9.7: Chalconide Hydrides

Dihydrides

The hydrides of sulfur, selenium and tellurium are all extremely toxic gases with repulsive smells. Hydrogen sulfide (H_2S) is very toxic, in fact it is more than 5x as toxic as HCN (Table 9.7.1). Hydrogen sulfide is considered a broad-spectrum poison, meaning that it can poison several different systems in the body, although the nervous system is most affected. It forms a complex bond with iron in the mitochondrial cytochrome enzymes, thereby blocking oxygen from binding and stopping cellular respiration. Exposure to low concentrations can result in eye irritation, a sore throat and cough, nausea, shortness of breath, and fluid in the lungs. Long-term, low-level exposure may result in fatigue, loss of appetite, headaches, irritability, poor memory, and dizziness.

Table 9.7.1: Toxicity levels for hydrogen sulfide.

Concentration (ppm)	Biological effect
0.00047	Threshold.
10–20	Borderline concentration for eye irritation.
50–100	Eye damage.
100–150	Olfactory nerve is paralyzed and the sense of smell disappears, often together with awareness of danger.
320–530	Pulmonary edema with the possibility of death.
530–1000	Stimulation of the central nervous system and rapid breathing, leading to loss of breathing.
800	Lethal concentration for 50% of humans for 5 minutes exposure (LC50).
+1000	immediate collapse with loss of breathing, even after inhalation of a single breath.

Each of the hydrides is prepared by the reaction of acid on a metal chalcogenide, e.g., (9.7.1) and (9.7.2). The unstable H_2Po has been prepared by the reaction of HCl on Po metal.

$$\mathrm{Fe + S \rightarrow FeS} \tag{9.7.1}$$

$$\mathrm{FeS + 2HCl \rightarrow H_2S \uparrow + FeCl_2} \tag{9.7.2}$$

The thermal stability and bond strength of the dihydrides follows the trend:

$$\mathrm{H_2S > H_2Se > H_2Te > H_2Po} \tag{9.7.3}$$

While H_2Se is thermodynamically stable to 280 °C, H_2Te and H_2Po are thermodynamically unstable.

All the dihydrides behave as weak acids in water. Thus, dissolution of H_2S is water results in the formation of the conjugate bases, (9.7.4) and (9.7.5), with dissociation constants of 10^{-7} and 10^{-17}, respectively.

$$\mathrm{H_2S + H_2O \rightleftharpoons H_3O^+ + SH^-} \tag{9.7.4}$$

$$\mathrm{SH^- + H_2O \rightleftharpoons H_3O^+ + S^{2-}} \tag{9.7.5}$$

Sulfanes

The propensity of sulfur for catenation means that while the hydrides of oxygen are limited to water (H_2O) and hydrogen peroxide (H_2O_2), the compounds H_2S_n where n = 2 - 6 may all be isolated. Higher homologs are also known, but only as mixtures. All of the sulfanes are yellow liquids whose viscosity increases with increased chain length.

A mixture of lower sulfanes is prepared by the reaction of sodium sulfides (Na_2Sn) with HCl, (9.7.6). From this mixture the compounds H_2S_n where n = 2 - 5 are purified by fractional distillation. However, higher sulfanes are made by the reaction of either H_2S or H_2S_2 with sulfur chlorides, (9.7.7) and (9.7.8).

$$Na_2S_2 + 2HCl \rightarrow 2NaCl + H_2S_n \tag{9.7.6}$$

$$2H_2S + S_nCl_2 \rightarrow 2HCl + H_2S_{n+2} \tag{9.7.7}$$

$$2H_2S_2 + S + nCl_2 \rightarrow 2HCl + H_2S_{n+4} \tag{9.7.8}$$