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Is fibrous ferrierite a potential health hazard? Characterization and comparison with fibrous erionite

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Abstract

Fibrous erionite is classified by the International Agency for Research on Cancer (IARC) as carcinogenic substance to humans (Group 1). In the areas where it is present in the bedrock, it may cause environmental exposure, and both professional and environmental exposures are possible when the bedrock is used for industrial applications (e.g., building materials). For health and environment protection, prevention is a priority action. In this framework, the recent guidelines of the Consensus Report of the Weinman International Conference on Mesothelioma suggest identifying locations where potentially hazardous mineral fibers (like erionite) are found in the environment, to prevent environmental exposure. The present study will show that one such potentially hazardous mineral fiber might be fibrous ferrierite. Here, the mineralogy, chemical-physical properties, and surface activity of a hydrothermal fibrous ferrierite from Monte Lake British Columbia (Canada) and a diagenetic fibrous ferrierite from Lovelock, Nevada (U.S.A.), were investigated using a combination of "state of the art" experimental methods including optical microscopy, electron microscopy and microprobe analysis, laser ablation-inductively coupled plasma-mass spectrometry (for the trace elements), vibrational spectroscopy, electron paramagnetic resonance, and synchrotron powder diffraction. The chemical-physical properties of these fibrous ferrierites (morphometric parameters, specific surface area, chemical composition with special attention to metals, mainly iron) that prompted adverse effects in vivo were compared to those of the positive carcinogenic standard fibrous erionite-Na from Jersey, Nevada (U.S.A.). The results of our study have demonstrated that, although there are differences in the crystal chemistry and genetic environment, ferrierite samples exhibit outstanding similarities with fibrous erionite samples: both fibrous erionite and fibrous ferrierite may occur in large amounts as microcrystalline fibrous–asbestiform phases in diagenetic rocks with fibers of breathable sizes. For both zeolites, iron is not structural but is associated with impurities lying at the surface of the fibers. Moreover, data useful to understand the surface activity of these fibrous ferrierites were collected. As far as hydrothermal sample is concerned, the EPR data indicate the presence of hydrophilic (SiO-, AlO-, SiOH) and hydrophobic (Si-O-Si) interacting surface groups able to bind the charged CAT1 probes at close sites and attract the probes in the water pools formed into the fiber aggregates. A high percentage of CAT1 probes weakly interacting with the surface due to competition with metal ions were observed for surface of the diagenetic sample. CAT8 probes were less adsorbed by its surface if compared to the diagenetic sample but the more charged surface provided a stronger binding strength for the diagenetic sample compared to the hydrothermal one. In summary, the results of this study indicate that fibrous ferrierite may represent a potential health hazard and, applying the precautionary principle, it should undergo a procedure of toxicity testing.

Keywords: Zeolite, ferrierite, erionite, mineral fiber, health hazard; Microporous Materials: Crystal-chemistry, Properties, and Utilizations