Study on natural and synthetic CO_2 adsorbents for application as supplementary cementitious materials

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Carbon dioxide emissions related to industrial activity and the global warming associated with them are problems which needs to be tackled as soon as possible, cement industry in particular is responsible for approximatively 7% of global CO_2 emissions. Currently carbon capture, utilization and storage (CCUS) technologies seem to be the only sufficiently powerful and effective technologies capable of significantly reduce CO_2 emissions from the industrial sector. This study falls within the framework of a CCUS project aimed at creating a circular economy around CO_2 from cement production, studying carbon dioxide adsorption properties of some selected materials, and the possibility of using them as supplementary cementitious materials (SCM) in mortar production, which implies replacing part of the cement required for mortar production with the CO_2 loaded materials allowing the reintroduction of the carbon dioxide generated during the cement production process into the final cementitious product. The materials subject to analysis were natural and synthetic zeolites, since zeolites themselves exhibit good characteristics in terms of adsorption capacity and affinity towards carbon dioxide compared to other materials; during the study materials have also been distinguished in two distinct particle size classes, fine and coarse, classified according to their dimensions. The first stage of the experimental work involved thermogravimetric analysis, used to quantify the moisture content and the CO_2 load and release capacity of the materials; the experimental procedure subsequently included the use of a laboratory scale pilot plant which compared to the thermogravimetric analysis, allows to involve larger quantity of materials during the analysis and a better contact area between the sample material and the carbon dioxide stream. The results of the two different type of tests showed that synthetic zeolites have better properties in terms of adsorption properties compared to natural ones, due to the functionalization process performed on those materials that contributes to the formation of extra-frameworks channels resulting in an increased specific surface area. Theoretically, the introduction of the carbon dioxide through zeolites inside the mortar paste should promote the reaction between CO_2 and cement hydrated phases obtaining calcium carbonate, which should improve mortar mechanical strength. From the mechanical strength test performed during the last part of the study it has not been observed a significant increase in the mechanical properties of the mortar, but not even a significant decrease, meaning that it is indeed possible to replace part of the cement required for mortar preparation with the zeolites studied.

Keywords: *CO_2 emissions, Cement Industry, CCUS technology, Supplementary Cementitious Materials.*