The sustainable management of macroalgae “Gelidium Sesquipedale” waste from the Agar-Agar industry. Its feasibility for CO_2 capture.

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Introduction

Agar-agar is a combination of polysaccharides obtained from different types of red algae. Due to its special properties it is a product commonly used in the food, chemical, agricultural and pharmaceutical industries. This has led to an increase in the demand for macroalgae in recent years and has stimulated the development of industries related to it.

The Roko S.A. industry, which is located in Asturias (Northern Spain) and is partner of this research study, is the principal European producer of Agar-Agar from the “*Gelidium Sesquipedale*” macroalgae. During the production of Agar-Agar a solid residue called seaweed meal is generated. Currently, this seaweed meal is used as fodder for livestock or as fertilizer for the soil, although most of the residue is disposed of in landfills

In this research work, solutions are sought for the sustainable management of this seaweed meal residue, one of which is its conversion into sustainable activated carbons for CO_2 capture.

It is well known that CO_2 is the greenhouse gas that has the greatest impact on climate change and for this reason CO_2 capture is a technology of great interest. One of the potential options for this technology is the adsorption by pressure oscillation (PSA), not only for pre-combustion CO_2 capture but also as a means of natural gas purification, to reduce and separate impurities such as CO_2 (Schell *et al.*, 2013). However, the success of this technology depends on the development of an adsorbent with a high CO_2 selectivity and adsorption capacity.

Accordingly, the present work is aimed at the development of sustainable activated carbons using the seaweed meal residue from the Agar-agar industry for its utilization as adsorbents in the capture of CO_2. A complete and rational management of this waste would bring with it substantial economic benefits and can be expected to have a positive impact on the circular economy.

Methodology

The industrial process for obtaining agar-agar from which the macroalgae waste is generated is described in Ferrera-Lorenzo et al. (2014a). The sampling process used to obtain the residue was carried out over a period of one month by the workers in the participating in the study to ensure sound and representative sampling.

The entire sample was stabilized and then quartered and reduced it to a size suitable to be handled in the laboratory. The sample thus prepared was subjected to a series of chemical activation tests. Chemical activation was directly applied both to the macroalgae waste (HA) and to the pyrolysates of the residue (HAP).

The activated carbons were obtained from the macroalgae waste by chemical activation by means of K_2CO_3, an alternative chemical agent to the alkaline hydroxides usually employed. K_2CO_3 is less aggressive and more sustainable. The chemical activation was directly performed on the macroalgae waste and on the pyrolysates of this residue.

Moreover, this chemical activation was carried out under different conditions in order to investigate the effects of different activation temperatures and amounts of the activating agent on the final properties of the obtained adsorbents.

Ferrera-Lorenzo *et al.* (2014b) describe both, the activation methodology and the experimental device.

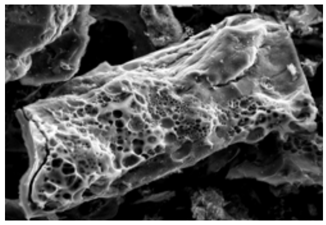

Fig. 1. SEM image of macroalgae residue based-activated carbon

The resulting activated carbons, the precursor materials (the macroalgae residue and the corresponding pyrolysates) were then characterized. The study of the gas (CO_2, H_2 and CH_4) adsorption capacity at high pressure of the activated carbons was carried out on a Rubotherm-VTI magnetic suspension balance under room temperature and static conditions.

Results

The activated carbons obtained display good chemical characteristics in the form of a high carbon content, a moderate nitrogen and low ash contents. Their textural properties show high BET surface areas (up to 1925 $m^2 g^{-1}$) and a high pore volume in which micropores predominate (> 80%).

The adsorbent materials developed in the present research study by using K_2CO_3 as chemical activating agent display textural properties similar to those of absorbent materials obtained by Ferrera-Lorenzo *et al.* (2014b) using KOH as agent.

Consequently, the activated carbons obtained in this work show a high CO_2 adsorption capacity at high pressures with properties similar to, or even better than, those of the commercial activated carbons tested in this work for comparison purposes.

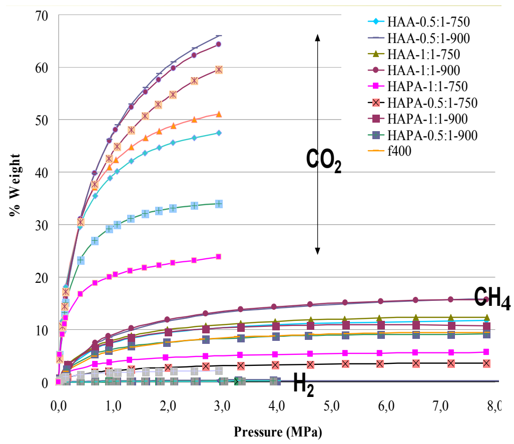

Fig. 2. High pressure (CO_2-CH_4-H_2) adsorption isotherms for the activated carbons obtained and the commercial activated carbon (f400)

Conclusions

In this study, an industrial waste from macroalgae "*Gelidium Sesquipedale*" originating from the Agar-agar industry, was subjected to a series of sustainability tests and finally converted and valorized into a product with a high added value, activated carbon, which turned out to be totally competitive and a good alternative for CO_2 capture. Macroalgae industrial waste has shown that it can be expected to have a positive impact on the circular economy in the future.

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