

Solubility and toxicity of different fluorides

Consumption of fluoride cannot be avoided. It appears in so many different forms and in so many different environments (in our water supplies, our food, the air we breath, etc.). Therefore, it is important to know exactly how toxic each type of fluoride is and how much is considered safe when exposed to this chemical.

Toxicity is related to solubility. If a compound of fluoride (fluorine + one or more other elements) is very soluble, the fluoride ion is made more readily available. In 1971, former Aston University chemist Malcolm Harris investigated some fluoride compounds and determined the following table of solubility (solubility: "... a critical aspect of toxicity");-

Solubility

Calcium fluoride [natural] 16 ppm at 18°C and 17 ppm at 26°C

Sodium Fluoride [artificial] 42,200 ppm at 18°C

Sodium fluosilicate [artificial] 6,520 ppm at 17°C

Hydrofluorosilic acid [artificial] miscible liquid

It can be clearly seen that sodium-fluoride compounds are far more soluble than calcium fluoride. Hydrofluorosilic acid (used to fluoridate water supplies in the UK and [extensively] in the USA) is a "miscible" liquid. A miscible liquid means something which can be mixed (in this instance, with water).

By definition, hydrofluorosilic acid has 6 atoms of fluorine (H_2SiF_6). Of these six atoms, it is sometimes assumed that all six will become simple fluoride ions. However, there is no known published to demonstrate this actually happens. In fact, the best available knowledge suggests that only four of these atoms will become fluoride ions and the remaining two will form more 'exotic' complexes (depending on the quality of water the compound is mixed with).

More information on solubility:

Lanthanum Fluoride (LaF_3) Insoluble in water

Magnesium Fluoride (MgF_2) 0.0002g/100g water

Calcium Fluoride (CaF_2) 0.0017gm/100gm water at 20°C

Strontium Fluoride (SrF_2) 0.012g/100g water at 27°C

Barium Fluoride (BaF_2) 0.17g/100g water at 23°C

Lithium Fluoride (LiF) 0.27g/100g water at 20°C

Sodium Fluoride (NaF) 4.22g/100g water at 18°C

Source: www.crystran.co.uk

Considering that solubility is "... a critical aspect of toxicity", it is now prudent to examine another table which shows different types of fluoride. Professor Kaj Roholm's table of toxicity gives three categories of inorganic fluorine compounds (it should be noted that Prof. Roholm is the author of the first and most comprehensive monograph on fluorine toxicity);-

Extremely Toxic

Hydrogen Fluoride (anhydrous)

Silicon Tetrafluoride

Hydrofluoric Acid

Hydrofluorosilicic Acid

Potassium Fluorosilicate

Ammonium Fluorosilicate

Very Toxic (Easily soluble fluorides and fluorosilicates)

Sodium Fluoride

Potassium Fluoride

Ammonium Fluoride

Sodium Fluorosilicate

Moderately Toxic (Poorly soluble fluorides)

Cryolite

Calcium Fluoride

Hydrofluoric acid and hydrofluorosilicic acid are classified as being extremely toxic. Hydrofluorosilicic acid is used to fluoridate UK water supplies. The similarly dangerous hydrofluoric acid carries the following warning issued by the Health & Safety Executive (2001);-

Hydrofluoric acid poisoning

Recommendations on first aid procedures. Health & Safety Executive: <http://www.hse.gov.uk>

Information contained within this document is accurate as of 1/1/2001

IMPORTANT. ALWAYS contact the HSE for advice. See Disclaimer (below).

This leaflet is aimed at employers and employees in industries where hydrofluoric acid is used. It provides information on:

- health effects;
- precautions to be taken when working with hydrofluoric acid;
- first aid procedures to be followed in cases of hydrofluoric acid poisoning;
- first aid training.

DISCLAIMER

[1] THE INFORMATION PROVIDED ON THIS WEB-PAGE IS PURELY FOR THE PURPOSE OF HIGHLIGHTING THE DANGERS OF HYDROFLUORIC ACID.

[2] ANYONE WHO WORKS WITH HYDROFLUORIC ACID SHOULD ENSURE THAT THEIR EMPLOYER HAS THE APPROPRIATE MEASURES TO DEAL WITH ANY INCIDENT RELATING TO THE USE OF THIS CHEMICAL.

Health Effects

Hydrofluoric acid is corrosive. It can cause severe burns to the skin and eyes. If it comes into contact with skin, you may not feel pain at once Hydrofluoric acid is also highly irritating to the respiratory system and very toxic if swallowed.

Precautions

The Control of Substances Hazardous to Health Regulations 1999 (COSHH) apply. A COSHH assessment should be completed. Consider the use of safer alternatives. If there are no suitable alternatives, the assessment should detail appropriate precautions to be taken when using hydrofluoric acid, which include using a safe system of work. Employers should ensure that employees are given adequate information and training on the hazards to health posed by hydrofluoric acid, and the precautions to take to avoid them.

Employers should:

- always use the protections provided;
- always wash gloves and other impervious clothing before removing them;
- test gloves for pinholes using a method advised by the manufacturers (this might be done by filling them with water, before drying and putting them away for use again), discarding gloves that are not sound;
- always wash their hands before leaving the work area

First aid:

- Urgent action is required. Obtain immediate medical attention.
- When giving first aid, protect yourself and the casualty from further exposure.
- Casualties should be sent to hospital as soon as possible (see opposite). In all cases, the hospital should be informed of the cause of injury.

Skin contact

- Remove contaminated clothing while protecting your hands with suitable gloves.
- Flood the skin with plenty of water for at least 5-10 minutes.
- Apply calcium gluconate gel on and around the affected area and continuously massage into the skin for at least 15 minutes after pain is relieved. Cover the area with a dressing soaked in the gel and lightly bandage. these procedures can be continued during transit to hospital.
- Send to the Accident and Emergency Department.

Eye contact:

- Flush the eye with water for at least 20 minutes. This can be continued during transit to the hospital.
- Send the casualty to the Accident & Emergency Department or local Eye Casualty Department.

Gassing:

- Remove the casualty from the contaminated area and place in fresh air.
- If necessary, resuscitate the casualty.
- If suitably trained, give oxygen.
- Send to the Accident & Emergency Department.

Swallowing:

- Never attempt to induce vomiting.
- If the casualty is conscious, rinse out their mouth with water.
- Send to Accident & Emergency Department.

Obviously, hydrogen-related fluorine compounds are extremely dangerous. While hydrofluorosilicic acid breaks down in water, the raw material poses a significant threat to those who come into contact with it.