Activated carbon production from brewer's spent grain lignin

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Activated carbons are adsorbents that are industrially used in multiple processes for product separation and purification, and for the treatment of liquid and gaseous effluents. Despite its frequent use in the water and waste industries, activated carbons remain an expensive material. In view of the high cost and the tedious procedures for the preparation and regeneration of activated carbons, there is a continuing search for low-cost potential adsorbents. The preparation of activated carbons from lignin is an attractive way of giving added value to this material, which is mainly used as in-house fuel for the recovery of both energy and residual inorganic matter. Over the past few decades, some works have been done on the activation of agricultural lignocellulosic waste materials to carbons, due to their low cost and high availability. Nevertheless, there is not any literature report about the activated carbon production from brewer's spent grain (BSG) lignin. Use of BSG lignin as starting material for activated carbon production is interesting because BSG (the main brewery by-product) is produced in large amounts during all year, and is a lignin-rich material. Lignin can be converted in activated carbon by physical or chemical activation, the last one being more amply used than physical activation, because it requires lower activation temperatures and gives higher product yields. The purpose of the present work was to prepare activated carbon from BSG lignin, by chemical activation using phosphoric acid as impregnating agent, and to examine the influence of preparation conditions (acid/lignin ratio and carbonization temperature) on the textural characteristics of the materials produced (surface area, volume of pores, and pores size distribution) as well as on its adsorption capacities.

Chemical activation of BSG lignin using phosphoric acid as impregnating agent was performed at various acid/lignin ratios (1, 2, or 3 g/g) and carbonization temperatures (300, 450, or 600 ºC), according to a 2^2 full factorial design. The resulting materials were characterized (regarding the surface area, volume of pores, and pores size distribution), and used for detoxification of the BSG hemicellulosic hydrolysate, which consists in a mixture of sugars, phenolic compounds, metallic ions, among other compounds.

BSG carbons presented BET surface areas between 33 and 692 m^2/g, and volume of pores between 0.058 and 0.453 cm^3/g, which generally consisted in micro and mesopores. Adsorption capacity also varied to each carbon, according to the used activation condition. However, all of them showed high capacity for adsorption of metallic ions, mainly nickel, iron, chromium and silicon. In most of the cases, the BSG carbons efficiency for removal of these metals was higher than that obtained when using a commercial carbon sample. Phenolic compounds concentration and color were also reduced by using these sorbents, and the sugars content was practically not affected, which is benefic if the hydrolysate use in bioconversion processes is desired.

The present work allowed to conclude that it is possible to produce activated carbons with good efficiency for phenolic compounds and metallic ions removal (mainly Ni, Fe, Cr, and Si), by chemical activation of the BSG lignin. The adsorption capacity of the carbons compared well and even favorably with that of a commercial activated carbon, suggesting that they have potential to be successfully used in detoxification processes in substitution of commercial sorbents. Regarding to the preparation of these activated carbons, an impregnation ratio and activation temperature of 3 g H_3PO_4/g lignin and 600 ºC, respectively, was the best combination of operating conditions leading to activated carbons with good capacity for adsorption of different toxic compounds. Acknowledgements: CAPES, FAPESP and CNPq (Brazil).

Keywords brewer's spent grain; lignin; chemical activation; activated carbons; hemicellulosic hydrolysate