Development a sustainable CO_2 mineralization process using alkaline industrial waste for enhanced carbon sequestration

Ilaria Tocci[a], Domenico Flagiello[b], Simeone Chianese[a], Alessandro Erto[b] & Dino Musmarra[a]

[a] Dipartimento di Ingegneria, Università degli Studi della Campania Luigi Vanvitelli, Aversa (CE), Italy
[b] Dipartimento di Ingegneria Chimica, dei Materiali e della Produzione Industriale, Università degli Studi di Napoli Federico II, Napoli (NA), Italy

E-mail: *ilaria.tocci@unicampania.it*

Current industrial energy production from fossil fuels results in the annual release of large amounts of CO_2 into the atmosphere, with proven effects on climate and environmental dynamics. The current concentration of CO_2 is about 380 ppm and is expected to reach 800 ppm by the end of the century if no emission reduction measures are taken. To prevent CO_2 release into the environment, various technologies have been developed for its capture from flue gases, but suitable final destinations of the separated CO_2 are still investigated. One of the most promising solution to assure long-term sequestration and safe storage is to turn the anhydride into a solid by Mineral Carbonation, which involves the reaction of CO_2 with oxides or hydroxides to form stable carbonates. Among the possible different sources of oxides/hydroxides, alkaline industrial wastes such as fly ashes can be a proficient option, which allows the simultaneous definition of an interesting solution for their reuse, in line with a circular economy vision. Indeed, fly ashes are a byproduct of coal combustion, largely composed of calcium oxide. Typically, calcium oxide derives from carbonates calcination, which produces CO_2, hence making the use of alkaline industrial wastes more meaningful and sustainable.

This study aims to define an effective mineralization process by singularly optimizing the distinct steps, i.e. the L.A.M. (Leaching-Absorption-Mineralization). To this aim, various CO_2 absorption liquids and water-based solvents for oxide leaching, among those proposed in the literature, were compared by means of software simulations (MATLAB, Aspen Plus).

The comparison aimed at defining the most appropriate materials and working conditions that simultaneously allow maximizing the CO_2 removal efficiency (>95%), the formation of CO_3^{2-} ions, Ca^{2+} ions concentration in the leaching solution and solution pH, so to favour the formation of calcium carbonate in the final mineralization step.

The final objective of this study is to carry out an experimental study based on the results obtained from simulations aimed at determining specific operating conditions (e.g. solid-to-liquid (S/L) ratio) that will enable efficient production of calcium carbonate from carbon dioxide and calcium oxide contained in fly ash, considering the environmental and economic impact of the process.

Keywords: Mineralization, Decarbonization, CO2-absorption, Fly ash.