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Biodurability of chrysotile and tremolite asbestos in simulated lung and gastric fluids

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Abstract

Chrysotile [$Mg_3Si_2O_5(OH)_4$] and tremolite [$Ca_2Mg_5Si_8O_{22}(OH)_2$] asbestos represent two distinct mineralogical categories of regulated asbestos commonly evaluated in epidemiological, toxicological, and pathological studies. Human respiratory and gastric systems are sites of asbestos deposition where chrysotile and tremolite asbestos are undersaturated with respect to biological fluids and dissolution kinetics control the persistence of these minerals in biological environments. Here we examined the biodurabilities (i.e., the resistance to dissolution) of chrysotile and tremolite asbestos in simulated body fluids as a function of mineral surface area over time. Batch experiments in simulated gastric fluid (SGF; HCl and NaCl solution at pH 1.2) and simulated lung fluid (SLF; modified Gamble's solution at pH 7.4) were performed at 37 °C over 720 h to evaluate the dissolution of chrysotile vs. tremolite asbestos in acidic and near-neutral biological fluids. The rate-limiting step of Si release for both minerals was used to obtain rate constants (k) and reaction orders (n) allowing comparisons of mineral dissolution rates. Both chrysotile and tremolite asbestos are less biodurable in SGF (low pH) compared to SLF (near-neutral pH). Based on equivalent surface area comparisons, the surface chemistry of tremolite is more reactive in lung fluid than chrysotile and vice versa in digestive fluid. However, the relative biodurabilities of these asbestos silicates (from most to least) are tremolite (SLF) > chrysotile (SLF) > tremolite (SGF) > chrysotile (SGF) when accounting for the greater surface area of chrysotile per mass or per fiber compared to tremolite. Overall, this study illustrates the importance of surface area and fiber morphology considerations when evaluating the biodurabilities of asbestiform minerals.

Keywords: Chrysotile, tremolite, serpentine, amphibole, asbestos, dissolution, biodurability