The joint virtual event of the
African Light Source AfLS-2024 (7th)
and the
African Physical Society AfPS2024

Contribution ID: **212** Type: **not specified**

High-Pressure dependence of structure evolution and adsorption behavior in Nano-Layered Double Hydroxides (LDHs): impact for their uses in Cements

Friday, 22 November 2024 12:15 (15 minutes)

1.Introduction

Ensuring the sustainability of cement production is crucial in the construction sector. One effective approach to achieve this goal is by integrating suitable additives into traditional cement formulations. Layered Double Hydroxides (LDHs) offer promising potential as additives, as they can capture CO_2, enhance the carbonation resistance of cement, and remove CO_2, ${SO_4}^{2-}$, and Cl^- ions that may compromise the durability of cement paste. Classified as ionic solids with a layered structure, LDHs are known as anionic clays with controllable supramolecular structures and unique physicochemical properties, such as anion exchange, which make them particularly attractive in the field of cementitious materials [1,2]. In nature, these minerals are found in ultramafic rocks and form through high-temperature carbonation of spinel-type minerals or low-temperature carbonation of brucite ($Mg(OH)_2$). Investigating the structural evolution, phase transitions, and amorphization conditions of both natural and synthesized LDHs under high pressure using synchrotron light is of significant interest. Pressure-induced irreversible phase transition in hydrotalcite-like minerals comes together with a decrease in electrical resistivity and a progressive amorphization of the crystal structure [3]. Different microstructural characteristics of LDHs evolve as a function of pressure and temperature and influence the interlayer space, which is reflected in an increase in CO_2 adsorption [4].

2.Results and discussions

Nano Mg-Al-NO_3 LDHs were synthesized using both direct and ultrasound co-precipitation methods. The nanometric size and purity of the LDHs were confirmed through X-ray powder diffraction (XRPD), transmission electron microscopy (TEM), scanning electron microscopy (SEM), dynamic light scattering (DLS), and Fourier-transform infrared spectroscopy (FTIR). The ultrasound co-precipitation methods provide nanometric 2D size crystals and high purity of the LDHs species. The initial findings presented here contribute to understanding the precise role of selected nanomaterials in cement paste, particularly regarding how pressure influences their shape memory and the stability of trapped CO_2 and other anions responsible for the chemical attack of cement, such as Cl^- and ${SO_4}^{2-}$. At high pressure, the anion absorption increases exponentially [4] and to understand this behaviour, the knowledge of the evolution in interlayer distance and dehydration and dihydroxylation processes of the brucite-type layers is essential. The ongoing HP single-crystal X-ray diffraction (SC-XRD) data will be collected at the ID15B beamline at the European Synchrotron Radiation Facility (ESRF, Grenoble, France) using diamond anvil cell (DAC) and, given the high-resolution and very small size of the beam spot, is being essential to characterize the nanomaterial structure of the synthesized LDHs. These results could also reveal potential adverse effects and aid in refining the procedures for incorporating LDHs additives into cement pastes. This abstract is one of the contributions from Commission of Physics of Minerals (CPM), International Mineralogical Association (IMA).

3.Acknowledgements

This work is funded by the European Union – Next Generation EU under the Italian Ministry of University and Research (MUR) National Innovation Ecosystem grant ECS00000041 - VITALITY - CUP J97G22000170005.

4.References

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Session Classification: AfLS Contribution

Track Classification: AfLS