the 550 mg/kg bw dose group were hypoactivity, piloerection, hunched posture, ano-genital staining and reduced faecal volume. In the 1,750 and 5,000 mg/kg bw groups all animals died within 1 day of dosing, with clinical signs prior to death including hypoactivity, abnormal posture and gait and piloerection.
Remarks - Results	No gross abnormalities were noted in animals that survived to the end of the study. In animals that died prematurely red discoloration of the intestines was noted.
CONCLUSION	All surviving animals gained weight over the course of the study.
TEST FACILITY	The notified polymer is harmful via the oral route.
	Eurofins (2010b)

B.3. Acute toxicity – oral

TEST SUBSTANCE	Notified polymer – variation 3
METHOD	OECD TG 425 Acute Oral Toxicity: Up-and-Down Procedure.
Species/Strain	Rat/Crl:CD(SD)
Vehicle	Test substance administered as supplied.
Remarks - Method	No significant protocol deviations.

RESULTS

<i>Group</i>	<i>Number and Sex of Animals</i>	<i>Dose mg/kg bw</i>	<i>Mortality</i>
1	1 female	175	0/1
2	3 female	550	0/3
3	3 female	1,750	3/3

LD50	1,030 mg/kg bw
Signs of Toxicity	In the animal treated at 175 mg/kg bw, ataxia, decreased muscle tone, low posture, pupil mydriasis (prolonged dilation), curled toes, splayed limbs, bobbing head and abnormal gait were observed for up to 1 day after dosing. In the animals treated at 550 mg/kg bw, ataxia, decreased muscle tone, high or low posture, pupil mydriasis (prolonged dilation), fast breathing, stained skin/fur, splayed limbs, bobbing head, paralysis and abnormal gait were observed for up to 2 days after dosing. All 3 rats dosed at 1,750 mg/kg bw died on the first day, with clinical signs including ataxia, cold to touch, immobility, moribundity decreased muscle tone, paralysis, low posture, pupil mydriasis (prolonged dilation), abnormal breathing, wet fur, salivation, splayed limbs and abnormal gait were observed.
Effects in Organs	No gross abnormalities were noted in animals that survived to the end of the study. In one animal that died prematurely red discoloration of the intestines and nose and a white substance in the esophagus was noted.
Remarks - Results	All surviving animals gained weight over the course of the study.
CONCLUSION	The notified polymer is harmful via the oral route.
TEST FACILITY	DuPont (2010a)

B.4. Acute toxicity – dermal

TEST SUBSTANCE	Notified polymer – variation 3
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METHOD	OECD TG 402 Acute Dermal Toxicity – Limit Test
Species/Strain	Rat/Crl:CD(SD)
Vehicle	None
Type of dressing	Semi-occlusive
Remarks - Method	No significant protocol deviations.

RESULTS

<i>Group</i>	<i>Number and Sex of Animals</i>	<i>Dose mg/kg bw</i>	<i>Mortality</i>
1	5 per sex	5000	0/10

LD50	> 5,000 mg/kg bw
Signs of Toxicity - Local	None
Signs of Toxicity - Systemic	None
Effects in Organs	A single incidence of kidney dilation was observed at necropsy but was considered to be a common finding in rats and was not considered to be treatment related.

CONCLUSION The notified polymer is of low toxicity via the dermal route.

TEST FACILITY DuPont (2010b)

B.5. Acute toxicity – dermal

TEST SUBSTANCE Notified polymer – variation 1

METHOD	OECD TG 402 Acute Dermal Toxicity.
Species/Strain	Rat/Sprague-Dawley
Vehicle	Test substance administered as supplied
Type of dressing	Semi-occlusive.
Remarks - Method	No significant protocol deviations.

RESULTS

<i>Group</i>	<i>Number and Sex of Animals</i>	<i>Dose mg/kg bw</i>	<i>Mortality</i>
1	5 per sex	5,000	0/10

LD50	> 5,000 mg/kg bw
Signs of Toxicity - Local	There were no test substance related dermal reactions.
Signs of Toxicity - Systemic	There were no deaths or test substance related clinical signs.
Effects in Organs	No gross abnormalities were noted upon necropsy at the end of the study.
Remarks - Results	All animals gained weight during the course of the study.

CONCLUSION The notified polymer is of low toxicity via the dermal route.

TEST FACILITY Eurofins (2010c)

B.6. Acute toxicity – inhalation

TEST SUBSTANCE Notified polymer – variation 1

METHOD	Equivalent to OECD TG 403 Acute Inhalation Toxicity
Species/Strain	Rat/Crl:CD(SD)
Vehicle	None
Method of Exposure	Nose-only exposure
Exposure Period	4 hours
Physical Form	liquid aerosol
Particle Size	MMAD = 1.1-1.8 µm (GSD = 2.0)

Remarks - Method

Necropsy was not conducted for this study.

RESULTS

<i>Group</i>	<i>Number and Sex of Animals</i>	<i>Concentration (mg/L)</i>	<i>Mortality</i>
1	5 male	0.61 ± 0.29	0/5
2	5 male	5.9 ± 1.0	0/5

LC50

Signs of Toxicity

> 5.9 mg/L

There were no mortalities in the study. Just after exposure, red discharge from the nose and eyes, and a clear discharge from the mouth were observed in animals treated at 0.61 mg/L but were considered to be related to nose-only administration and therefore not related to treatment. Slight weight loss (1-7 g) was observed over the first day in the group but body weight increases were observed on day 2.

Lethargy, laboured breathing and lung noise were observed in the animals treated at 5.9 mg/L but resolved within one day. Additional signs of toxicity include red discharge from the nose, ruffled fur, irregular respiration, wet perineum and red stain on the face, resolving by day 4. Animals in this group lost body weight (41-42 g) after exposure with body weight gains occurring on day 3.

CONCLUSION

The notified polymer is of low toxicity via inhalation.

TEST FACILITY

DuPont (2010c)

B.7. Irritation – skin

TEST SUBSTANCE

Notified polymer – variation 3

METHOD

Species/Strain
Number of Animals
Vehicle
Observation Period
Type of Dressing
Remarks - Method

OECD TG 404 Acute Dermal Irritation/Corrosion
Rabbit/New Zealand White
3 Females
None
72 Hours
Semi-occlusive
No significant protocol deviations

RESULTS

Remarks - Results

Erythema and oedema scores were zero for all animals at all observation points.

CONCLUSION

The notified polymer is non-irritating to the skin.

TEST FACILITY

Eurofins (2010d)

B.8. Irritation – skin

TEST SUBSTANCE

Notified polymer – variation 1

METHOD

Species/Strain
Number of Animals
Vehicle
Observation Period
Type of Dressing
Remarks - Method

OECD TG 404 Acute Dermal Irritation/Corrosion.
Rabbit/New Zealand White
3 (1 Male and 2 females)
Test substance administered as supplied
72 Hours
Semi-occlusive.
No significant protocol deviations.

RESULTS

Remarks - Results There were no deaths or test substance-related clinical signs or remarkable body weight changes during the study period. No signs of erythema or oedema were observed at any time.

CONCLUSION The notified polymer is non-irritating to the skin.

TEST FACILITY Eurofins (2010e)

B.9. Irritation – skin

TEST SUBSTANCE Notified polymer – variation 2

METHOD OECD TG 404 Acute Dermal Irritation/Corrosion.
 Species/Strain Rabbit/New Zealand White
 Number of Animals 3 Females
 Vehicle Test substance administered as supplied.
 Observation Period 72 Hours
 Type of Dressing Semi-occlusive.
 Remarks - Method No significant protocol deviations.

RESULTS

Remarks - Results There were no deaths or test substance-related clinical signs or remarkable body weight changes during the study period. No signs of erythema or oedema were observed at any time.

CONCLUSION The notified polymer is non-irritating to the skin.

TEST FACILITY Eurofins (2010f)

B.10. Irritation – eye

TEST SUBSTANCE Notified polymer – variation 1

METHOD OECD TG 405 Acute Eye Irritation/Corrosion
 Species/Strain Rabbit/New Zealand White
 Number of Animals 3 male
 Observation Period 72 hours
 Remarks - Method Prior to instillation of the test substance, two to three drops of ocular anaesthetic (tetracaine hydrochloride 0.5%) were placed into both eyes of each animal.

RESULTS

Lesion	Mean Score* Animal No.			Maximum Value	Maximum Duration of Any Effect	Maximum Value at End of Observation Period
	1	2	3			
Conjunctiva: redness	1.0	1.0	1.0	2	< 72 hours	0
Conjunctiva: chemosis	0.3	0.3	0	1	< 48 hours	0
Conjunctiva: discharge	1.0	0.7	0.7	2	< 72 hours	0
Corneal opacity	0	0	0	0	no effect	no effect
Iridial inflammation	0	0	0	0	no effect	no effect

*Calculated on the basis of the scores at 24, 48, and 72 hours for EACH animal.

Remarks - Results Irritant effects observed were reversible within 3 days and were below levels required for classification.

CONCLUSION The notified polymer is slightly irritating to the eye.

TEST FACILITY Eurofins (2010g)

B.11. Irritation – eye

TEST SUBSTANCE Notified polymer – variation 2

METHOD OECD TG 405 Acute Eye Irritation/Corrosion.
 Species/Strain Rabbit/New Zealand White
 Number of Animals 3 males
 Observation Period 4 days
 Remarks - Method Prior to instillation of the test substance, two to three drops of ocular anaesthetic (tetracaine hydrochloride 0.5%) were placed into both eyes of each animal.

RESULTS

Lesion	Mean Score* Animal No.			Maximum Value	Maximum Duration of Any Effect	Maximum Value at End of Observation Period
	1	2	3			
Conjunctiva: redness	1	1.7	1	2	< 4 days	0
Conjunctiva: chemosis	0.3	0.7	0.3	1	< 72 hours	0
Conjunctiva: discharge	1	1	0.7	3	< 72 hours	0
Corneal opacity	0	0	0	1	< 24 hours	0
Iridial inflammation	0	0.7	0.3	1	< 72 hours	0

*Calculated on the basis of the scores at 24, 48, and 72 hours for EACH animal.

Remarks - Results A single application of the test material to the non-irrigated eye of three rabbits produced iridial inflammation and moderate conjunctival irritation in all animals and corneal opacity in two animals. Two treated eyes appeared normal at the 72 hour observation with the remaining treated eye appearing normal at the 4 day observation.

There were no deaths or test substance-related clinical signs or remarkable body weight changes during the study period.

CONCLUSION The notified polymer is slightly irritating to the eye.

TEST FACILITY Eurofins (2010h)

B.12. Skin sensitisation – mouse local lymph node assay (LLNA)

TEST SUBSTANCE Notified polymer – variation 1

METHOD OECD TG 429 Skin Sensitisation: Local Lymph Node Assay (2002 version)
 Species/Strain Mouse/CBA/JHsd (female)
 Vehicle N,N-dimethylformamide
 Remarks - Method An irritation screening study was not conducted and 100% was selected as the highest concentration based on the lack of severe irritant effects observed with the test substance.

The main study was conducted using 5 mice/group at 0, 5, 25, 50 or 100% concentration. A concurrent positive control was conducted using 25% hexylcinnamaldehyde (HCA) in the vehicle (5 mice/group).

RESULTS

<i>Concentration (% w/w)</i>	<i>Proliferative response (DPM/lymph node)</i>	<i>Stimulation Index (Test/Control Ratio)</i>
<i>Test Substance</i>		
0 (vehicle control)	743	n/a
5	1140	1.54
25	1560	2.10
50	1357	1.83
100	-	-
<i>Positive Control</i>		
25 (HCA)	5494	7.40

Remarks - Results

The animals treated at 100% concentration lost 17-21% of the initial body weights by day 2. Clinical signs in this group included wet fur, dehydration and decreased faeces. This group was sacrificed on day 2 due to excessive toxicity and were not evaluated for lymphocyte proliferation potential.

Dehydration was observed in one mouse treated at 50% concentration on day 2. Wet fur was observed in one mouse treated at 25% and in all mice treated at 50%. Mice treated at 50% concentration lost 7-12% of the initial body weight by day 2 but gained weight by day 5. One control group mouse lost body 18% of the initial body weight by test day 2 but gained weight by day 5.

The disintegrations per minute (dpm) value for one animal in the vehicle control group was higher than the range of historical controls, and was considered an outlier. This value was not included in the data analysis.

There were no increases in stimulation index indicative of a positive response in concentrations up to 50%. Results were not available for the 100% group as the animals were sacrificed early due to clinical signs and weight loss. A positive response was observed in the positive control group using hexylcinnamaldehyde (HCA).

CONCLUSION

There was no evidence of induction of a lymphocyte proliferative response indicative of skin sensitisation to the notified polymer.

TEST FACILITY

DuPont (2010d)

B.13. Skin sensitisation – mouse local lymph node assay (LLNA)

TEST SUBSTANCE

Notified polymer – variation 3

METHOD

OECD TG 429 Skin Sensitisation: Local Lymph Node Assay (2002 version)

Species/Strain

Mouse/CBA/JHsd (female)

Vehicle

N,N-dimethylformamide

Remarks - Method

An irritation screening study was not conducted and 100% was selected as the highest concentration based on the lack of severe irritant effects observed with the test substance.

The main study was conducted using 5 mice/group at 0, 5, 25, 50 or 100% concentration. A concurrent positive control was conducted using 25% hexylcinnamaldehyde (HCA) in the vehicle (5 mice/group).

RESULTS

<i>Concentration (% w/w)</i>	<i>Proliferative response (DPM/lymph node)</i>	<i>Stimulation Index (Test/Control Ratio)</i>
<i>Test Substance</i>		
0 (vehicle control)	1233.4	n/a
5	1621.8	1.31
25	2080.2	1.69
50	2988.8	2.42
100	2630.8	2.13
<i>Positive Control</i>		
25 (HCA)	8641.0	7.01

Remarks - Results

Three animals treated at 100% concentration exhibited wet fur for 2 days after the test substance was applied. The average body weight of this group decreased slightly over the time of the study.

Statistically significant increases in cell proliferation measurements compared to the control group were seen in the 25, 50 and 100% concentration groups. However, the stimulation index remained below 3 for the test substance at all of the concentrations.

A positive response was observed in the positive control group using hexylcinnamaldehyde (HCA).

CONCLUSION

There was no evidence of induction of a lymphocyte proliferative response indicative of skin sensitisation to the notified polymer.

TEST FACILITY

DuPont (2010e)

B.14. Genotoxicity – bacteria

TEST SUBSTANCE

Notified polymer – variation 1

METHOD

OECD TG 471 Bacterial Reverse Mutation Test – Plate Incorporation Procedure

Species/Strain

S. typhimurium: TA1535, TA1537, TA98, TA100
E. coli: WP2uvrA

Metabolic Activation System

S9 fraction from Aroclor 1254 induced rat liver

Concentration Range in

a) With metabolic activation: 333-5000 µg/plate

Main Test

b) Without metabolic activation: 333-5000 µg/plate

Vehicle

Dimethyl sulfoxide

Remarks - Method

No significant protocol deviations.

A cytotoxicity assay was conducted in all strains (in duplicate) in the presence and absence of metabolic activation between 33.3-5000 µg/plate. These plates subsequently became test 1. Vehicle and positive controls were used in parallel with the test substance. Plates in test 2 were conducted in triplicate.

RESULTS

<i>Metabolic Activation</i>	<i>Test Substance Concentration (µg/plate) Resulting in:</i>			
	<i>Cytotoxicity in Preliminary Test</i>	<i>Cytotoxicity in Main Test</i>	<i>Precipitation</i>	<i>Genotoxic Effect</i>
<i>Absent</i>				
Test 1	>5000	>5000	>5000	negative
Test 2	-	>5000	>5000	negative
<i>Present</i>				
Test 1	>5000	>5000	>5000	negative

Test 2	-	>5000	>5000	negative
Remarks - Results	The negative controls were within historical controls, and the positive controls showed large increases in revertants, confirming the validity of the test system.			
CONCLUSION	The notified polymer was not mutagenic to bacteria under the conditions of the test.			
TEST FACILITY	DuPont (2010f)			

B.15. Toxicity to reproduction – 90-day gavage study with one generation study

TEST SUBSTANCE	Analogue 1
METHOD	90-Day Gavage Study with One-Generation Reproduction Toxicity Study
Species/Strain	Rat/Crl:CD®(SD)IGS BR
Route of Administration	Oral – gavage
Exposure Information	Oral toxicity study: 90 - 96 days dosing Reproductive toxicity study: 72 days prior to cohabitation until weaning (postnatal day 21).
Vehicle	Water
Remarks – Method	A range-finding study was conducted at concentrations up to 1,000 mg/kg bw/day. Due to body weight loss and reductions in body weight gain the maximum dose level in the main study was set at 500 mg/kg bw/day.

10 Rats/sex/group were used in the 90 day exposure evaluation and were necropsied after 95 or 96 days of exposure for male and female rats respectively. 5 Rats/sex/group were used for biochemical, clinical, anatomic and fluorine evaluations and were used for recovery evaluations 3 months after administration of the test substance had ended. 20 Rats/sex/group were used for reproductive evaluations and lastly 10 rats/sex in each of the high dose and control groups were used in a 1-month recovery. An additional 5 rats/sex/dose were dosed for 10 days and used for evaluation of hepatic biochemical analysis.

RESULTS

Group	Number and Sex of Animals	Dose mg/kg bw/day	Mortality
1	45 per sex	0	2/90
2	35 per sex	25	0/70
3	35 per sex	100	1/70
4	45 per sex	500	2/90

Mortality and Time to Death

1 Male rat in the 100 mg/kg bw/day group and 1 female rat in the control group died of trauma secondary to the bleeding process. 1 Male rat in the control group and 2 male rats dosed with 500 mg/kg bw/day died of kidney inflammation and/or obstruction.

Effects on adult animals:

Clinical Observations

Compared to control animals lower body weight and lower body weight gain were generally observed in the 100 and 500 mg/kg bw/day dose groups. In the 500 mg/kg bw/day dose groups reductions were statistically significant during most test days and weekly intervals of the study. Male rats in the 100 mg/kg bw/day group had mean body weights lower than the control over the entire dosing phase and the reduction was statistically significant on days 35-70. No effects on body weight or body weight gain were seen in female rats in the 100 or 25 mg/kg bw/day dose groups. Weight effects were more readily reversible in males than females over the three month recovery period.

Male rats dosed with 500 mg/kg bw/day exhibited reduced mean food consumption and food efficiency compared to controls. Males dosed with 100 mg/kg bw/day also showed reductions in mean food efficiency. These changes tended to be reversible over the recovery period. Female rats did not display changes in mean food consumption though there were reductions in mean food efficiency in females dosed at 500 mg/kg bw/day.

There were statistically significant increases in the incidences of wet fur (chin/perineum), clear discharge from the mouth, hair loss and stained fur/skin in male and female animals in the 500 mg/kg bw/day dose group. Statistically significant increases in clear discharge from the mouth (both sexes) and in hair loss (females) was observed in the 100 mg/kg bw/day dose group.

Statistically significant reductions in forelimb (25 %) and hindlimb (18 %) strength were observed in male animals in the 500 mg/kg bw/day group at the end of the 90 day dosing period but were partially reversible with only the reduction in hindlimb (15 %) strength being still significantly lower at the end of the recovery period.

Laboratory Findings – Clinical Chemistry, Haematology, Urinalysis

Male and female animals in the 500 and 100 mg/kg bw/day dose groups had reductions in parameters relating to red blood cell mass (haemoglobin, haematocrit, and/or red cell count), all findings were completely reversed after three months of recovery. Male rats in the 500 mg/kg bw/day group had increased alanine aminotransferase and sorbitol dehydrogenase during the dosing period, which persisted during the recovery period, but these were not present in female animals at this dose at the end of the study. Alkaline phosphatase and total bilirubin were increased in male and female animals in the 500 mg/kg bw/day group during the dosing period with the effects not present during the recovery period. Minimal but statistically significant increases in parameters reflecting glomerular filtration (urea nitrogen, creatine and inorganic phosphorus) were present in male and female animals, which correlate with histologic evidence of renal failure in animals in the 500 mg/kg bw/day group. The effects were not observed at the end of the recovery period. Decreased sodium and chloride levels were seen in male (500 mg/kg bw/day) and female (100 and 500 mg/kg bw/day) animals. Statistically significant and dose dependent increases in total protein and albumin were observed in both male and female animals during the dosing period. Total protein and albumin levels were not significantly elevated at the end of the 3 month recovery period. Globulin levels were only significantly increased during the recovery period suggesting this change may not be treatment related. Male and female animals in the 100 and 500 mg/kg bw/day dose groups had increased calcium and cholesterol levels and decreased triglyceride concentrations during the dosing period, which reverted to levels similar to the control values by the end of the 3 month recovery period. Male and female animals dosed with 500 mg/kg bw/day of the test substance had decreased urine specific gravity/osmolality, urine pH and urine protein concentration with the effects reversed during the recovery period. Plasma and urine fluoride levels in males and females showed a dose dependent increase and urine fluoride values were still elevated at the end of the recovery period although they had decreased considerably compared to the end of the study.

The rate of β -oxidation, which is a measure of peroxisome proliferation, was statistically significantly increased in male rats at the 10 day point (171 and 286% in dose groups 100 and 500 mg/kg bw/day respectively) and at the 90 day point (181% in the 500 mg/kg bw/day dose group) and 1 month recovery (195% in the 500 mg/kg bw/day dose group) but had returned to control values by the end of the 3 month recovery. The increases in the rate of β -oxidation was accompanied by an increase in the liver weights of animals in the same dose groups. There was a decrease in the rate of β -oxidation in female rats dosed with 25 mg/kg bw/day of the test substance at the 10 day point and an increase (131 %) in animals dosed with 500 mg/kg bw/day of the test substance at the 1 month recovery test point. The changes in the rate of β -oxidation in female rats was considered to be incidental by the study authors due to the lack of dose response in the decrease and the small difference in the increase over the controls.

Effects in Organs

Increased mean liver weights and/or microscopic hepatocellular hypertrophy were present in male animals in all the dose groups and female animals in the two highest dose groups at 90 days and in male and female animals in the 500 mg/kg bw/day dose group at the 1 and 3 month recovery (with the exception of the absence of hepatocellular hypertrophy at the three-month recovery point).

Mean kidney weights (absolute and relative to the body or brain weight) were significantly higher than controls for female animals in the 100 or 500 mg/kg bw/day dose groups. The mean kidney weights (relative to the body) were significantly higher in the 1 and 3 month recovery groups in female animals dosed with

500 mg/kg bw/day. In male animals mean kidney weights (relative to the body) were significantly higher in the 100 and 500 mg/kg bw/day dose groups and in the 500 mg/kg bw/day 1 month recovery group. The incidence of chronic progressive nephropathy was significantly increased in both sexes at the higher doses and may partially explain the higher liver weights seen. This effect was still observed in females at the 3 month recovery, though not in males.

The mean spleen weight and spleen weight relative to the brain was significantly decreased in males in the 500 mg/kg bw/day dose group. The mean spleen weight relative to the brain was significantly increased in females in the 100 and 500 mg/kg bw/day dose groups. The mean spleen weight relative to the body weight was significantly increased in female animals in the 500 mg/kg bw/day dose group both at the end of the 13 week dosing period and at the 3 month recovery, but not in the 1 month recovery. Significantly increased incidences of extramedullary hematopoiesis were observed in both sexes in the 100 and 500 mg/kg bw/day dose groups at the 90 day sacrifice. The incidence of extramedullary hematopoiesis remained significantly increased in male and female animals in the 500 mg/kg bw/day dose group at the 1 month recovery; there were no significant increases in any of the treatment groups at the 3 month recovery. Increased pigment in the spleen was observed in male animals in the 100 and 500 mg/kg bw/day dose group at the 90 day sacrifice and in the 500 mg/kg bw/day dose group at the 1 month recovery. In female animals significantly increased pigment in the spleen was observed in the 500 mg/kg bw/day dose group at the 90 day sacrifice and in the 100 and 500 mg/kg bw/day dose groups at the 3 month recovery.

Other changes in organ weights were predominantly decreases in mean organ weights in male animals in the 500 mg/kg bw/day dose group at the 90 day sacrifice and was significant in the heart, brain, thymus, adrenal glands and epididymis.

Follicular hypertrophy in the thyroid glands was present in numerous male and female rats in the 100 and 500 mg/kg bw/day dose groups at the 90 day sacrifice and in 1 male rat in the 25 mg/kg bw/day dose group. At the 1 month recovery follicular hypertrophy was still present in the 500 mg/kg bw/day dose group (the only dose group measured at this time point) in both sexes, but at the three month recovery was only present in male animals in the 500 mg/kg bw/day dose group. In the absence of hormonal data to demonstrate maintenance of normal hormonal levels, the thyroid hypertrophy was considered to be potentially adverse by the study authors. Stippled, granular, clumped and/or diffusely basophilic colloid was found in follicles in thyroids from both the controls and all treated groups with an increased incidence and severity in the treated groups. The alterations in the colloid were not associated with adverse cellular morphologic changes and hence not considered to be of toxicological significance.

Reproductive Effects

The mean estrous cycle length was significantly greater in treated animals. However, there was no dose response relationship and values were within historical controls and hence the changes are considered to be of uncertain toxicological significance. In addition there were no differences between the treated and control groups on the percent of days in estrus, diestrus or proestrus or the mean precoital interval.

There were statistically significant decreases in the number of epididymal sperm (88%, 91% and 88% of controls for the 25, 100 and 500 mg/kg bw/day dose groups respectively), however, there was no dose response relationship and the values were within the historical control range for the testing facility and hence are considered to be of no toxicological significance. There was a statistically significant increase (108% of the control) in the number of testicular spermatids per testis in the 500 mg/kg bw/day dose group, however this change was not observed on per gram of testis basis and hence is considered to be of no toxicological significance. There were no significant changes in the percent of motile sperm or sperm with normal morphology.

There were no test substance related effects on the mating index (females with evidence of mating/females cohoused with males \times 100), gestation length or implantation efficiency. In the 500 mg/kg bw/day group there was a significant reduction in the number of uterine implantation sites (10.7 vs 15.3 for the control). The fertility index (no. of females with litters/no. of females with evidence of mating \times 100) was reduced in the treatment groups (55.0%, 57.9% and 65.0% for the 25, 100 and 500 mg/kg bw/day dose groups respectively) in comparison to the control group (85.0%).

Effects on 1st Filial Generation (F1)

The number of pups born and born alive (72% and 66% of the control respectively) was significantly reduced in rats in the 500 mg/kg bw/day dose group. The number of pups surviving at any stage of the study was

significantly lower in the 500 mg/kg bw/day dose group with only 10% of the number of pups left alive in comparison to the controls 21 days after birth. Due to this the number of litters in the 500 mg/kg bw/day dose group with at least 1 pup surviving at day 21 was also significantly reduced (25%) in comparison to the control group. In the 100 mg/kg bw/day dose group survival was similar to controls up until 14 and 21 days after birth where it was 79% and 76% of the control respectively.

At all measurements of the mean pup weight at birth and on days 4, 7, 14 and 21 in the 500 mg/kg bw/day dose group there were significant decreases (90%, 71%, 54%, 56% and 57% respectively) in comparison to the control. In the 100 mg/kg bw/day dose group the mean pup weight was only significantly decreased in comparison to the control on days 4, 7 and 14 with decreases of 94%, 86% and 94% respectively.

Apart from one partially cannibalised pup in the control group, clinical signs in the F1 generation during lactation were limited to the 500 mg/kg bw/day dose group and consisted of lethargy, weakness and stained or wet perineum. The clinical signs in the 500 mg/kg bw/day dose group were present in only 1 out of a total of 12 litters and hence are considered to be of no toxicological significance. Clinical signs at day 21 were limited to isolated incidences of alopecia.

Due to the poor survival in the 500 mg/kg bw/day dose group there was insufficient data to evaluate post weaning in life parameters or post weaning anatomical pathology. In the 25 and 100 mg/kg bw/day dose groups there were no test substance related effects in any of the in life parameters measured. A significant decrease was seen in mean absolute liver weights (91% of control) and also relative to the body or brain and an increase in the mean brain weight relative to the body was seen in male animals in the 100 mg/kg bw/day dose group. The difference in the organ weights in the 100 mg/kg bw/day dose group is considered secondary to the lower body weight at this dose. There were no test substance related effects noted in the gross and microscopic observations on the organs of the F1 animals.

Remarks - Results

In the parental animals, 90 days of exposure to the test substance at doses of 100 or 500 mg/kg bw/day resulted in adverse treatment related effects. Adverse effects included changes in body weight and organ weight parameters, food efficiency, thyroid follicular hypertrophy, chronic progressive nephropathy, clinical signs, liver enzyme and red blood cell parameters. There were no adverse systemic effects on the parental animals at the lowest dose of 25 mg/kg bw/day.

Reproductive effects included a significant reduction in the number of implantation sites in the 500 mg/kg bw/day dose group in comparison to the control group and a reduction in the fertility index at all doses in comparison to the control group. Adverse effects in the F1 generation were seen in the 100 and 500 mg/kg bw/day dose groups and consisted of reductions in the mean litter size, number of pups born and born alive, pup survival and pup weight.

CONCLUSION

Based on the presence of adverse reproductive effects at all of the doses tested a NOAEL for reproductive and neonatal toxicity could not be set.

Due to a range of adverse effects in the parental animals dosed at 100 or 500 mg/kg bw/day the NOAEL for systemic effects in both male and female animals is the next lowest dose of 25 mg/kg bw/day.

TEST FACILITY DuPont (2002a)

B.16. Toxicity to reproduction – one generation study

TEST SUBSTANCE Analogue 1

METHOD Similar to OECD 415 One-Generation Reproduction Toxicity Study
 Species/Strain Rat/Crl:CD®(SD)IGS BR
 Route of Administration Oral – gavage
 Exposure Information Exposure period - female: 72 days before mating, during mating period (max. 15 days), during pregnancy, and until final sacrifice (after day 4 post-partum).
 Exposure period - male: 72 days before mating, during mating period (max. 15 days), and until final sacrifice (day 96/97).

Vehicle	Water
Remarks – Method	The dose levels were based on a previous 90-day subchronic toxicity and one-generation reproduction study where adverse reproductive effects were seen down to the lowest dose tested which was 25 mg/kg bw/day.

RESULTS

Group	Number and Sex of Animals	Dose mg/kg bw/day	Mortality
1	24 per sex	0	0/48
2	24 per sex	1	0/48
3	24 per sex	10	0/48
4	24 per sex	25	0/48

Mortality and Time to Death

There were no unscheduled deaths in any group during the study.

Effects on Parental (P) animals:

There were no test substance related effects on body weight, body weight gain or food consumption in either male or female animals.

There were no test substance related effects on estrous cycle parameters, mating, precoital interval, fertility, gestation length, number of implantation sites, implantation efficiency and number of *corpora lutea* at each dose level.

Statistically significant test substance related increases in the liver weight and liver weight relative to body weight were seen in both male and female animals dosed with 25 mg/kg bw/day of the test substance. The increase in the liver weight relative to body weight was 110 and 114% for male and female rats respectively in comparison to the control group. The following effects were noted in a microscopic examination of the liver in animals dosed with 25 mg/kg bw/day: minimal hepatocellular vacuolation in 1 male, minimal focal necrosis in 1 male, minimal inflammation in 8 males and 4 females and minimal increased extramedullary haematopoiesis in 2 females. A similar level of microscopic observations was seen in the livers of the animals in the control group. In the absence of histopathological or clinical chemical changes indicative of liver injury the study authors considered the liver weight increases to be a physiologic response to metabolism of a xenobiotic and not toxicologically adverse.

Effects on 1st Filial Generation (F1)

There were no test substance related effects on the number of pups born, whether they were born alive, their sex ratio, survival to the end of the study (lactation day 4), birth weight and weight at the end of the study. Clinical signs in the F1 generation were limited to 1 pup from the 25 mg/kg bw/day displaying a subcutaneous haemorrhage.

Remarks - Results

There were no test substance related adverse effects on any parental animals or on the F1 offspring.

CONCLUSION

Based on the absence of adverse effects on any parental animals or on the F1 offspring the NOAEL is the highest dose tested at > 25 mg/kg bw/day.

TEST FACILITY

DuPont (2010g)

APPENDIX C: ENVIRONMENTAL FATE AND ECOTOXICOLOGICAL INVESTIGATIONS

C.1. Environmental Fate

C.1.1. Ready biodegradability

TEST SUBSTANCE	Variation 2 of the notified polymer
METHOD	OECD TG 301 B Ready Biodegradability: CO ₂ Evolution Test.
Inoculum	Activated sludge
Exposure Period	28 days
Auxiliary Solvent	None
Analytical Monitoring	Dissolved organic carbon (DOC), inorganic carbon (IC), total carbon (TC)
Remarks - Method	The method was conducted according to test guidelines using good laboratory practice (GLP) with no significant deviations.

RESULTS

<i>Test substance</i>		<i>Sodium benzoate</i>	
<i>Day</i>	<i>% Degradation</i>	<i>Day</i>	<i>% Degradation</i>
9	26.2	9	64.1
20	54.3	20	83.3
28	62	28	90.1

Remarks - Results

All test validity criteria were met. A toxicity control indicated the inoculum was active and the test substance is not toxic to microorganisms. Under the constraints of the test guidelines, the test substance passed the 60% TCO₂ production within the 28 day timeframe. However, the test substance failed to exceed 60% degradation within a ten day period, therefore failing the criteria to be classified as readily biodegradable. Since the test substance is still degraded within the 28 days, it can be considered to be rapidly degradable.

Characterisation of the degradants was not undertaken. The entire carbon content of the notified polymer is not expected to completely mineralise. The perfluorinated portion is expected to remain at the completion of the test. A recent study on perfluorinated polymers with similar structures also indicated that after shortening of the non-perfluorinated portion of the polymer, the resulting polymer is expected to be stable (see Exempt Information). Therefore, degradation products may include more stable lower molecular weight polymer with perfluorinated functionality.

CONCLUSION

The notified polymer is rapidly degradable.

TEST FACILITY

Wildlife International, Ltd. (2010)

C.2. Ecotoxicological Investigations

C.2.1. Acute toxicity to fish (Test 1)

TEST SUBSTANCE	Variation 1 of the notified polymer
METHOD	OECD TG 203 Fish, Acute Toxicity Test - Static.
Species	<i>Oncorhynchus mykiss</i> (Rainbow trout)
Exposure Period	96 hours
Auxiliary Solvent	None
Water Hardness	139 to 157 mg CaCO ₃ /L
Analytical Monitoring	HPLC

Remarks – Method

The method was conducted according to test guidelines using good laboratory practice (GLP) with no significant deviations. The test substance formed a slightly foamy solution after stirring with the water.

RESULTS

Concentration mg/L		Number of Fish	Mortality			
Nominal	Actual		24 h	48 h	72 h	96 h
0	0	7	0	0	0	0
7.5	6.66	7	0	0	0	0
15	13.0	7	0	0	0	0
30	29.0	7	0	0	0	0
60	46.5	7	7	7	7	7
120	112	7	7	7	7	7

LC50

36.7 (29.0 to 46.5) mg/L at 96 hours.

NOEC

13.0 mg/L at 96 hours (based on DSEWPaC interpretation)

Remarks – Results

All relevant test validity criteria were met. The geometric mean of the measured concentrations was used to calculate the LC50. The 95% fiducial limits are 29.0 to 46.5 mg/L. Sublethal effects were observed at 29.0 mg/L including erratic swimming, lethargy, rapid respiration and lying on the bottom of the test vessel.

CONCLUSION

The notified polymer is harmful to fish

TEST FACILITY

DuPont (2010h)

C.2.2. Acute toxicity to fish (Test 2)

TEST SUBSTANCE

Variation 3 of the notified polymer

METHOD

OECD TG 203 Fish, Acute Toxicity Test - Static.

Species

Oncorhynchus mykiss (Rainbow trout)

Exposure Period

96 hours

Auxiliary Solvent

None

Water Hardness

177 to 184 mg CaCO₃/L

Analytical Monitoring

HPLC

Remarks – Method

The method was conducted according to test guidelines using good laboratory practice (GLP) with no significant deviations. The test substance formed a slightly foamy solution after stirring with the water.

RESULTS

Concentration mg/L		Number of Fish	Mortality			
Nominal	Actual		24 h	48 h	72 h	96 h
0	0	7	0	0	0	0
7.5	6.64	7	0	0	0	0
15	12.8	7	0	0	0	0
30	26.5	7	0	0	0	0
60	42.4	7	5	7	7	7
120	105	7	7	7	7	7

LC50

33.5 (26.5 to 42.4) mg/L at 96 hours.

NOEC

12.8 mg/L at 96 hours (based on DSEWPaC interpretation)

Remarks – Results

All relevant test validity criteria were met. The geometric mean of the measured concentrations was used to calculate the LC50. The 95% fiducial limits are 26.5 to 42.4 mg/L. Sublethal effects were observed at 26.5 mg/L including erratic swimming, lethargy, loss of equilibrium and lying on the bottom of the test vessel.

CONCLUSION The notified polymer is harmful to fish

TEST FACILITY DuPont (2011)

C.2.3. Acute toxicity to aquatic invertebrates

TEST SUBSTANCE Variation 1 of the notified chemical

METHOD OECD TG 202 *Daphnia* sp. Acute Immobilisation Test - Static.
 Species *Daphnia magna*
 Exposure Period 48 hours
 Auxiliary Solvent None
 Water Hardness 140 to 150 mg CaCO₃/L
 Analytical Monitoring HPLC
 Remarks - Method The method was conducted according to test guidelines using good laboratory practice (GLP) with no significant deviations.

RESULTS

Concentration mg/L		Number of <i>D. magna</i>	Number Immobilised	
Nominal	Actual		24 h	48 h
0	0	4 × 5	0	0
2.5	2.4	4 × 5	0	0
5	4.92	4 × 5	0	2
10	10.3	4 × 5	0	2
20	21.6	4 × 5	0	7
40	45.1	4 × 5	9	17

EC50 28.8 (23.9 to 35.5) mg/L at 48 hours
 NOEC 2.4 mg/L at 48 hours (based on DSEWPac interpretation)
 Remarks - Results All relevant test validity criteria were met. The geometric mean of the measured concentrations was used to calculate the EC50. The 95% fiducial limits are 23.9 to 35.5 mg/L. No immobilisation was observed at 2.4 mg/L however one daphnid was floating on the surface. No other sublethal effects were observed at any concentration. Therefore this is likely to be an anomaly.

CONCLUSION The notified polymer is harmful to aquatic invertebrates

TEST FACILITY DuPont (2010i)

C.2.4. Algal growth inhibition test

TEST SUBSTANCE Variation 1 of the notified polymer

METHOD OECD TG 201 Alga, Growth Inhibition Test.
 Species *Pseudokirchneriella subcapitata* (Green algae)
 Exposure Period 72 hours
 Concentration Range Nominal: 0, 7.5, 15, 30, 60, 120 mg/L
 Actual: 0, 7.47, 14.7, 27.5, 54.8, 114 mg/L
 Auxiliary Solvent None
 Water Hardness Not reported
 Analytical Monitoring HPLC
 Remarks - Method The study was conducted according to test guidelines using good laboratory practice (GLP) with no significant deviations.

RESULTS

<i>Biomass</i>		<i>Growth</i>	
<i>E_bC₅₀</i> <i>mg/L at 72 h</i>	<i>NOEC</i> <i>mg/L at 72 h</i>	<i>E_rC₅₀</i> <i>mg/L at 72 h</i>	<i>NOEC</i> <i>mg/L at 72 h</i>
50.1 (48.8 to 51.3)	27.5	88.3 (87.8 to 88.8)	27.5

Remarks - Results

All relevant test validity criteria were met. The geometric mean of the measured concentrations was used to calculate the EC₅₀. The 95% fiducial limits are 48.8 to 51.3 mg/L for biomass and 87.8 to 88.8 mg/L for growth rate.

A recovery test was conducted for test concentrations where greater than 50% inhibition of growth was observed. The effects on growth and reproduction of the algae were found to be algistatic within 4 days at the mean measured concentrations that were ≤ 114 mg/L.

CONCLUSION

The notified polymer is harmful to algae.

TEST FACILITY

DuPont (2010j)

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 *et al.*, 2009a; Gannon *et al.*, 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 *et al.*, 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 *et al.*, 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 *et al.*, 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 (Klaunig *et al.*, 2014). The US EPA considers PFOA is “likely to be carcinogenic to humans” (US EPA, 2012).

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