

Crystal chemistry of cement-asbestos and its high temperature products

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Asbestos-containing materials (ACM) are an example of hazardous waste which has become matter of great concern due to its widespread diffusion. Cement asbestos (CA) are the most represented ACM. Recently, an industrial process for the thermal destruction of CA wastes was developed [1] in compliance with the European directives and Italian legislation. Sealed packages of CA slates undergo prolonged annealing in the temperature range 1200-1300 °C, during which both serpentine and amphibole asbestos minerals are completely transformed into newly-formed silicates.

The potential of this product as secondary raw material relies on the effectiveness and reproducibility of the inertization process at the industrial scale, and on the choice of suitable recycling solutions. At the scope, is of great interest to investigate how the high temperature transformed product is affected by the chemistry and mineralogy of the starting CA material. Literature data on CA slates are scarce and incomplete, and a comprehensive picture with emphasis on areal distribution and compositional variability at a large scale is lacking.

In this work, 27 CA samples coming from different localities in Italy, and their high-temperature inertization products were characterized with a combination of analytical techniques, including XRF, XRPD, SEM/EDS, FTIR and micro-Raman. Raw materials revealed a complex mineralogy comprising cement hydrated phases, a residual non-hydrated component, and a relevant fraction attributable to various processes of alteration. The industrial inertization process was reproduced at the laboratory scale by heat treating small chunks of cement-asbestos at 1200 °C. A series of solid state reactions leading to global structural changes of the matrix with complete transformation of asbestos minerals was observed. Chemical gradients due to limited ionic diffusion testified recrystallization under non-equilibrium conditions. This didn't prevented the use of the CaO-SiO₂-MgO phase diagram in order to relate the mineralogy of thermally treated samples with their chemistry. Effects of annealing time and temperature on the crystallization kinetics were investigated with further thermal treatments. With the aid of thermodynamic calculations both factors were considered to act in favour of equilibrium. Three classes of heat-treated CA, showing distinct chemical and mineralogical fingerprints, were identified. XRF data allow for the content of CA packages, and thus, the corresponding heat-treated products, to be quickly classified. Analyses could be carried out indifferently before or after the thermal treatment. This result is of importance in view of the potential recycling applications. Classes of transformed product can be selected and eventually mixed in function of the solution adopted. This is the case of larnite-rich products, already recognized as larnite-rich cements high in magnesium, potential constituent of green cements, and tested as substitute for cement in commercial concrete [2].

[1] A. F. Gualtieri, C. Cavenati, I. Zanatto, M. Meloni, G. Elmi, M. Lassinantti Gualtieri, The transformation sequence of cement-asbestos slates up to 1200 °C and safe recycling of the reaction product in stoneware tile mixtures, *J. Haz. Mat.*, 152 (2008) 563-570.

[2] A.F. Gualtieri, M. Boccaletti, Recycling of the product of thermal inertization of cement-asbestos for the production of concrete, *Construction and Building Mat.*, 25 (8) (2011) 3561-3569.