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15. Supplementary Notes

16. Abstract (Limit: 200 words)

Information on potential occupational hazards from exposure to carbonyl-fluoride (353504) was reviewed. Topics discussed included chemical and physical properties, production, use, manufacturers and distributors, manufacturing processes, occupational exposure, and biological effects. Production of carbonyl-fluoride was assumed to be less than 10,000 pounds annually. Potential exposure to carbonyl-fluoride occurs as a result of the thermal decomposition of polytetrafluoroethylene (PTFE) in air. Effects of acute exposure in animal studies included extreme malaise and weakness which preceded death. Subchronic exposure studies with PTFE pyrolysis products revealed pathologic changes in the respiratory tracts and livers of exposed animals. Exposure of rats to pyrolysis products containing 52, 43, 29, 25, and 9 parts per million carbonyl-fluoride increased the fluoride in urine and decreased body weights by 30 percent. Succinic-dehydrogenase activity was increased in the lungs but not in the kidneys. Changes were also noted in the blood leukocyte composition, but not in total count. Protein, glucose, ketones, and occult blood appeared in the urine following exposure. No information was available concerning chronic exposures, carcinogenicity, mutagenicity, teratogenicity, or reproductive effects.

17. Document Analysis a. Descriptors

b. Identifiers/Open-Ended Terms

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## SUMMARY

Carbonyl fluoride has been identified as the dominant product during pyrolysis of polytetrafluorethylene (PTFE) at temperatures of 490 to 650°C. As an end-use product, production of carbonyl fluoride is judged to be small, probably less than 10,000 pounds annually. It is used for a variety of fluorosynthesis reactions.

Acute exposure to lethal doses of carbonyl fluoride (LC50, 350-450 ppm x 1 hour) or PTFE pyrolysis products results in lung injury in animals that is reversible if the exposure duration is short (1 hour). Carbonyl fluoride is a respiratory irritant gas that is about as toxic as hydrogen fluoride. The long term effects of carbonyl fluoride are related to its capacity to act as a fluoride-liberating agent in the body since it is rapidly hydrolyzed in the body to yield carbon dioxide and 2 moles of hydrogen fluoride. Repeated exposure to carbonyl fluoride causes liver damage in animals. No specific cases of human health effects attributable to carbonyl fluoride exposure have been reported in the literature.

1. Chemical Name: Carbonyl Fluoride

2. Chemical Structure:

3. Synonyms: Carbon fluoride oxide
Carbon difluoride oxide
Carbon oxyfluoride
Carbonic difluoride
Carbonyl difluoride
Difluoroformaldehyde
Fluophosgene
Fluoroformyl fluoride
Fluorophosgene

4. Chemical Abstracts Service (CAS) Number: 353-50-4

5. Registry of Toxic Effects of Chemical Substances (RTECS) Number: FG6125000

6. Chemical and Physical Properties:

| | |
|---|---|
| Description: | pungent, colorless gas |
| Molecular Weight: | 66.01 |
| Boiling Point: | -83.1°C |
| Melting Point: | -114°C |
| Vapor Pressure: | --- |
| Solubility: | instantly hydrolyzed by water |
| Specific Gravity: | 1.139 (at -114°C) |
| Stability: | unstable in presence of water<br>nonflammable |

7. Production

No production figures for carbonyl fluoride are available. Based on use, end-use production is judged to be small, probably less than 10,000 pounds annually (SRC estimate).

At the present time, the chief source of exposure to carbonyl fluoride results from the thermal decomposition of polytetrafluoroethylene (PTFE) in air (ACGIH, 1979). The amount of carbonyl fluoride generated annually by this decomposition is not availbele.

8. Use

Various patent literature indicates that carbonyl fluoride is useful for synthesizing fluoroalkanes, difluoroisocyanates, and fluorinated alkyl isocyanates. It is also probably used for other similar types of fluoro-syntheses reactions.

9. Manufacturers and Distributors

The following companies are listed as manufacturers of carbonyl fluoride (SRI International, 1980):

| | |
|---|---|
| G.D. Searle and Co. | Cucamanga, CA |
| (Will Ross, Matheson Gas Products Division) | East Rutherford, NJ<br>Gloucester, MA<br>Joliet, IL<br>La Porte, TX<br>Morrow, CA<br>Newark, CA |
| SCM Corp. (PCR, Inc., Subsidiary) | Gainesville, FL |

G.D. Searle no longer manufactures carbonyl fluoride (Kozlowski, written communication, 1980)

The only manufacturer of carbonyl fluoride listed by the U.S. EPA (1980) is DuPont (Wilmington, DE); the production range is unavailable.

In addition to the previously listed manufacturers, the following are distributors (Chem Sources--USA, 1980):

Atomergic Chemetals
Chemical Procurement Labs.
Columbia Organic Chem.
ICN/K and K
Pfaltz and Bauer
Synthatron Corp. (producer of high-purity carbonyl fluoride)

10. Manufacturing Processes

The commercial methods of manufacture for carbonyl fluoride are not found in the literature. A variety of methods are described, however, particularly by patents.

Pure carbonyl fluoride, $COF_2$, is difficult to prepare directly from carbon monoxide and fluorine. However, carbonyl fluoride can be prepared by the action of silver flucride on carbon monoxide (Hawley, 1977) or by blowing carbon monoxide into anhydrous hydrogen fluoride and manufacturing electrolytically (Nagase et al., 1970).

Carbonyl fluoride may also be manufactured from carbonyl chloride (phosgene). By treating phosgene with sodium fluoride in an inert but polar medium such as acetonitrile, tetramethylene sulfone, nitromethane, dimethyl sulfate, or ethylene carbonate, over a five-hour period at 30°C, a 95% pure carbonyl fluoride can be obtained (Fawcett and Tullock, 1963). Similarly, phosgene can be reacted with $NH_4F$ or $NH_4HF$ in acetonitrile for an hour at 70°C to yield 89.8% carbonyl fluoride. The reaction of phosgene and hydrogen fluoride also yields carbonyl fluoride; the by-product hydrogen chloride is absorbed by a metal fluoride, $SO_3$, or $P_2O_5$ (Tullock, 1958).

Carbonyl fluoride may also be prepared by the following methods. Equimolar amounts of $C_2F_4$ and oxygen are reacted at 200 to 450°C in a stainless steel pipe which has previously been circulated with $COF_2$. Residence time in the reaction zone is from 1 to 10 seconds. The reaction product contains the following: carbonyl fluoride, 98.36 mol %; oxygen, 0.23; $CF_4$, 0.08; $CO_2$, 0.08; $C_2F_4$, 0.30; $CF_3COF$, 0.42; and $CF_3OCOF$, 0.53 (DuPont, 1965). In another manufacturing method, pulverized $CaF_2$, lampblack, and $TiO_2$ are mixed in approximate stoichiometric proportions in an electric arc furnace and heated to 2800 to 3500°C under an

Argon atmosphere. The gaseous carbonyl fluoride passes out of the furnace, is condensed in a liquid nitrogen trap, and can be purified by fractional distillation and absorption (Langer, 1967).

Carbonyl fluoride is supplied as a liquified gas in steel cylinders (Hawley, 1977; PCR, 1978).

11. Impurities or Additives

Potential impurities, as suggested in Section 10, include oxygen, tetrafluoromethane, $CO_2$, $C_2F_4$, $CF_3COF$, and $CF_3OCOF$.

12. Occupational Exposures

The National Occupational Hazard Survey does not provide an estimate of the number of workers who are potentially exposed to carbonyl fluoride.

13. Control Technology and Work Practices

Specific factors that may contribute to or prevent employee exposure to carbonyl fluoride were not found in the literature searched.

14. Biological Effects

Interest in the toxic effects of carbonyl fluoride has resulted from the identification of the compound in the pyrolysis products of polycarbon monofluoride (Yoshida et al., 1977) and polytetrafluoroethylene (PTFE: Teflon, Halon, Fluon). During the pyrolysis of PTFE in air at temperatures of 490 to 650°C, carbonyl fluoride is the dominant product, and accounts for as much as 63% of the products (Coleman et al., 1968). Carbon dioxide is also a major PTFE pyrolysis product at high temperatures, but it should be noted that the aforementioned temperatures are higher than those commonly used in PTFE fabrication processes. At lower temperatures, however, the predominant products are higher molecular weight fluorocarbons. The toxicity of carbonyl fluoride has been addressed both in studies using carbonyl fluoride exposures and in studies using exposures of the PTFE pyrolysis products.

a. Animal Studies

(1) Acute Exposures

Available LC50 data suggest that, in rats, the lethal effect is a function of exposure concentration multiplied by the time of exposure (Scheel et al., 1968a). Scheel et al. (1968b) noted that, in rats, the signs of toxicity which preceeded death included extreme malaise and weakness. The acute toxic effects of carbonyl fluoride are summarized in Table 1.

Exposure of rats to the vapors emitted during oxidative pyrolysis of PTFE at 550°C produced animal lethality similar to that resulting from exposure to carbonyl fluoride (Coleman et al., 1968; Scheel et al., 1968a). Scheel et al. (1968a) determined the LC50 of these pyrolysis products for a one-hour exposure to be 370 ppm (as carbonyl fluoride) in rats. Coleman et al. (1968) observed increased mortality in rats as the concentration of carbonyl fluoride increased in the PTFE pyrolysis products; these investigators concluded that the toxicity of PTFE pyrolyzed in air at 550°C was due to the presence of carbonyl fluoride.

Scheel et al. (1968a) exposed mice, rats, guinea pigs, rabbits, and dogs to carbonyl fluoride, and noted similar pathologic changes in all the species. Lung injury, observed in tissues from animals sacrificed 24 hours after a 1-hour exposure to 310 ppm carbonyl fluoride, consisted of focal hemorrhages and pulmonary edema. Extensive permanent damage did not occur; rapid organization and clearing of the edema from the lung was observed 48 hours after the single-dose exposure. An irreversible portion of the injury consisted of residual focal emphysema and interstitial fibrosis.

(2) Subchronic Exposures

Scheel et al. (1968a, 1968b) also examined the toxic effects resulting from subchronic exposure to PTFE pyrolysis products. It must be

Table 1. Acute Effects of Carbonyl Fluoride

| Compound | Route | Species | Dose | Response | References |
|---|---|---|---|---|---|
| Carbonyl fluoride | Inhalation | rats | 360 ppm x 1 h | LC50 (14-day); most deaths occurred within the first 24 h | Scheel et al., 1968a |
| Carbonyl fluoride | Inhalation | rats | 350-450 ppm x 1 h | LC50 | Coleman et al., 1968 |
| Carbonyl fluoride | Inhalation | rats | 90 ppm x 4 h | LC50 | Scheel et al., 1968a |
| Products of PTFE pyrolysis at 550°C[a] | Inhalation | rats | 370 ppm x 1 h | LC50 (14-day) | Scheel et al., 1968a |
| Products of PTFE pyrolysis at 550°C[a] | Inhalation | rats | 5 daily 1-h exposures containing 52, 43, 29, 25, and 9 ppm of $COF_2$ | 9/40 deaths (22% mortality) | Scheel et al., 1968b |

Abbreviation: h = hour.

[a]Carbonyl fluoride has been identified as the principal toxic component of polytetrafluoroethylene (PTFE) pyrolysis gases at 550°C.

emphasized, however, that the pathologic changes described by Scheel et al. are the result of exposure to the pyrolysis products, and although carbonyl fluoride was identified and is considered the principal component of the products (Coleman et al., 1968; Arito and Soda, 1977), the changes may not be solely attributable to carbonyl fluoride. Other fluoride-containing gases and particles may have been present.

Scheel et al. (1968a) exposed Greenacres Controlled Flora rats, mice, guinea pigs (20 animals each), 6 rabbits, and 4 dogs to the products emitted during pyrolysis of PTFE at 550°C. Daily 1-hour exposures were given for 5 consecutive days. Pathologic changes were produced in the respiratory tract and in the livers of the exposed animals, and were similar for all the species. Following three daily 1-hour exposures to pyrolysis products containing 50 ppm carbonyl fluoride, a yellow-brown pigment was seen in most of the alveoli of the lungs. Atrophy of the alveolar lining cells was also present. A macrophage response around the pigment with periarteriolar inflammatory cells and focal emphysema began to develop 3 days after the fifth daily exposure. Pyrolysis particulate matter accumulated in the alveoli after the fifth daily 1-hour exposure, and a macrophage response around this material was also observed. The lung irritation persisted for at least 7 to 10 days following inhalation, but this effect was attributed to the particulate material. After five 1-hour exposures to PTFE pyrolysis products with a cumulative dose of 185-ppm hours of carbonyl fluoride, fatty liver degeneration marked by fat-filled vacuoles in the cytoplasm of the cells and enlarged nuclei were observed.

Scheel et al. (1968b) also subjected 20 male and 20 female Greenacres Controlled Flora rats to five daily 1-hour exposures of PTFE pyrolysis products containing 52, 43, 29, 25, and 9 ppm of carbonyl fluoride. These exposures increased the fluoride in the urine from 3 µg/ml to 42 µg/ml in 5 days,

and coincidentally decreased body weight by 30%. An increase in activity of the fluoride-sensitive enzyme succinic dehydrogenase was observed in the lungs (the target organ for exposure), but not in the kidneys (where no pathologic changes were noted). The liver tissues of exposed rats showed enlarged nuclei and fatty infiltration of the cells. The exposures also produced changes in blood leukocyte composition (but not in total count), and caused protein, glucose, ketones, and occult blood to appear in the urine.

(3) Chronic Exposures

No information was found in the literature searched.

(4) Carcinogenicity

No information was found in the literature searched.

(5) Mutagenicity

No information was found in the literature searched.

(6) Teratogenicity

No information was found in the literature searched.

(7) Reproductive Effects

No information was found in the literature searched.

(8) Other Relevant Information

When carbonyl fluoride comes in contact with water, it rapidly hydrolyzes to form $CO_2$ and 2 moles of hydrogen fluoride. Scheel et al. (1968b) found that the toxic syndrome in rats resulting from the inhalation of PTFE pyrolysis products was compatible with descriptions of fluoride poisoning. Scheel and coworkers concluded that carbonyl fluoride generated during the pyrolysis of PTFE hydrolyzed in the body fluids and produced fluoride toxicity in the exposed rats.

When PTFE is pyrolyzed in the absence of silica (eliminating production of silicon tetrafluoride), the pyrolysis products are slightly less toxic (Scheel et al., 1968a).

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b. Human Studies

(1) Pharmacokinetics

No information was found in the literature searched.

(2) Health Effects

No information on human health effects attributable to carbonyl fluoride exposure was found in the literature searched. In humans there has never been a death reported attributable to the pyrolysis of PTFE (Polakoff et al., 1974). A 1-day syndrome known as "polymer-fume fever" has been reported on numerous occasions (Lewis and Kirby, 1965), but it is apparently caused by inhalation of some particulate matter evolved during PTFE pyrolysis (Waritz and Kwon, 1968).

(3) Target Organ Toxicity

No information was found in the literature searched.

(4) Epidemiology

No information was found in the literature searched.

15. Ongoing Studies

No current toxicological or environmental studies of carbonyl fluoride were found.

16. Exposure Standards

The ACGIH has adopted a Time Weighted Average-Threshold Limit Value (TWA-TLV) of 5 ppm (15 $mg/m^3$) for carbonyl fluoride, and recently proposed a change of the TWA-TLV to 2 ppm (5 $mg/m^3$) (ACGIH, 1979). The proposed Short-Term Exposure Limit (STEL) value is 5 ppm (15 $mg/m^3$).

17. Sources of Additional Relevant Information

A NIOSH Health Hazard Evaluation relating to carbonyl fluoride has been conducted at the Digital Equipment Corp., Colorado Springs, CO (HHE No. 79-127-644).

18. Other Pertinent Data

No other information which may aid in the assessment of carbonyl fluoride as an occupational hazard was found in the literature searched.

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