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Thermal conversion of a novel biomass agricultural residue (vine shoots) into activated carbon using activation with CO_2

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ABSTRACT

The use of a novel biomass precursor (vine shoot) for the production of activated carbons (ACs) via carbon dioxide activation is reported. The carbons produced are all essentially microporous with apparent BET surface area and micropore volume up to 1173 $m^2 g^{-1}$ and 0.53 $cm^3 g^{-1}$, respectively. By XRD it was possible to identify in the activated carbon samples the presence of traces of inorganic heteroatoms such as Fe, Si, Al, K and Pb. All activated carbons produced have basic characteristics with point of zero charge always higher than 9.24. By FTIR it was possible to identify the formation on the activated carbon's surface of several functional groups, namely hydroxyls (free and phenol), ethers, quinones, lactones, pyrones and Si–H bonds.

1. Introduction

Activated carbons (ACs) are porous materials prepared in an artificial way to acquire specific chemical and physical structure, which are responsible for the adsorbent properties. ACs are widely used in a huge number of applications such as medical uses, gas storage, removal of pollutants and odours, gas purification and separation and in catalysis as catalyst or catalytic support. In the production of ACs the porosity and surface chemistry can be, to some extent, controlled according to the needs of the application. Nowadays, one of the main objectives in this research field lies in the attempt to find new precursors, which are cheap and accessible with great valorisation potential, such as industrial and agricultural residues.

Lignocellulosic materials are widely used as raw materials for the production of ACs with more than 300,000 ton/yr [1], wood and coconut shell being the most used materials. Other agricultural by-products like eucalyptus wood, almond shell, vetiver grass, peanut shells, coir pith, chestnut, pistachio-nut shells, corncobs, coffee endocarp and palm stones have also been investigated for the production of ACs [2–11]. Vine shoot (*Vitis vinifera*) is the major sub-product of vineyards, as it is produced from the annual pruning, with a production of approximately 2–4 tons/ha [12]. Wine production is one of the most spread cultures in the world, being one of the principal agricultural activities in Mediterranean countries, such as Portugal, Spain, Italy and Greece. Taking Portugal as example, per year the production of wine takes up about 222,700 ha, which gives per year around 670,000 ton of vine shoots that could be used for the ACs production. Actually, the vine shoots are dumped in the agriculture fields as it has a low potential to be used in other purposes, like energy production. The availability, the annual production and the relatively low price give this material a high profile to be used as precursor for the ACs production.

To our knowledge, vine shoots were never used before as precursors for the ACs production using CO_2 as activating agent. The only published paper regarding the use of this material has reported the production of ACs by chemical activation with H_3PO_4, which is a method more expensive and much less environmentally friendly [13].

The work now reported has two distinct and synergetic objectives: to use a novel precursor to produce activated carbons and to create economic surplus by using an agricultural sub-product.

2. Experimental

2.1. Activated carbon production

The precursor, vine shoot, was crushed and sieved in order to standardize the granulometry and homogenise the raw material. For the ACs production was used the 2–4 mm fraction and about 30 g of precursor. We have used a horizontal tubular furnace and a suitable container for the precursor, made of stainless steal with 15 cm length, 3 cm wide, 2 cm high and 0.3 cm thickness.

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