ICCDU 2016 Abstract Submission

Presenting author details

Title: Professor

Name: Carla I. Costa Pinheiro

Organisation: Instituto Superior Técnico/Universidade de Lisboa

Country: Portugal

Email address: carla.pinheiro@tecnico.ulisboa.pt

Are you a PhD student?: Yes☐ No☒

Abstract Information

Abstract title: Use of activated carbon in the synthesis of highly active and stable sol-gel CaO sorbents for CO2 capture

All Authors with Affiliation:

Author	Affiliation
Joana F. Hipólito	CQE-Centro de Química Estrutural, Instituto Superior Técnico/Universidade de Lisboa, Avenida Rovisco Pais 1, 1049–001 Lisboa, Portugal.
Auguste Fernandes	CQE-Centro de Química Estrutural, Instituto Superior Técnico/Universidade de Lisboa, Avenida Rovisco Pais 1, 1049–001 Lisboa, Portugal.
Carla I.C. Pinheiro	CQE-Centro de Química Estrutural, Instituto Superior Técnico/Universidade de Lisboa, Avenida Rovisco Pais 1, 1049–001 Lisboa, Portugal.
Maria F. Ribeiro	CQE-Centro de Química Estrutural, Instituto Superior Técnico/Universidade de Lisboa, Avenida Rovisco Pais 1, 1049–001 Lisboa, Portugal.
Click here to enter text.	Click here to enter text.
Click here to enter text.	Click here to enter text.

Conference Theme

CO_2 insertion ☐ (any processes in-which CO_2 is inserted i.e. polymerisation, mineralisation)

CO_2 splitting ☐ (any process in which CO_2 is split, i.e. electrochemistry, plasma, photochemistry)

Enabling technologies ☒ (i.e. carbon capture, LCA, circular economy, hydrogen, energy integration)

Presentation style

Oral ☒ **Poster** ☐ **Flash**☐*

*There will be a specific session for short 5 minute presentations from PhD students or those not wanting to give a full presentation but to highlight their work.

Abstract (Abstracts should be no longer than ¾ of a page or 750 words)

Among emerging alternatives for post-combustion CO2 capture using solid sorbent materials, Calcium (Ca) looping cycle is one of the most promising processes [1]. Such regenerative process is based on the capacity of calcium oxide (CaO) based sorbents for reacting with gaseous CO2 at high temperatures (600-750°C) forming solid calcium carbonate (CaCO3). The Ca-based cyclic CO2 capture relies on the reversible reaction between CaO and CO2 to form CaCO3. Since this carbonation reaction is highly exothermic, heat must be provided to decompose CaCO3 back into the CaO sorbent generating a concentrated CO2 stream ready for sequestration or utilization [2-4]. One major advantage of Ca-looping cycle over many competing technologies is that the exhausted/purged CaO can be used as raw material in cement production, presenting an opportunity to partially decarbonize both power generation and the cement process [2, 4]. However, some important challenges still remain such as the loss of sorbent activity with increasing number of reaction cycles [4, 5]. CaO based sorbents can be used as synthetic or natural and there is substantial R&D being done worldwide to answer questions about whether the performance of natural limestone sorbents can be improved, or whether it would be better to use synthetic ones. The main problem of natural CaO sorbents is the progressive deactivation usually due to sintering during the carbonation/calcination cycles [4]. To solve this problem, the synthetic CaO sorbents become a potential target for research [5]. The advantages of synthetic CaO sorbents are related to the higher mechanical and structural stability and sorption capacity in long-term cyclic operation and to the higher specific surface area. The sol-gel method is a recent method for synthesizing this type of sorbents with high stability and activity for CO2 capture [5]. In a recent work Santos et al. (2012) concluded that synthetic sol-gel CaO sorbents are more reactive and sintering resistant than natural CaO sorbents [5]. The present work focuses on the synthesis and comparative study of the CO2 carrying capacity and stability of two different types of sol-gel CaO sorbents with and without activated carbon used as structuring pores generating agent during CaO sorbent preparation. The main idea for using activated carbon is to modify the sorbents pore structure by promoting porosity formation through carbon burning during the synthesis final calcination step. Several synthetic CaO sorbent samples were prepared by sol-gel method using calcium precursors and granular

activated carbon (Norit GAC 1240 plus) as structuring pores generating agent. The influence of several conditions used in the sorbents synthesis was studied such as the amount of activated carbon, and the heating rate and the temperature of the synthesis final calcination step. These sorbents were tested in Ca looping cycle CO_2 capture tests for 10 cycles of carbonation-calcination reactions in a laboratory scale fixed-bed quartz reactor with 4.5 cm diameter and 4.5 cm high, and their performance in terms of initial carbonation capacity and of reactivity decay and stability is compared to the performance of a commercial $CaCO_3$ sorbent and to synthetic CaO sorbents prepared by the sol-gel method without using activated carbon. In the unit, the gas stream is fed to the reactor and, when in presence of CO_2, the carbonation reaction takes place. The inlet stream is 100 % N_2 when performing the calcination step at 800 ºC and a mixture of 15 % in CO_2 and 85 % N_2 for the carbonation step at 700 ºC. The CO_2 analyser, a Guardian Plus®, measures concentrations in the range of 0 - 30 % with ± 0.75 % accuracy. Through the monitoring of the CO_2 concentration in the experimental set-up off-gases, the carrying capacity of the sorbent and the extent of the conversion of the oxide form to the carbonate form were determined. The conversion is determined based on the theoretical carrying capacity allowed by stoichiometry: 0.786 $gCO_2/gCaO$. Fresh and used samples of calcium sorbents were characterized by several characterization procedures: (i) nitrogen adsorption; (ii) x-ray diffraction and (iii) scanning electron microscopy (SEM). The results obtained show that the granular activated carbon is an excellent structuring pores generating agent to be used in the synthesis of sol-gel CaO sorbents, leading to sorbents with a higher activity and a higher stability than the sol-gel CaO sorbents prepared without activated carbon, if adequate synthesis conditions are used. The amount of activated carbon used, and the heating rate and temperature of the synthesis final calcination step, are important factors for increasing the carrying capacity and decreasing the sorbent reactivity decay.

References [1] Romano, M.C., Spinelli, M., Campanari, S., Consonni, S., Cinti, G., Marchi, M., Borgarel, E. (2013) The Calcium looping process for low CO_2 emission cement and power. Energy Procedia, 37, 7091–7099. [2] Rodriguez, N., Alonso, M., Grasa, G., Abanades, C. (2008) Process for capturing CO_2 arising from the calcinations of the $CaCO_3$ used in cement manufacture. Environmental Science & Technology 42, 6980-6984.[3] Dean, C.C., Balmey, J., Florin, N.H., alJeboori, M.J., Fennel, P.S. (2011) The calcium looping cycle for CO_2 capture from power generation, cement manufacture and hydrogen production. Chem. Eng. Res. Des. 89, 836-855.[4] Blamey J., Anthony E.J., Wang J., Fennell P.S. (2010) The calcium looping cycle for large-scale CO_2 capture. Progress in Energy and Combustion Science 36, 260-279. [5] Santos, E.T., Alfonsin, C., Chambel, A.J.S., Fernandes, A., Soares Dias, A.P., Pinheiro, C.I.C., Ribeiro, M.F. (2012) Investigation of a stable synthetic sol-gel CaO sorbent for CO_2 capture. Fuel, 94, 624-628.

Publication

Has this work been published? Yes☐No☒

If published, year of publication* Choose an item.

*preference will be given to the most recent work.

Journal of Publication: Click here to enter text.

DOI or weblink: Click here to enter text.

Once completed, please save with your full name_oral/poster/flash

e.g. *joe smith_oral.doc* and mail this form back to