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Preparation of Activated Carbon From Waste Feedstock: Activation Variables Optimization and Influence

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Abstract : In the last decade, the global peanut cultivation has seen increased demand, which is attributed to their health benefits, rising to ~ 41.4 MMT in 2019/2020. Peanut and other nutshells are considered as waste in various parts of the world and are usually used for their fuel value. However, this agricultural by-product can be converted to a higher value product such as activated carbon. For many years, due to the highly porous structure of activated carbon, it has been widely and effectively used as an adsorbent in the purification and separation of gases and liquids. Those used for commercial purposes are primarily made from a range of precursors such as wood, coconut shell, coal, bones, etc. However, due to difficulty in regeneration and high cost, various agricultural residues such as rice husk, corn stalks, apricot stones, almond shells, coffee beans, etc, have been explored to produce activated carbons. In the present study, the potential of peanut shells as precursors in the production of activated carbon and their adsorption capacity is investigated. Usually, precursors used to produce activated carbon have carbon content above 45 %. A typical raw peanut shell has 42 wt.% carbon content. To increase the yield, this study has employed chemical activation method using zinc chloride. Zinc chloride is well known for its effectiveness in increasing porosity of porous carbonaceous materials. In chemical activation, activation temperature and impregnation ratio are parameters commonly reported to be the most significant, however, this study has also studied the influence of activation time on the development of activated carbon from peanut shells. Activated carbons are applied for different purposes, however, as the application of activated carbon becomes more specific, an understanding of the influence of activation variables to have a better control of the quality of the final product becomes paramount. A traditional approach to experimentally investigate the influence of the activation parameters, involves varying each parameter at a time. However, a more efficient way to reduce the number of experimental runs is to apply design of experiment. One of the objectives of this study is to optimize the activation variables. Thus, this work has employed response surface methodology of design of experiment to study the interactions between the activation parameters and consequently optimize the activation parameters (temperature, impregnation ratio, and activation time). The optimum activation conditions found were 485 °C, 15 min and 1.7, temperature, activation time, and impregnation ratio respectively. The optimum conditions resulted in an activated carbon with relatively high surface area ca. 1700 m2/g, 47 % yield, relatively high density, low ash, and high fixed carbon content. Impregnation ratio and temperature were found to mostly influence the final characteristics of the produced activated carbon from peanut shells. The results of this study, using response surface methodology technique, have revealed the potential and the most significant parameters that influence the chemical activation process, of peanut shells to produce activated carbon which can find its use in both liquid and gas phase adsorption applications.

Keywords : chemical activation, fixed carbon, impregnation ratio, optimum, surface area
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