Removal of sulphur and nitrogen compounds from model fuel by adsorption of modified activated carbon

ABSTRACT

This study aimed to achieve the highest percentage removal of dibenzothiophene (DBT), quinoline (QUI), and indole (IND) adsorbed by double-impregnated modified activated carbon (MAC). Modification of commercial activated carbon (AC) by sulphuric acid (H2SO4) of 15%, 30%, 45%, 60%, and 75% w/v followed by subsequent 1 zinc chloride (ZnCl2): 1 AC impregnation ratio and activated at 500 oC in a muffle furnace under self-generated atmosphere for an hour. The determination of optimized MAC was identified through the highest removal rate of DBT, QUI, and IND from adsorption experiments which were analysed using an ultraviolet-visible (UV-Vis) spectrophotometer. It was found that DBT and IND showed a removal high percentage of up to 86.23% and 82.77% respectively by using 75% H2SO4 with ZnCl2 MAC. Meanwhile, QUI favoured 30% H2SO4 with ZnCl2 MAC with a removal percentage of 33.17% which was still higher than unmodified AC. Physical and chemical properties such as the morphological structure, elemental analysis, porosity, pore size, surface functional group, percentage yield, pH, bulk density, content, ash content, and iodine number were studied for the optimized MAC. Scanning electron microscopy (SEM) and energy dispersive X-ray (EDX) spectroscopy and Fourier transform infrared spectroscopy (FTIR) were used to characterize the MAC. Both MACs showed high percentage yields of 72.08% and 71.13% for 30% and 75% H2SO4 and ZnCl2 MAC respectively. Meanwhile, the pH was between the ranges of 5.36-5.53 for both MACs. Bulk densities were also favourable while the moisture and ash content were within acceptable limits. Iodine numbers for 30% and 75% H2SO4 and ZnCl2 MAC were 857 and 861 mg/g respectively, hence indicating that the MAC achieved high porosity and good adsorption performance. Langmuir, Freundlich, and Temkin adsorption isotherm models as well as pseudo-first order (PFO) and pseudo-second order (PSO) kinetic models were considered for understanding the adsorption mechanisms. The study revealed that DBT, QUI, and IND removal processes, followed the Langmuir adsorption isotherm model with correlation coefficients, R2 of 0.9905, 0.9791, and 0.9964 respectively. Moreover, the adsorption kinetic data of DBT, QUI, and IND provided a better fitting to the PSO kinetic model with R2 of 0.9992, 0.9987, and 0.9998 respectively. According to the Langmuir isotherm model and PSO kinetic model, the adsorption mechanisms of DBT QUI and IND were chemisorbed under monolayer formations.