Pyrolysis of Cork Granules Suitable for Producing Ceria Ecoceramics Used in Water Splitting Under Concentrated Solar Energy

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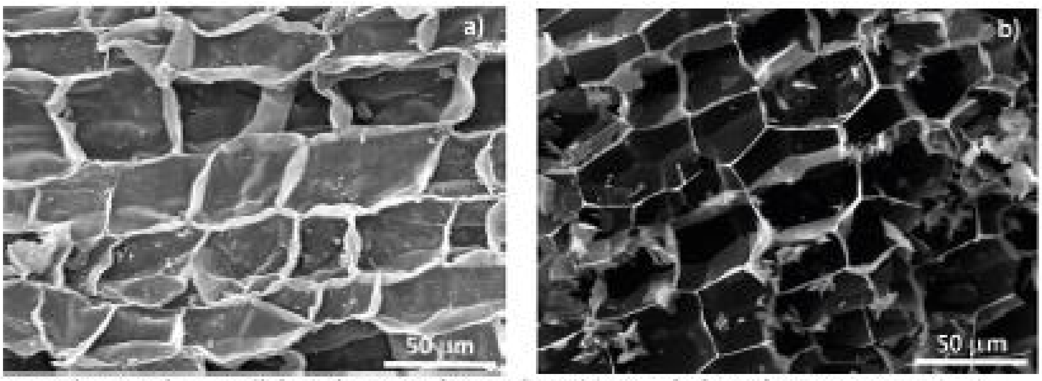
Developing solar technologies for converting H_2O into H_2 is a great challenge, as it leads to a sustainable alternative to the production of transportation fuels. The solar thermochemical approach seems particularly interesting since it uses high temperature process heat to drive a two-step cycle based on metal oxide redox reactions. Such process appears reasonably simple: a focused beam of light heats the metal oxide up to temperatures in excess of 1400 ºC, driving its endothermic reduction and consequent release of oxygen. The reduced oxide is then cooled to 1000 ºC or below, being deoxidized in the presence of steam liberating H_2.

Amongst several redox materials, non-stoichiometric ceria ($CeO_{2-\delta}$) has emerged in view of its structural stability and fast oxygen ion diffusivity. The non-stoichiometry δ determines the fuel production yield being a function of temperature and morphology. Several morphologies, including honeycomb monoliths and foams, have been examined, as well as those resulting from the use sustainable materials, such as wood, as a template to create biomimetic ceramics, known as environmentally conscious ceramics, termed as ecoceramics.

Cork is interesting in view of its regular three-dimensional ordered macroporous structure consisting of elongated hexagonal cells, typically with 20-50 μm diameter and 40-50 μm long. The main drawback is that the cells are mostly closed making infiltration of such porous structures by ceria-containing suspensions rather difficult. Thence, it is of upmost importance to optimize the pyrolysis conditions of cork granules in order to obtain suitable substrates to produce cork-templated ceria ecoceramics.

The goal of this work was therefore to convert cork into carbon templates under well controlled conditions, in particular to study its thermal decomposition at 400-700 ºC under flowing N_2, not only in terms of the pyrolytic char morphology (assessed by SEM) but also through evaluation of the resulting by-products of pyrolysis consisting mainly of H_2, CO_2, CH_4 and oxygen compounds, respectively, as determined by GC-FID and GC-MS analysis.

It was also found that the pyrolytic char morphology was dependent on temperature and the cellular structure of the cork granules was kept.



SEM micrographs of radial section a) cork granule and b) pyrolytic cork (700 ºC) structures.

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