File No: NA/723

23 April 2020

**NATIONAL INDUSTRIAL CHEMICALS NOTIFICATION AND ASSESSMENT SCHEME**

# FULL PUBLIC REPORT

## 1,3-benzenedimethanamine, N,N,N',N'-tetrakis(oxiranylmethyl)-, polymer with 1,3-benzenedimethanamine

This Assessment has been compiled in accordance with the provisions of the *Industrial Chemicals (Notification and Assessment) Act* 1989 (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 National Occupational Health and Safety Commission which also conducts the occupational health & safety assessment. The assessment of environmental hazard is conducted by the Department of the Environment and the assessment of public health is conducted by the Department of Health and Aged Care.

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Director
Chemicals Notification and Assessment

# FULL PUBLIC REPORT

## 1,3-benzenedimethanamine, N,N,N',N'-tetrakis(oxiranylmethyl)-, polymer with 1,3-benzenedimethanamine

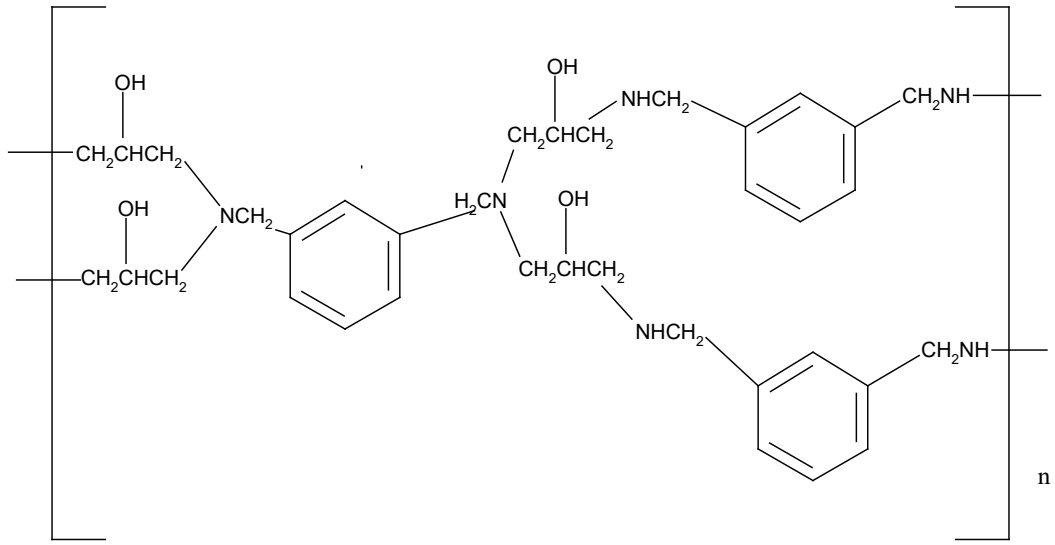
## 1. APPLICANT

Amtrade International of Level 2, 570 St. Kilda Rd, MELBOURNE, VIC 3004 has submitted a limited notification statement in support of their application for an assessment certificate for 1,3-benzenedimethanamine, N,N,N',N'-tetrakis(oxiranylmethyl)-, polymer with 1,3-benzenedimethanamine.

## 2. IDENTITY OF THE CHEMICAL

| | |
|---|---|
| **Chemical Name:** | 1,3-benzenedimethanamine, N,N,N',N'-tetrakis(oxiranyl-methyl)-, polymer with 1,3-benzenedimethanamine |
| **Other Name:** | m-xylenediamine, N,N,N',N'-tetrakis(oxiranylmethyl)-, polymer with m-xylenediamine |
| **Chemical Abstracts Service (CAS) Registry No.:** | 130151-67-6 |
| **Marketing Name:** | Amtrade C15 (30 % notified polymer in 1-methoxy-2-propanol) |
| **Molecular Formula:** | $(C_{20}H_{28}N_2O_4.C_8H_{12}N_2)_x$ |
| **Number-Average Molecular Weight (NAMW):** | 2108 |
| **Weight-Average Molecular Weight (NAMW):** | 14635 |
| **Polydispersity:** | 6.9 |
| **Maximum Percentage of Low Molecular Weight Species** | |
| **Molecular Weight < 500:** | ~ 5 % |
| **Molecular Weight < 1 000:** | ~ 15 % |

**Structural Formula:**




**Weight Percentage of Ingredients:**

| *Chemical Name* | *CAS No.* | *Weight %* |
|---|---|---|
| 1,3-benzenedimethanamine, N,N,N',N'-tetrakis(oxiranyl-methyl)- | 63738-22-7 | 59.5 |
| 1,3-benzenedimethanamine (m-XDA) | 1477-55-0 | 40.5 |

**Method of Detection and Determination:** the notified polymer can be identified using infrared spectrometry

**Spectral Data:** IR 3348, 3286, 3225, 3025, 2901, 2820, 1606, 1589, 1484, 1448, 1368, 1318, 1155, 1043, 977, 906, 865, 788, 701 $cm^{-1}$

## 3. PHYSICAL AND CHEMICAL PROPERTIES

The physical and chemical property data provided by the notifier are for the product, Amtrade C15, containing 30 % notified polymer in 1-methoxy-2-propanol, unless otherwise stated.

**Appearance at 20°C and 101.3 kPa:** viscous opaque liquid (Amtrade C15)
amber solid resin (notified polymer)

**Boiling Point:** 117-120°C

**Specific Gravity:** 0.996

**Vapour Pressure:** 1.064 kPa at 25°C (solution, notified polymer not

| | |
|---|---|
| | expected to be volatile) |
| **Water Solubility:** | 88 mg/L at 25°C (calculated for the monomer, 1,3-benzenedimethanamine, N,N,N',N'-tetrakis(oxiranyl-methyl)-, see comments below) |
| **Particle Size:** | not applicable, as the polymer is imported in solution |
| **Partition Co-efficient (n-octanol/water):** | log $P_{ow}$ = 3.68 (calculated for the monomer, 1,3-benzenedimethanamine, N,N,N',N'-tetrakis(oxiranyl-methyl)-, see comments below) |
| **Hydrolysis as a Function of pH:** | not determined (see comments below) |
| **Adsorption/Desorption:** | not determined (see comments below) |
| **Dissociation Constant:** | $pK_a$ ~ 11 (see comments below) |
| **Flash Point:** | 37°C (for the solution, see comments below) |
| **Flammability Limits:** | Upper Explosive Limit = 13.1 %<br>Lower Explosive Limit = 1.5 % (for the solution, see comments below) |
| **Autoignition Temperature:** | 270°C (for the solution, see comments below) |
| **Explosive Properties:** | not expected to be explosive |
| **Reactivity/Stability:** | expected to undergo reactions typical of amines; otherwise expected to be stable |

**Comments on Physico-Chemical Properties**

The boiling point for the notified polymer has not been supplied. It is likely that the notified polymer will decompose prior to reaching the boiling point.

Model estimates using ADC software (Advanced Chemical Developments, 1999) provided by the notifier for the monomer 1,3-benzenedimethanamine, N,N,N',N'-tetrakis(oxiranylmethyl)-, which comprises approximately 60% of the notified polymer, suggest a solubility of 88 mg/L. However, information provided in the notification package indirectly indicates that the polymer is of lower water solubility. Firstly, the acute toxicity test report on *Daphnia magna* clearly indicates that the notified polymer resin is poorly soluble in water. Secondly, correspondence contained in the notification package states that an analytical method for detecting the notified polymer resin in water could not be developed since the substance was suspected of partially hydrolysing with water and possibly reacting with the dilution solvent used.

The notified polymer is likely to become positively charged under environmental conditions.

Log $P_{ow}$ for the charged molecule is likely to be lower than the calculated value of 3.68. The charged species is not likely to associate with the organic component of soils and sediments, but may adsorb to the silicate mineral surface.

The estimated $pK_a$ value of 11 for the notified polymer is typical for secondary and tertiary aliphatic amines and is appropriate for the structure of the notified polymer.

The flammability limits provided by the notifier relate to the solvent, 1-methoxy-2-propanol, rather than the notified polymer. The polymer is not expected to be highly flammable, but it does contain approximately 10 % of the flammable impurity m-XDA.

## 4. PURITY OF THE CHEMICAL

**Degree of Purity:** ~ 90 %

**Hazardous Impurities:**

| | |
|---|---|
| *Chemical name:* | 1,3-benzenedimethanamine, N,N,N',N'-tetrakis(oxiranyl-methyl)- |
| *CAS No.:* | 63738-22-7 |
| *Weight percentage:* | < 0.1 % |
| *Toxic properties:* | R23 'Toxic by inhalation'<br>R21/22 'Harmful in contact with skin and if swallowed'<br>R38 'Irritating to skin'<br>R41 'Risk of serious damage to eyes'<br>R43 'May cause sensitisation by skin contact'<br>R46(2) 'May cause heritable genetic damage'<br><br>this chemical has been notified and assessed under NICNAS as NA/667 (National Occupational Health and Safety Commission, 1999c); the risk phrases are derived in part from analogue data for triglycidylisocyanurate (TGIC) |
| *Chemical name:* | 1,3-benzenedimethanamine |
| *Synonyms:* | m-XDA, 1,3-xylylenediamine, 1,3-bis(aminomethyl)-benzene |
| *CAS No.:* | 1477-55-0 |
| *Weight percentage:* | 10.12 % |
| *Toxic properties:* | On the *List of Designated Hazardous Substances* (National Occupational Health and Safety Commission, 1999b) (risk phrases not stipulated)<br>NOHSC exposure standard 0.1 mg/m$^3$ (peak limitation) with skin notation (National Occupational Health and Safety Commission, 1995) |

| | |
|---|---|
| | Eye: Corrosive. Contact with eyes may cause severe irritation, and possible eye burns.<br>Skin: Corrosive. May cause severe irritation and possible burns. Skin sensitiser<br>Ingestion: Gastrointestinal irritant.<br>Inhalation: May cause severe irritation of the respiratory tract with sore throat, coughing, shortness of breath and delayed lung oedema.<br>(American Conference of Government Industrial Hygienists, 1998) |
| **Non-hazardous Impurities (> 1% by weight):** | none |
| **Maximum Content of Residual Monomers:** | see above, "Hazardous Impurities" |

**Additives/Adjuvants:**

| | |
|---|---|
| *Chemical name:* | 1-methoxy-2-propanol |
| *Synonyms:* | propylene glycol monomethyl ether |
| *CAS No.:* | 107-98-2 |
| *Weight percentage:* | 69 – 71 % |
| *Toxic properties:* | eye, nose and throat irritant<br>anaesthetic effects are seen at above 1000 ppm<br>repeated exposure to high vapour concentrations may lead to brain and nervous system damage<br>(American Conference of Government Industrial Hygienists, 1998) |
| *Regulatory controls:* | NOHSC exposure standard 100 ppm TWA, 150 ppm STEL |

## 5. USE, VOLUME AND FORMULATION

The notified polymer is an epoxy curing agent and will be used in Part A of a two part epoxy coating for application to plastic surfaces such as beverage bottles.

The notified polymer will not be manufactured in Australia. It will be imported at 30 % in the product Amtrade C15. It will not be reformulated other than by mixing with Part B and glycol ether solvent in preparation for application. The import volume of notified polymer is estimated to be 5 000 kg/year.

## 6. OCCUPATIONAL EXPOSURE

*Transport and Storage*

Transport and storage workers may be involved with the notified polymer for 2-3 hours per day on 10-15 days per year. The notified polymer will be imported in 200 L drums. The drums will be transported directly from the docks to the customer facility where they will be stored in a chemical warehouse prior to use on the same site. Waterside workers, transport drivers and warehouse workers would only be exposed to the notified polymer in the case of an accident involving rupture of the packaging.

*Plant Operators*
Metered quantities of the product containing the notified polymer will be pumped or gravity fed from the 200 L drums directly into the application machinery. The epoxy resin Part A will be mixed with a glycol ether solvent before being mixed with Part B. The coating mix will then be sprayed onto the plastic material using an electrostatic mechanism to minimise overspray. The treated material will then be heated to 63°C for 15 minutes within the process line to complete the curing of the resin before the article is removed. The equipment used for mixing and applying the epoxy resin will be completely enclosed and automated, so exposure would not occur during this process. The production area is stated to have local exhaust and general ventilation to remove any vapours which may escape.

Plant operators will be working with the notified polymer for 8 hours per day for up to 250 days per year. In the coated products the notified polymer will be crosslinked and immobilised within the cured epoxy matrix. The greatest exposure is likely to occur during drum connection and disconnection, and during cleaning and maintenance of equipment, when skin contamination may occur due to drips and spills of the polymer. Cleaning of the equipment will be carried out using a suitable solvent, which will be collected and disposed of to a liquid waste facility by a licensed contractor.

The notifier states that plant operators will be required to wear impervious gloves (butyl rubber is indicated in the Material Safety Data Sheet (MSDS)), coveralls, suitable respirator and eye protection during connection and disconnection of containers to transfer lines and during cleaning and maintenance of equipment.

*Laboratory Technicians*
The notifier indicated that 2 laboratory workers would also be involved in handling the notified chemical. The role of laboratory staff has not been described, but they would be expected to be involved in sampling and testing small quantities of the notified chemical. The use of appropriate laboratory ventilation facilities and personal protective equipment such as a laboratory coat and safety glasses would be expected.

## 7. PUBLIC EXPOSURE

There is little potential for exposure of the public to the notified polymer, as it is not available for retail sale. The public will only come in contact with the coated materials where the notified polymer will be trapped inside the cured matrix of the coating.

## 8. ENVIRONMENTAL EXPOSURE

### Release

Spills of the notified polymer will harden as the solvent evaporates, and residual polymer is likely to be scraped up for disposal.

The majority of release of the polymer is expected to occur during spray application of the coating mix. In conventional spray coating processes, up to 60 % of the coating mix may be lost as a result of overspray. In such situations, overspray is normally collected on screens and then disposed of to land fill or licensed waste contractors. The notifier has indicated that the notified polymer mix will be applied using an electrostatic mechanism which would reduce waste. However they have not indicated the extent of overspray mitigation as a result of the electrostatic mechanism. It is therefore necessary to assume a worst case loss of 50 % (2500 kg/year), although this will be mixed with Part B and will cure and immobilise the notified chemical.

The notifier estimates that 1 % (50 kg) of the notified polymer will be released through accidental spillage in the warehouse and during transfer from steel drums to the application machinery. However, the areas where the notified polymer will be handled, pumped and stored will be bunded. There has been no estimate made regarding potential release of polymer as a result of transport accidents.

Further release is anticipated as residues in the 200 L steel drums (1.5 % of drum volume, or 75 kg per annum). The notifier states that residues in the imported drums will be mixed with Part B and allowed to cure prior to disposal. Cleaning and maintenance is expected to release a further 75 kg of the notified polymer (1.5 % of import volume).

This represents a total annual release of 2700 kg (54 % of the imported volume) of notified polymer. The notifier has stated that all releases will be collected and disposed of to a licensed waste contractor.

Release may also occur as the result of incineration or disposal of plastic beverage bottles to landfill. The notifier expects most bottles to be recycled whereby the polymer will become part of the plastic matrix.

**Fate**

It is anticipated that the majority of released notified polymer will be sent to a licensed waste disposal contractor. The subsequent fate of the notified polymer will be either incineration or disposal to landfill. Incineration is likely to produce oxides of carbon and nitrogen. If disposed of to landfill, the polymer is expected to be in a solid form, either as the polymer resin or crosslinked with Part B, where little is expected to migrate to the aquatic compartment. Migration through the soil profile is likely to be attenuated due to the presence of positively charged sites on the polymer. These positively charged sites are likely to bind to negatively charged sites on aluminosilicate minerals.

The fate of the remaining polymer matrix sprayed on beverage bottles will be the same as the fate of the bottles. It is anticipated that a large proportion of the bottles will be recycled whilst the remainder will be disposed of to landfill or incinerated.

It is difficult to predict the course of degradation of the notified polymer in the environment, particularly in the absence of polymer specific physico-chemical data. It is anticipated that

small portions of the polymer resin will slowly degrade via aerobic, anaerobic and abiotic processes. The cross linked polymer (i.e. the cured epoxy mixture) is likely to degrade more slowly via similar processes. Degradation products may include ammonia and oxides of carbon and nitrogen. These products are expected to be released slowly to air and aquatic compartments. The high molecular weight suggests that bioaccumulation is unlikely to occur (Connell, 1990).

## 9. EVALUATION OF TOXICOLOGICAL DATA

No toxicity studies are required for a limited notification of a polymer with NAMW > 1000. However, one acute toxicity study is available and has been provided for assessment by the notifier.

### 9.1 Acute Toxicity

Summary of the acute toxicity of 1,3-benzenedimethanamine, N,N,N',N'-tetrakis-(oxiranylmethyl)-, polymer with 1,3-benzenedimethanamine

| *Test* | *Species* | *Outcome* | *Reference* |
|---|---|---|---|
| acute oral toxicity | rat | $LD_{50}$ > 2000 mg/kg | (Allen, 1998) |

#### 9.1.1 Oral Toxicity (Allen, 1998)

| | |
|---|---|
| *Species/strain:* | rat/Sprague-Dawley CD |
| *Number/sex of animals:* | 5/sex |
| *Observation period:* | 14 days |
| *Method of administration:* | gavage, test material suspended in DMSO; dose level 2353 mg/kg (equivalent to 2000 mg/kg pure notified polymer) |
| *Test method:* | OECD TG 401 |
| *Mortality:* | there were no deaths during the study |
| *Clinical observations:* | hunched posture was observed in seven animals on the day of dosing; this persisted to the following day in two females; lethargy was noted in two females, and ataxia in one of these, at 4 hours after dosing |
| *Morphological findings:* | no gross abnormalities were observed on Day 14 |
| *$LD_{50}$:* | > 2000 mg/kg |
| *Result:* | the notified chemical was of very low acute oral toxicity in rats |

### 9.4 Overall Assessment of Toxicological Data

The notifier has indicated that Amtrade C15 is classified as a type I hazardous substance.

The acute oral toxicity of the notified polymer is very low (LD50 > 2000 mg/kg). Polymers of high molecular weight and low water solubility do not readily cross biological membranes. It is therefore assumed that there should be little or no systemic toxicity from the notified polymer.

However, topical effects may be found. Irritant effects to the skin and eyes may occur due to the formation of hydroxide ions from dissociation of water in contact with the notified polymer, as a result of the pKa of approximately 11.

The imported product containing the notified chemical also contains approximately 3 % (w/w) of the lower molecular weight amine, m-XDA as a manufacturing impurity. This chemical is corrosive and a skin sensitiser (American Conference of Government Industrial Hygienists, 1998). The polymer therefore is classified as irritant, with risk of serious eye damage, and a skin sensitiser as the m-XDA concentration exceeds the threshold of 1 % for classification as a sensitiser (National Occupational Health and Safety Commission, 1999a).

## 10. ASSESSMENT OF ENVIRONMENTAL EFFECTS

The notifier has presented results from acute toxicity tests on *Daphnia magna* (Wetton, 1998). The notified polymer was reported to be non toxic to *Daphnia magna* when mixed to its maximum solubility in water. As the polymer resin was found to be insoluble in water and auxiliary solvents and surfactants, it was decided to perform the test using a Water Accommodated Fraction (WAF) which may contain dissolved test material and/or leachates from the test material. The reported 48-hr $EC_{50}$, based on nominal test concentrations, was greater than 100mg/L (WAF).

The study report states that it was not possible to develop an acceptable analytical method for detection of the test substance in water because of poor chromatography and unacceptable recoveries. Because test concentrations of the polymer in water were not provided, and because replicated tests showed large variations in Total Organic Carbon (TOC), the data must be considered to be of limited value.

## 11. ASSESSMENT OF ENVIRONMENTAL HAZARD

It is expected that at least 2700 kg/year (54 %) of the notified polymer will be disposed of to landfill or incinerated. It is anticipated that much of this will be in the cross linked or resin form. In these forms, the notified polymer offers minimal foreseeable environmental risk.

The polymer solution is predicted to be miscible with water due to the presence of 1-methoxy-2-propanol, which is very water soluble. The polymer resin also contains approximately 10% 1,3-benzenedimethanamine. Amines are rapidly and easily taken up by organisms and are therefore considered to be compounds of environmental concern (Manahan, 1993). Consequently, the polymer solution may present a hazard if accidentally

released to the aquatic compartment.

In light of the mobility and expected toxicity of the polymer solution components, accidental spills should be prevented from entering sewers and waterways. The MSDS provides adequate instructions for this in the event of accidental spillage.

## 12. ASSESSMENT OF PUBLIC AND OCCUPATIONAL HEALTH AND SAFETY EFFECTS

The acute oral toxicity of the tested component of the notified chemical is low. No additional toxicology studies were provided. Given the high pH of the notified polymer, it can be concluded that it will be a skin irritant and may cause serious eye damage. The imported material, Amtrade C15, also contains up to 3 % of 1,3-benzenedimethanamine (m-XDA) as a consequence of the manufacturing process. This chemical is corrosive, a respiratory irritant and a skin sensitiser. The risk phrases R37/38 'Irritating to respiratory system and skin', R41 'Risk of serious eye damage' and R43 'May cause sensitisation by skin contact' are therefore required for the product.

The product is scheduled as a poison (S5, Liquid epoxy resin) under SUSDP. It is a Class 3 dangerous good (flammable liquid).

The notified chemical may be recommended to the National Occupational Health and Safety Commission for consideration for inclusion in the NOHSC List of Designated Hazardous Substances.

*Occupational Health and Safety*
Considering the high acute hazard associated with the notified chemical, stringent measures to prevent occupational exposure are required. The occupational health and safety data provided with this notification indicated that this will be the case. The equipment used for mixing and applying the epoxy resin will be completely enclosed and automated. The resin mixture will remain in the enclosed system until it is heat treated to effect crosslinking, which will immobilise the notified chemical as part of the resin matrix. The most significant exposure is therefore likely to occur during drum connection and disconnection, and during cleaning and maintenance of equipment, where skin contamination may occur. The m-XDA contained in the mixture of reaction products may also pose an inhalation hazard.

The production area is stated to have local and general ventilation to remove any solvent vapours which may escape. The notifier states that plant operators will be required to wear impervious gloves, coveralls, suitable respirator and eye protection during connection and disconnection of containers to transfer lines and during cleaning and maintenance of equipment.

Therefore the risk of adverse health effects arising from exposure to the notified chemical are confined to possible skin irritation and sensitisation and eye irritation during operations outside the main process, which is fully enclosed. Due to the toxic nature of the notified chemical, brief exposures may be harmful.

The imported product also contains m-XDA as a major constituent. This chemical has a low NOHSC exposure standard (0.1 mg/m$^3$ peak limitation) with skin notation (National

Occupational Health and Safety Commission, 1995). Stringent precautions are required to minimise exposure to the product Amtrade C15.

The impurity m-XDA is included on the NOHSC List of Designated Hazardous Substances (National Occupational Health and Safety Commission, 1999b), with no risk phrases or cutoffs included. It is also listed on the NOHSC Exposure Standards for Atmospheric Contaminants (National Occupational Health and Safety Commission, 1995). It is proposed that m-XDA be classified for health effects on the List of Designated Hazardous Substances. The solvent 1-methoxy-2-propanol is also listed on the NOHSC Exposure Standards for Atmospheric Contaminants. It is proposed that it be considered for listing on the List of Designated Hazardous Substances.

Workers other than the production workers applying the resin are not expected to be exposed to the notified chemical, as it will be imported and transferred to the site where it is used in sealed containers, and will not be generally available. It will not be available for retail sale.

*Public Health*
There is negligible potential for public exposure to the notified chemical arising from its use as a curing agent as part of epoxy coatings applied to plastic surfaces. There will be public contact with the notified chemical when incorporated into products, but since the notified chemical is an integral part of the epoxy matrix, no significant exposure should occur, and the pattern of exposure will be intermittent. It is therefore considered that the notified chemical will not pose a significant hazard to public health.

## 13. RECOMMENDATIONS

To minimise occupational exposure to 1,3-benzenedimethanamine, N,N,N',N'-tetrakis-(oxiranylmethyl)-, polymer with 1,3-benzenedimethanamine the following guidelines and precautions should be observed:

- The notified chemical should only applied in a completely enclosed system;
- Safety goggles should be selected and fitted in accordance with Australian Standard (AS) 1336 (Standards Australia, 1994) to comply with Australian/New Zealand Standard (AS/NZS) 1337 (Standards Australia/Standards New Zealand, 1992); industrial clothing should conform to the specifications detailed in AS 2919 (Standards Australia, 1987) and AS 3765.1 (Standards Australia, 1990); impermeable gloves should conform to AS/NZS 2161.2 (Standards Australia/Standards New Zealand, 1998); all occupational footwear should conform to AS/NZS 2210 (Standards Australia/Standards New Zealand, 1994);
- Spillage of the notified chemical should be avoided. Spillages should be cleaned up promptly with absorbents which should be put into containers for disposal;
- Good personal hygiene should be practised to minimise the potential for ingestion;

- A copy of the MSDS should be easily accessible to employees.

The following regulatory action is recommended:

- Nomination of the notified chemical to the National Occupational Health and Safety Commission for consideration for inclusion in the NOHSC List of Designated Hazardous Substances.

- Consideration of m-XDA and the solvent 1-methoxy-2-propanol by the National Occupational Health and Safety Commission for hazardous substances health effects classification.

If the conditions of use are varied from the notified use, greater exposure of the public may occur. In such circumstances, secondary notification may be required to assess the hazards to public health.

## 14. MATERIAL SAFETY DATA SHEET

The MSDS for the notified chemical was provided in a format consistent with the *National Code of Practice for the Preparation of Material Safety Data Sheets* (National Occupational Health and Safety Commission, 1994).

This MSDS was provided by the applicant as part of the notification statement. It is reproduced here as a matter of public record. The accuracy of this information remains the responsibility of the applicant.

## 15. REQUIREMENTS FOR SECONDARY NOTIFICATION

Under the Act, secondary notification of the notified chemical shall be required if any of the circumstances stipulated under subsection 64(2) of the Act arise. No other specific conditions are prescribed.

## 16. REFERENCES

Advanced Chemical Developments (1999). Physico-chemical Laboratory.

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American Conference of Government Industrial Hygienists (1998). TLVs and Other Occupational Exposure Values.

Connell D. W. (1989) General characteristics of organic compounds which exhibit bioaccumulation. In Connell D. W., (Ed) Bioaccumulation of Xenobiotic Compounds. CRC Press, Boca Raton, USA.

Manahan, S. E. (1993). Toxicological Chemistry (Chapter 21). In: Fundamentals of Environmental Chemistry. Lewis Publishers, Boca Raton, USA.

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Standards Australia (1987) Australian Standard 2919-1987, Industrial Clothing. Standards Association of Australia, Sydney.

Standards Australia (1990) Australian Standard 3765.1-1990, Clothing for Protection against Hazardous Chemicals Part 1 Protection against General or Specific Chemicals. Standards Association of Australia, Sydney.

Standards Australia (1994) Australian Standard 1336-1994, Eye protection in the Industrial Environment. Standards Association of Australia, Sydney.

Standards Australia/Standards New Zealand (1992) Australian/New Zealand Standard 1337-1992, Eye Protectors for Industrial Applications. Standards Association of Australia/Standards Association of New Zealand, Sydney/Wellington.

Standards Australia/Standards New Zealand (1994) Australian/New Zealand Standard 2210-1994, Occupational Protective Footwear. Standards Association of Australia/Standards Association of New Zealand, Sydney/Wellington.

Standards Australia/Standards New Zealand (1998) Australian/New Zealand Standard 2161.2-1998, Occupational protective gloves, Part 2: General requirements. Standards Association of Australia, Sydney.

Wetton PM (1998) PMN 2365: Acute Toxicity to *Daphnia magna*, Project No. 1014/067, Safepharm Laboratories Ltd, Derby, UK.