Joint Assessment of Commodity Chemicals

No. 13

1,1-DICHLORO-2,2,2-TRIFLUOROETHANE (HFA-123)

CAS Reg. No. 306-83-2

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Correction

Page 5 - Half life should read lifetime.

JACC Report

THE ECETOC SCHEME FOR THE

"JOINT ASSESSMENT OF COMMODITY CHEMICALS" (JACC)

This report has been produced as part of a programme for reviewing critically the toxicity and environmental hazards of selected industrial chemicals. A number of organisations world-wide produce such reviews so that, based on up-to-date knowledge, existing chemicals can continue to be produced and used safely. ECETOC is contributing to this with its JACC reviews.

In general, commodity chemicals, that is those produced in large tonnage by several companies and having widespread and multiple uses, are reviewed. Every effort is made to discover whether an adequate review exists already, but when this is not so a review is produced jointly by experts from a number of companies with interests in the chemical. Whenever good scientific reviews on certain toxicological or ecotoxicological aspects exist, their conclusions are summarised and only the subsequent literature is assessed. Only the uses of the chemical as such are considered; its occurrence as an impurity in other products is not normally taken into account.

In this document a critical assessment of the toxicology and ecotoxicology of 1,1-dichloro-2,2,2-trifluoroethane is presented. Strictly this is not a commodity chemical, it is a product undergoing process development, but in view of the interest that exists in chlorinated fluorocarbons it was considered that an interim statement was needed on the state of knowledge that exists with respect to this group of chemicals.

CONTENTS

1. SUMMARY AND CONCLUSIONS

1,1-Dichloro-2,2,2-trifluoroethane (dichlorotrifluoroethane) is a non-flammable colourless liquid under normal conditions and has a faint odour of ether. It is still undergoing process development and is not yet available in commercial quantities.

No information on biodegradation, bioconcentration and bioaccumulation is available.

Most of the dichlorotrifluoroethane which might eventually be released into the atmosphere would be destroyed before reaching the stratosphere. It has a low estimate ozone depletion potential (ODP) of 0.013 - 0.022, compared to the fully halogenated chlorofluorocarbon trichlorofluoromethane (CFC-11) which has an ODP of 1.0. Dichlorotrifluoromethane also has a low estimate global warming potential (GWP) of 0.017 - 0.020, compared to CFC-11 with a GWP of 1.0.

Specific kinetic and metabolism studies on dichlorotrifluoroethane are lacking but the increased urinary fluoride level in a 90 day toxicity study suggest absorption and some metabolic transformation do take place.

The acute and subchronic toxicological activity of dichlorotrifluoroethane have been evaluated. It has also been subjected to a variety of mutagenicity (in vitro and in vivo) and developmental toxicity investigations and is currently undergoing a chronic toxicity/ carcinogenicity bioassay in rats by the inhalation route.

Results of studies suggest dichlorotrifluoroethane has a relatively low order of acute and subchronic toxicity. In the rat, its approximate oral

lethal dose when dissolved in corn oil is 9000 mg/kg, its 4-hour LC_{50} is 200,000 mg/m^3 and it is not absorbed through the skin in significant amounts (LD50 = >2000 mg/kg). Tests in rabbits also show no potential for significant dermal absorption (LD_{50} > 2000 mg/kg), no indication of dermal irritation potential, but some evidence that the liquid is a mild-to-moderate eye irritant. Rats exposed to dichlorotrifluoroethane for 6 h/d, 5 d/w for 4 weeks at concentrations $\leq$ 125,000 mg/m^3 showed CNS depression, slight decreases in the rate of weight gain and slight liver weight change. Three 3-month inhalation toxicity studies have been conducted with dichlorotrifluoroethane. Typically reductions in body weight gain and increases in liver weight have been reported with exposures of 6,250 mg/m^3 and above. With the possible exception of one report of hepatic effects in the dog at an exposure level of 62,500 mg/m^3, there has been no histopathological evidence of adverse effects associated with these exposures.

When pregnant rats and rabbits were exposed to dichlorotrifluoroethane during a critical part of their gestation, at concentrations as high as 31,300 and 62,500 mg/m^3, respectively, there was no evidence of teratogenicity or embryotoxicity and only slight maternal toxicity.

Dichlorotrifluoroethane has shown no mutagenic potential as evidenced by negative results from both *in vitro* and *in vivo* tests.

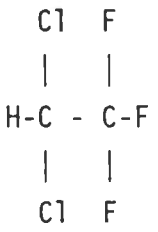
The compound induced cardiac sensitisation at concentrations of 119,000 mg/m^3 in dogs after challenged with injections of adrenaline. The no effect level was 62,500 mg/m^3.

Dichlorotrifluoroethane is currently being evaluated as part of the Programme for Alternative Fluorocarbon Toxicity Testing (PAFT) and includes chronic toxicity/carcinogenicity potential in a lifetime inhalation study in rats. Exposures are 6 h/d, 5 d/wk for 104 weeks at concentrations of 0, 1,875, 6,250, and 31,300 mg/m^3. In addition, ecotoxicology studies are being planned for this compound.

2. IDENTITY, PHYSICAL AND CHEMICAL PROPERTIES, ANALYTICAL METHODS

2.1 Identity

Chemical structure:



Chemical formulae: $CHCl_2CF_3$

Common name: 1,1-Dichloro-2,2,2-trifluoroethane
Dichlorotrifluoroethane

Common synonyms: 2,2-Dichloro-1,1,1-trifluoroethane; Fluorocarbon 123; FC-123; *HFA-123; HCFC-123; F-123; Ethane, dichlorotrifluoro-; Propellant 123; Refrigerant 123; R-123

CAS Registry Number: 306-83-2

Conversion factors: 1 ppm = 6.25 mg/m^3
1 mg/l = 160 ppm

*HFA-123 abbreviation means : Hydro Fluor Alkane : $C_2HF_3Cl_2$
First figure = Number of C-Atoms minus 1 = 1
Second figure = Number of H-Atoms plus 1 = 2
Third figure = Number of F-Atoms = 3
HFA-123
The number of Cl-Atoms is not included in the abbreviation, but represents the rest to the total saturation of the formula.

2.2 Physical and Chemical Properties

Dichlorotrifluoroethane is a nonflammable, volatile, colourless liquid at normal temperatures and pressures. It has a faint odour of ether. Dichlorotrifluoroethane is sparingly soluble in water. Some physical and chemical data for dichlorotrifluoroethane are given in Table 1.

2.3 Analytical Methods

A method for analysis has been described for dichlorotrifluoroethane which involves gas chromatography with dual flame ionization detection (Rusch, 1985).

3. PRODUCTION, STORAGE, TRANSPORT AND USE

There is no known natural source of dichlorotrifluoroethane. The manufacturing process is in the developmental stage and thus there is no information on producers and production levels at this time and as a consequence there are also no known releases.

Dichlorotrifluoroethane is being developed as a substitute for existing fully halogenated CFCs with comparable physical properties. These materials may find applications as blowing agents, refrigerants and solvents.

4. ENVIRONMENTAL TRANSPORT, DISTRIBUTION, AND TRANSFORMATION

4.1 Introduction

Dichlorotrifluoroethane is undergoing process development and is not available in commercial quantities. Therefore, information on biodegradation, bioconcentration and bioaccumulation has not been developed.

4.2 Environmental Factors

The physical and chemical properties of dichlorotrifluoroethane suggest that it would mix rapidly within the lower region of the troposphere by normal conditions. In the troposphere reaction with naturally occuring hydroxyl radicals (OH) is expected to be the primary degradation route. The tropospheric half-life related to this reaction is about 1.6 years (UNEP/WMO, 1989).

UNEP/WMO (1989) reports the ozone depletion potential (ODP) to be 0.013 - 0.016 and 0.013 - 0.022 determined by one-dimensional and two-dimensional models, respectively. This is compared with an ODP-value of 1 for the fully halogenated chlorofluorocarbons such as trichlorofluoromethane (CFC-11). The estimates were made assuming that the reference compound, methyl chloroform, for which there is an inferred lifetime of 6.3 years; the stratospheric lifetime of dichlorotrifluoroethane is much shorter (1.6 years) than CFC-11 (60 years).

The global warming potential (GWP) range for dichlorotrifluoroethane is reported by UNEP/WMO (1989) to be 0.017-0.020, compared to CFC-11 which is the reference compound with a GWP taken as 1.0. The range was determined by one-dimensional models assuming a methyl chloroform lifetime of 6.3 years.

5. ENVIRONMENTAL LEVELS AND HUMAN EXPOSURE

At the present time, environmental levels and human exposure are negligible since dichlorotrifluoroethane is not in commercial production.

6. EFFECTS ON ORGANISMS IN THE ENVIRONMENT

No data are available on the effects of dichlorotrifluoroethane on environmental organisms. An ecotoxicology program is being developed within an industry sponsored Program for Alternative Fluorocarbon Toxicity Testing, (PAFT, 1989).

7. KINETICS AND METABOLISM

7.1 Animal Studies

Kinetic and metabolism studies have not been conducted, but the increased urinary fluoride levels observed in the 90-day inhalation toxicity study in dogs and rats (Crow, 1978) indicate absorption and some metabolic transformation do take place (see also Section 8.2).

7.2 Human Studies

No data are available for human absorption, distribution and transformation of dichlorotrifluoroethane.

8. EFFECTS ON EXPERIMENTAL ANIMALS AND IN VITRO TEST SYSTEMS

8.1 Single Exposure

8.1.1 Oral Toxicity

The approximate lethal dose in male rats was reported to be 9000 mg/kgbw dichlorotrifluoroethane when administered as a corn oil solution by intra-gastric intubation (Henry, 1975).

8.1.2 Inhalation Toxicity

The results of inhalation toxicity studies are summarised in Table 2. An acute inhalation toxicity study of dichlorotrifluoroethane on Chinese hamsters showed the 4-hour LC_{50} to be 178,000 mg/m^3 (2.84%), indicating a low order of acute inhalation toxicity (Darr, 1981). Surviving animals were anaesthetised but recovered on cessation of exposure. There was 100% mortality at 194,000 mg/m^3 (3.1%) and no mortality at 163,000 mg/m^3 (2.6%) indicating a steep dose-response curve. Hall (1975) found the LC_{50} to be 200,000 mg/m^3 in male Ch.R.-CD rats exposed for 4 hours. The animals showed loss of mobility, lethargy, prostration, unresponsiveness to sound and dyspnoea within 5 minutes when exposed to concentrations of dichlorotrifluoroethane ranging from approximately 129,000 to 344,000 mg/m^3. Surviving rats showed no observable clinical signs 30 minutes after the cessation of exposure.

The rat 6-hour LC_{50} was determined to be approximately 329,000 mg/m^3 (95% confidence limits, 263,000 mg/m^3 - 411,000 mg/m^3). One group of Ch.R-COBS rats exposed to a concentration of about 145,000 mg/m^3 developed mild convulsions after 3 hours of exposure (Coate, 1976). Compared to studies described above, the 6-hour LC_{50} figure would seem to be rather high.

An LC_{50} of ±463,000 mg/m^3 was reported for mice exposed to dichlorotrifluoroethane vapours for 30 minutes (Raventos and Lemon, 1965).

Behavioural effects were evaluated in rats before, during and after a 15 minute exposure to dichlorotrifluoroethane at concentrations of 0, 6,250, 15,600, 31,300 or 62,500 mg/m^3. The exposures were carried out in a "glovebox" thereby allowing measurements of unconditioned reflexes, locomotor activity and coordination while exposure was taking place. At concentrations up to 62,500 mg/m^3, these behavioural parameters were effected adversely but the 31,300 mg/m^3 exposed animals recovered fully within 5 to 15 minutes after exposure ceased. At 30 minutes after cessation of exposure, no behavioural effects were observed with any of the exposure levels. A no-observable-effect level (NOEL) was determined to be 15,600 mg/m^3 (Trochimowicz, 1989).

These results demonstrate that dichlorotrifluoroethane has a low order of acute inhalation toxicity, the primary toxic effect being depression of central nervous system activation.

8.1.3 Dermal Toxicity

Two acute dermal toxicity studies have been performed. In the first study (Trochimowicz, 1989), a single dose of 2,000 mg/kgbw of dichlorotrifluoroethane was applied to the clipped, intact skin of 5 male and 5 female New Zealand white rabbits. The application sites were occluded for a period of 24 hours and were observed for 14 days post treatment. One day following treatment, 6 of 10 rabbits had slight to moderate erythema which resolved by day 5. No deaths occurred in this study and no gross pathological abnormalities were found in any of the rabbits. It was concluded that the dermal LD_{50} for dichlorotrifluoroethane was greater than 2,000 mg/kgbw for rabbits.

In the second acute dermal toxicity study (Trochimowicz, 1989), 2,000 mg/kgbw of undiluted dichlorotrifluoroethane was applied to the backs of 5 male and 5 female Crl:CD^{R}BR rats. The application sites were

occluded for a period of 24 hours. No dermal irritation was observed and no deaths occurred during the 14 days after dosing. The only clinical signs of toxicity in this study were of red nasal or ocular discharges in only one male and one female rat and slight to moderate body weight losses (up to 12% of initial body weights). As with the rabbits, no gross pathological abnormalities were observed. The rat dermal LD_{50} was concluded to be greater than 2,000 mg/kg body weight.

8.2 Repeated Exposure

Studies on the subacute and subchronic toxicity of dichlorofluorethane are described here. Studies concerned with cardiac sensitisation are described in Section 8.5.1.

As part of the Program for Alternative Fluorocarbon Toxicity Testing Program (PAFT, 1989) four groups of 20 Crl:CD^{R}BR rats (10 per sex per group) were exposed for 6 h/d, 5 d/w for 4 weeks to concentrations of 6,250, 31,300, 62,500 or 125,000 mg/m^3 dichlorotrifluoroethane in air (Trochimowicz, 1989). Rats exposed to concentrations of 31,300 mg/m^3 and above exhibited dose related anaesthesia-like effects. In the 62,500 and 125,000 mg/m^3 exposure groups, the rats became lethargic immediately on exposure. 16 to 18h hours after exposure had ceased, all animals behaved normally. No exposure related deaths occurred during the study. Statistically significant body weight depression in all female groups and in the 62,500 and 125,000 mg/m^3 male groups, was dose-related only in male rats. A dose-related increase in liver-to-body weight ratio was observed in all female groups (27% in the high dose females and of 18% in the high-dose males). The toxicological significance of this finding is questionable since no histopathological changes were observed. This may be an adaptive response to the high dichlorotrifluoroethane exposure concentrations. A no-effect concentration for the increased liver-to-body weight ratios and the body weight depression was not determined in the study.

Sprague-Dawley rats and beagle dogs were exposed to dichlorotrifluoroethane at concentrations of 0, 6,250 and 62,500 mg/m^3

for 6 h/d, 5 d/w over a period of 90 days (Crow, 1978). At the high dose level, both species exhibited lack of motor coordination soon after the start of exposure. This was followed by reduced motor activity and a reduction in responsiveness to noise. After removal from exposure, coordination and activity returned to normal within 20 minutes. Other than final body weight reductions and increased urinary fluoride level at the two test levels at 90 days, no significant compound-related effects were observed in rats. At the high dose level, dogs exhibited histopathologic changes in the liver and clinical chemistry changes including increased levels of serum and liver ALT and AST which indicate slight liver damage. No compound-related effects were noted at the lower (6,250 mg/m^3) exposure level.

In a 90-day inhalation toxicity study albino rats (strain unspecified obtained from Charles River Breeding Laboratory) were exposed to nominal levels of 0, 3,130, 6,250 and 31,000 mg/m^3 of dichlorotrifluoroethane for 6 h/d, 5 d/w for 90 days (Rusch, 1985). No treatment-related deaths occurred in this study and mean body weight reductions observed in high dose males and the two highest dosed groups of females were significant only at the end of the study. Slight depressions were observed in heart weight in both male and female rats exposed to 31,000 mg/m^3 dichlorotrifluoroethane. While depression of kidney weights and kidney/brain weight ratios, (but not kidney/body weight ratios), was observed in male rats in all three exposure groups, these effects were outside the normal range only in the 31,000 mg/m^3 exposure group. A similar depression in kidney weight and kidney/body weight ratio (but not in kidney/brain weight ratio) occurred in the 31,000 mg/m^3 exposed females. Increased liver/body weight ratios (but not liver weight or liver/brain weight ratios) were observed in the 31,000 mg/m^3 exposed males and in all three exposure group females. However, no significant differences occurred in organ weights or ratios in animals sacrificed at the end of a 30-day recovery period. The absence of histopathological findings coupled with the absence of effects at the end of the recovery period suggest these effects to be of questionable toxicological significance.

In the PAFT Program (1989) a two-year inhalation toxicity study is currently in progress. Included in the experimental design is an examination of 10 male and 10 female animals after 90 days exposure. Groups of 90 male and 90 female Sprague-Dawley rats/group were exposed to dichlorotrifluoroethane at concentrations of 0, 1,880, 6,250 and 31,300 mg/m^3 for 6 h/d, 5 d/w. Rats exposed at 31,300 mg/m^3 showed slight anaesthetic effects and at this and the 6,250 mg/m^3 concentration, decreased body weight gain and food efficiency were observed. Except for slightly elevated urinary fluoride levels at 31,300 mg/m^3, no effects relating to haematology or urinary analysis were noted. Elevated levels of serum AST and ALT occurred at 6,250 and 31,300 mg/m^3 and reduced triglyceride levels at all levels of exposure. At the 90-day sacrifice increased liver weights were observed at the two highest exposure concentrations. No histopathological effects were noted at any of the exposure levels studied. (Trochimowicz, 1989).

In conclusion, repeated exposure to dichlorotrifluoroethane produces anaesthesia at concentrations of 31,000 mg/m^3 and above, reduction of body weight gain at 6,250 mg/m^3 and above, reduction of kidney weights and an increase in liver weight at 3,100 mg/m^3 and above. Indications of liver damage was seen in rats receiving 31,000 mg/m^3 and in dogs receiving 62,500 mg/m^3. Depression of triglyceride levels in serum occured at exposure level of 1,880 mg/m^3 and above. The toxicological significance of these findings has yet to be elucidated.

8.3 Long-Term Exposures

Investigation of chronic toxicity is being carried out in conjunction with a combined inhalation/carcinogenicity study in rats (see section 8.2 and 8.8).

8.4 Skin and Eye Irritation, Allergic Sensitisation

8.4.1 Skin irritation

Dichlorotrifluoroethane has been tested for acute skin irritation potential on 4 male and 2 female New Zealand rabbits. Dichlorotrifluoroethane (purity 99,98%) produced no skin irritation when 0.5 ml/6cm^2/4h were applied to clipped intact skin in any of the treated animals. This study was conducted under the PAFT Toxicology program (Trochimowicz, 1989)

8.4.2. Eye irritation

Dichlorotrifluoroethane, when tested undiluted by instilling 0.1 ml into the conjunctival sack of the rabbit eye without subsequent washing, produced mild to moderate conjunctival irritation (Daly, 1979). With washing, mild to slight transient corneal opacity and mild to moderate conjunctival irritation were observed. Whether or not the eyes were washed, complete recovery occurred within 3 to 7 days. Dichlorotrifluoroethane is, therefore, considered to be a mild to moderate eye irritant causing mild temporary corneal opacity.

8.4.3 Allergic sensitisation

Dichlorotrifluoroethane, when applied topically to the backs of male guinea pigs as 10% and 50% solutions in propylene glycol, produced no skin irritation or sensitisation at challenge (Daly, 1979).

8.5 Special Studies

8.5.1 Cardiovascular sensitisation

In a study in dogs by Trochimowicz and Mullin (1973) the EC_{50} for cardiac sensitisation was reported to be ~119,000 mg/m^3 and the no-observed-effect level (NOEL) was 62,500 mg/m^3 in response to adrenaline challenge.