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What is fluoride? (Main source of info.: Infopedia, v2.0)

It is unusual to find someone who has not heard of fluoride. Conversely, it is equally unusual to find someone who can explain precisely what fluoride is. It is an indictment of our educational system that we are not told more about a chemical which threatens to have an enormous impact on our lives. So what exactly is fluoride?

Firstly, a lesson in geology. The earth consists of five parts: the atmosphere (gaseous [air]), the hydrosphere (liquid [water]) and the third, fourth, and fifth, the lithosphere, mantle, and core. The lithosphere, consists mainly rocky crust of the earth, and extends to depths of 100 km. The lithosphere comprises two shells - the crust and upper mantle and are divided into tectonic plates.

The rocks of the lithosphere are almost entirely made up of 11 elements, which together account for about 99.5% of its mass. The most abundant is oxygen (about 46.60% of the total), followed by silicon (about 27.72%), aluminium (8.13%), iron (5.0%), calcium (3.63%), sodium (2.83%), potassium (2.59%), magnesium (2.09%) and titanium, hydrogen, and phosphorus (totalling less than 1%). In addition, 11 other elements are present in trace amounts of from 0.1 to 0.02%. These elements, in order of abundance, are carbon, manganese, sulphur, barium, chlorine, chromium, fluorine, zirconium, nickel, strontium, and vanadium. The elements are present in the lithosphere almost entirely in the form of compounds rather than in their free state. These compounds exist almost entirely in the crystalline state, so each is, by definition, a mineral.

Fluorine (From the Latin fluo, meaning "flow")

Fluorine is a member of the chemical family called the halogens, also composed of elements: chlorine, bromine, iodine and astatine. A non-metallic element, fluorine (Symbol F) is a pale yellowish flammable irritating toxic diatomic gas which is slightly heavier than air. It is also poisonous, corrosive and the most chemically ‘active’ of all the non-metallic elements (and the most electronegative and reactive of all elements). It was discovered in 1771 by the Swedish chemist Carl Wilhelm Scheele and was isolated in 1886 by the French chemist Henri Moissan.

Fluorine occurs naturally in the combined form as fluorite (or fluorspar), cryolite and apatite. Apatite (from the Greek ‘apate’ meaning “deception”), which is made up mainly of phosphate of lime, is a crystal which was once used in the preparation of fertilizer.

NB. Phosphate rock is now used in place of mineral phosphates of lime.

Fluorine also occurs as fluorides in seawater, rivers, and mineral springs, in the stems of certain grasses, and in the bones and teeth of animals.

Fluoride

Fluoride (*ion) is fluorine plus the addition of an extra electron taken from another element. One element which reacts easily with fluorine is calcium. When these two elements react with each other, the result is calcium fluoride. Reaction is caused by the sharing or exchange of electrons. In the case of fluorine and calcium, fluorine is 'deficient' of one electron and calcium has a 'surplus' of two. For the purpose of this exercise, 'deficiency' and 'surplus' are defined by the number of electrons in the outer shell in these elements.

*Depending on what fluoride reacts with, fluoride can appear as a single fluoride ion or it can be bound to another element such as calcium.

What is an atom?

Atoms are made of protons, neutrons (the nucleus) and electrons. Electrons are arranged in 'shells' around the nucleus. The nearest shell never contains more than 2 electrons. 2nd and 3rd shells can contain a maximum of eight electrons. The 4th shell has a potential to contain 18 electrons. The maximum number of electrons which can appear in each element defines the 'period' of the respective element. Hence, an element which has a maximum of 2 electrons will appear in the first period. Those elements which have up to eight electrons in their second shell will appear in the second period. Other elements are arranged according to the number of electrons in their shells.

Show me the Periodic table (hyperlink to external site)

Fluorine (hyperlink to external site)

Fluorine has an arrangement of 2-7 electrons (a 'deficiency' of 1 electron in the second shell) and calcium has an arrangement of 2-8-8-2 electrons (a 'surplus' of two electrons in the fourth shell). In the case of fluorine, it is 'easier' for this element to 'gain' one extra electron rather than 'lose' seven. Conversely, it is 'easier' for calcium to give up two electrons.

Therefore, when reacting, two atoms of fluorine will each 'steal' one electron from each of the two electrons that are 'surplus' in calcium. Ergo, calcium fluoride is one atom of calcium and two of fluorine (CaF2).

Fluorine compounds

Apart from naturally occurring fluorides, such as calcium fluoride which is found in 'naturally fluoridated' water supplies, there are also 'artificially manufactured' compounds of fluoride. Some of these are described below.

Hydrofluoric acid

Hydrofluoric acid (hydrogen fluoride, HF or H2F2), one of the most important fluorine compounds, is prepared by heating calcium fluoride in sulphuric acid. The aqueous solution of this acid, generally used commercially, is obtained by passing the anhydrous hydrogen fluoride vapours into a leaden receiver containing distilled water, thus yielding the acid in dilute form. Hydrofluoric acid is extremely corrosive and must be preserved in lead or steel containers. Hydrofluoric acid has the property of dissolving glass, and this property is used in a common test for the presence of a fluoride; hydrofluoric acid is also used extensively in various forms of glass etching, such as the marking of divisions on thermometer tubes and the etching of designs on glassware, and in other forms of ceramic etching, such as pottery decoration.

Silicofluorides

Another fluorine compound, *hydrofluosilicic acid, combines with such bases as sodium and potassium to form salts called fluosilicates or silicofluorides. Fluorine and many fluorides, such as hydrogen fluoride and sodium fluoride, are extremely poisonous.

*Also known as hexafluorosilicic acid (H2SiF6), which is used to fluoridate water supplies.

Potassium Fluoride (KF)

Used for fluoridated table salt (source: Laporte Chemicals)

Differences between natural and artificial fluorides

The best way to describe the differences between natural and artificially manufactured fluorides is to examine the solubility and toxicity of each type. This will be the subject of the next document in this series (2. Solubility and toxicity of different fluorides).

What else can be found in artificial fluorides?

There are many background contaminants in artificial fluorides. The following picture (from Ireland) will give the reader some idea of the toxic chemicals (such as lead, arsenic, mercury) that are present in fluorosilicates:

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CHEMICAL ANALYSIS CONFIDENTIAL REPORT No. W8158

Report Number	W8158
Invoice Number	10858
Laboratory Number(s)	23034
Your Order Number	
Number of Samples	1
Sample Description	Hydrofluorosilicic Acid
Date Reported	14/08/00

TEST	RESULT
Calcium	51 ppm
Magnesium	23.9 ppm
Sodium	33.6 ppm
Potassium	6.2 ppm
Aluminium	2.1 ppm
Boron	14 ppb
Manganese	571 ppb
Copper	90 ppb
Zinc	523 ppb
Phosphorus	26187 ppm
Barium	168 ppb
Iron	11.85 ppm
Sulphur	134.9 ppm
Arsenic	4826 ppb
Cadmium	4 ppb
Chromium	3763 ppb
Mercury	5 ppb
Nickel	1742 ppb
Lead	15 ppb
Selenium	2401 ppb
Thallium	<2 ppb
Antimony	14 ppb
Tin	4 ppb
Cobalt	56 ppb
Strontium	88 ppb
Molybdenum	490 ppb
Beryllium	<2 ppb
Vanadium	87 ppb