

Properties tuning of palm kernel shell biochar granular activated carbon using response surface methodology for removal of methylene blue

ABSTRACT

This study aimed to produce palm kernel shell granular activated carbon (PKSGAC) from slow vacuum pyrolysed PKS biochar (PKSB) via chemical activation using a horizontal tubular split zone furnace. The study also investigated the effects of varying parameters of the PKSGAC on its colour removal ability. The PKSB was activated through chemical activation using potassium hydroxide (KOH) at various parameters such as activation temperature (700°C to 850°C), KOH concentration (50 % w/v to 100 % w/v) and particle size of PKSB (0.4 mm to 2.5 mm). The novelty of this work lies in the study of chemical activation on various particle size ranges using response surface methodology (RSM) to model the relationships between various parameters. The PKSB was characterized to determine its thermal condition, and the PKSGAC was characterized to determine the iodine number, bulk density, ash content, moisture content, surface area and morphology structure. The parameters that were used for each sample were determined by using the RSM based on central composite design (CCD). In this study, design expert version 11.0 software was used and three parameters as independent variables were manipulated. Finally, three different PKSGAC samples of different particle sizes were used to test for the methylene blue (MB) dye removal with the concentration of 5 mg/l, 10 mg/l, 15 mg/l and 20 mg/l. Thermal analysis showed that the total weight loss of the PKSB sample was 58.30% and for PKSGAC the range of the product yield as shown from the RSM was from 33.23% to 96.33%. The RSM also showed that the values for moisture content were in a range from 0% - 39%, as for the ash content value from 2% - 12%, while for the bulk density ranged from 0.17 g/cm³ - 0.50 g/cm³. The highest iodine value achieved was 1320 mg/g at activation temperature of 850°C, KOH concentration of 50% w/v and particle size of 0.4 mm. From the RSM, an iodine number of 1100 mg/g could be obtained using an activation temperature of 850°C, the KOH concentration of 69.22% w/v and the particle size of 0.59 mm. From the BET analysis, the PKSGAC sample obtained 581 m²/g for SBET and 0.3173 cm³/g for the V_{tot}. The highest percentage dye removal of MB dye was 89.61% to 97.63% at 775°C activation temperature, 75% w/v KOH concentration and 0.4 mm particle size. This work produced RSM models to predict the relationships between the parameters and the response, as well as the performance on MB dye removal.

