GEOPOLYMER OXYGEN CARRIERS FOR CHEMICAL-LOOPING COMBUSTION

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One of the best alternatives to reduce the economic cost of CO_2 capture is represented by the chemical looping combustion (CLC). This technology accomplishes indirect fuel combustion by use of a solid oxygen carrier (OC), generally a metal oxide having the capability of transporting the oxygen needed for the combustion from an air reactor to a fuel reactor, usually designed as two coupled fluidized beds. The combustion takes place in the fuel reactor through the reaction between the fuel and the solid OC, which is consequently reduced to a lower oxidation state. The reduced OC is then transferred to the air reactor, where it is regenerated by oxidation in air at high temperature. Therefore, the CLC process enables the inherent separation of the produced CO_2, the stream exiting the fuel reactor being only composed of CO_2 and H_2O, easily separable by water condensation.

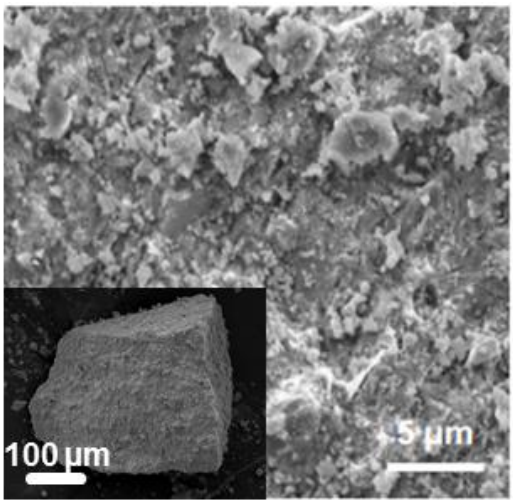

Figure 1 – SEM images of novel geopolymer-composite OCs

An innovative class of OCs are here reported, which documented the application of geopolymer-based materials for CLC. Mn_2O_3 and Fe_2O_3 were mixed to the geopolymer matrix, in order to investigate their interaction in the composite OC. The novel geopolymer-composite OCs (Fig 1) were tested in a combined gasification-CLC laboratory scale plant, consisting of two interconnected fixed bed reactors, fueled with coal char and operated at 800, 850 and 900 °C.

Only the Mn-based OCs were reduced at temperature below 900 °C. Furthermore, they were able to release oxygen in inert atmosphere, thereby demonstrating potentialities for the chemical looping combustion with oxygen uncoupling (CLOU), where free oxygen is produced by dissociation under inert atmosphere at high temperature, thus allowing direct combustion of fossil fuels (e.g. char, coal). The best performances in terms of CO conversion and oxygen rate were given by Mn based geopolymer OCs at 900 °C, even though mixed Mn-Fe geopolymer OCs provided highly comparable results. Both the systems were stable to the temperature and to multiple CLC cycles, since similar behavior in the reactor tests were observed and no relevant modifications to their macro- and micro-structure were detected after the process.

XRD analyses confirmed the OCs phase evolution predicted by the theoretical analysis. In particular, the formation of $MnFe_2O_4$ demonstrated the synergic action of the mixed oxides, and was reasonably related to the positive performances of the sample, by promoting the redox behavior. Similarly, the formation of Mn-silicates, known to enhance the CLOU behavior of Mn-based OCs, pointed out that the interaction of the metal oxide with the GP matrix could potentially improve the CLC performance of the system.