fumed silica is as additives in silicone rubbers used to increase the mechanical strength and the elasticity of these elastomers.

5.2.4.2.3 Functional silanes

This generic term covers a broad range of products built on silane molecules, in which an atom of hydrogen or of chlorine is substituted with an organic radical bearing a functional group, for example, amine, acid, ester, alcohol and so on.

$$X_{4-(n+p+q)}SiR_nR'_pR''_q$$

represents a general formula of functional silanes, in which R, R′, R″ are organic radicals and X is Cl or OH. There exist a multitude of functional silanes. One of their major applications is as coupling agent between inorganic and organic compounds, for example, inorganic fillers (glass, silica, clays etc.) in organic matrices (epoxy, polyester etc.)

Several routes may be imagined to generate such molecules. The current industrial praxis dictated by economical efficiency is the functionalisation of trichlorosilane according to

$$SiHCl_3(g) + RX(l) \rightarrow SiRCl_3(l) + HX(g)\ (X = Cl, OH, \ldots) \tag{5.7}$$

whereas trichlorosilane is produced by a direct synthesis in a fluidised or fixed bed reactor:

$$Si(s) + 3HCl(g) \rightarrow SiHCl_3(g) + H_2(g) \tag{5.8}$$

$$Si(s) + 3SiCl_4(g) + 6H_2 \rightarrow 4SiHCl_3(g) + 4H_2 \tag{5.9}$$

$$SiCl_4(g) + H_2(g) \rightarrow SiHCl_3(g) + HCl(g) \tag{5.10}$$

A variant recently developed for some classes of functional silanes is the direct synthesis involving silicon and methanol:

$$Si(s) + 3CH_3OH(l) \rightarrow SiH(OCH_3)_3 + H_2(g)\ (Cu\ catalyst) \tag{5.11}$$

$$SiH(OCH_3)_3 + RX \rightarrow SiR(OCH_3)_3 + HX \tag{5.12}$$

Orthoethylsilicate or tetraethoxysilane, $Si(OC_2H_5)_4$, is an important chemical molecule for glass, ceramic, foundry and painting. It is produced industrially by substitution of Cl in $SiCl_4$ or by direct reaction of ethanol with silicon in the presence of a catalyst following the same pattern as (5.7) and (5.12).

The total consumption of silicon metal to functional silanes and orthosilicates may be estimated at 10 000 to 20 000 MT per year.

5.2.4.3 Semiconductor silicon

Silicon is by far the most important and popular semiconductor material since the emergence of solid-state electronics in the late fifties and the early sixties. Ultra-pure