

Low-pressure decomposition of chrysotile as a function of time and temperature

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ABSTRACT

Chrysotile from Thetford, Quebec, was heated at constant temperature in quench furnaces from 200 to 1000 °C for 4 to 720 h, and the products were analyzed by XRD and optical microscopy. XRD patterns for chrysotile from Thetford, Jeffrey Quebec, and New Idria, California, heated for up to 8 h at constant temperatures from 400 to 800 °C in hydrothermal diamond-anvil cells, were obtained at 300 s intervals by using synchrotron radiation.

The studies show that differences in the decomposition temperatures of chrysotile reported in the literature can be explained by differences in the temperatures, time at temperature, particle size, and partial pressure of water. Chrysotile heated for 30 days is destroyed between 475 and 500 °C, whereas chrysotile heated to 800 °C survives for only minutes. A prograde heating experiment, consistent with the literature, shows chrysotile destruction beginning at 600 °C and completed at 750 °C, demonstrating that such experiments should not be used to establish temperatures of thermal stability.

Forsterite forms readily at 600 °C when water is retained transiently in the decomposition products, but does not form after 4 h of heating samples of small fiber size and high surface area from which water is readily lost. When water is retained in the sample chamber during heating to 800 °C over 4 h, a rapid destruction of chrysotile and formation of forsterite was observed, followed by the appearance and later destruction of the intermediate reaction products talc, a tridymite-like phase, and anthophyllite; enstatite appearance coincides with the destruction of the tridymite-like phase and talc. In quench experiments, a 10+ Å phase is observed between 500 and 600 °C, and talc is observed between 587 and 800 °C.

The optical properties of the run products between 600 and 900 °C are highly variable, with a range in the index of refraction perpendicular to length of up to 0.06 and a minimum index of refraction 0.03 below the starting material in fibers in the 650 °C run product; the variability reflects the inhomogeneity in products and reactants in this temperature range.

In quench experiments, the intensity of the XRD patterns of chrysotile decreased on heating between 200 and 400 °C, and increased at 450 °C, demonstrating recrystallization of chrysotile. A gradual heating experiment showed a similar pattern with the lowest intensities at 250 °C and maximum intensities at 550 °C.

The two types of chrysotile reported in the literature may reflect simply the presence of chrysotile of different particle sizes. Chrysotile may also possess a spectrum of stabilities due to variable strain energies of curvature. The presence of a tridymite-like phase supports the formation of a Si-rich dehydroxylate II. The absence of forsterite and chrysotile in brake-wear debris reflects the high temperature and disaggregated fiber bundles resulting from friction.

Keywords: Chrysotile, asbestos, thermal stability, brake wear debris, reaction products