



## Hydrolysis of copper (II) ions inside natural chrysotile nanotubes

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**Abstract** – The hydrolysis of copper ions in natural chrysotile asbestos were studied by chemical analysis, X-ray absorption (EXAFS and XANES) and diffraction measurements and, atomic force and electron transmission microscopy. Natural chrysotile samples were previously treated to eliminate impurities and then, modified with  $\text{Cu}^{2+}$  solution in alkaline medium. Results showed that copper is preferentially deposited inside nanotubes as hydroxide and oxide species.

Chrysotile,  $\text{Mg}_3\text{Si}_2\text{O}_5(\text{OH})_4$ , is a nanotubular mineral in nature whose crystal walls are constituted of sheets of tetrahedral silica joined to sheets of octahedral magnesium hydroxide creating a tubular structure with an empty cavity. When this nanometer-sized channel is filled with a suitable material, a unique environment for chemical reactions is provided generating unexpected physicochemical features of materials trapped there. Moreover, the large interchannel separation in chrysotile asbestos prevents the interaction between individual inner nanoparticles and act as confining barrier. A further advantage is the fiber length, up to few cm, which allows handling the samples as a bulk material. In fact, chrysotile nanotubes have been filled with molten metals, semimetals, semiconductor and oxides in view of producing nanowires with novel physical and physical-chemical properties [1]. In this way, we study the hydrolysis of copper ions in natural chrysotile nanotubes that can yields species of copper oxides with appreciable magnetic and thermal expansion properties [2].

Due to the high degree of impurities, natural chrysotile was submitted to a previous treatment using a permanent magnet to remove magnetic particles and then washing the fibers on 74  $\mu\text{m}$  mesh under tapwater and finally, the resulting chrysotile fibers were dried at 100°C for 24 h [3]. To fill chrysotile samples, fibers were sonicated in a 1 mol/L  $\text{Cu}^{2+}$  solution (pH = 2) during 30 min. After this, the mixture were centrifuged and washed with water twice. Then, fibers were dispersed in a 1 mol/L NaOH solution, sonicated during 15 min, centrifuged and rinsed twice with distilled water and dried at 75 °C [4].

X-ray diffraction measurements confirmed the crystalline structure of chrysotile and show qualitatively the presence of another phase relative to the hydrolyzed copper which is also verified by chemical dosages. Cross-analysis of atomic force and transmission electron microscopy showed deposited copper compounds in the mesopores of chrysotile rather than on the outer surfaces. The analysis of extended X-ray absorption fine structure (EXAFS) and X-ray absorption near-edge structure (XANES) spectra, measured at Nacional Laboratory of Synchrotron Light (LNLS) in Brazil (Cu K-edge), are being done to verify the local structure of copper species and thus, elucidate which kind of compound was formed inside nanotubes.

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