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ABSTRACT

In petroleum industry, sulphur compounds are undesirable due to potential corrosions and environmental challenges associated with these compounds. Sulphur occurs in varies forms in crude oil and petroleum products such as, marcaptans, disulphide, sulphides, disulphide H_2S and thiophenes. Commercial scale refineries utilises hydrodesulphurisation to reduce the sulphur content in fuels, though this technology is associated with high operating and capital cost.

Extractive, adsorptive, oxidative, membrane separation and bio desulphurisation are some of the alternative technology being investigated which have proven not to be as efficient and/or cost effective as compared to hydrodesulphurisation. Adsorption desulphurisation has been effective in separation processes where the sorbate concentrations are low and this technology was used to evaluate the performance of the polymer supported imidation agent (Sodium N-chloro-polystyrene sulphonamide) as an adsorbent in diesel fuel desulphurisation.

A mathematical model simulating adsorption on a fixed was developed. This model incorporates internal mass transfer assuming laminar flow, constant interstitial velocity and an isothermal system. To represent liquid solid equilibrium the Langmuir isotherm was used. The model contains partial differentiate equation that were linearised by using the Euler's forward implicit method, this enabled simulating the model using Microsoft Excel Visual Basic. The obtained simulation results were compared against experimental data. The impact of varying parameters such as initial sulphur concentration, adsorbent bed porosity and external bed surface area per particle volume was studied in detail. Existing isotherms and kinetics were discussed by using experimental data from Fadhel's study.

It was found that the adsorbate residence time is reduced by smaller adsorbent bed porosity resulting in increased adsorption rate. By decreasing the adsorbent particle diameter and an increase in initial sulphur concentration, the breakthrough time is decreased. The experiment data agreed with the simulation results and this validate that the proposed model is applicable to study the performance of fixed bed adsorption processes under isothermal conditions, no axial mixing and constant interstitial velocities.

The results from the analysed Fadhel's data showed that the modelled light oil can be desulphurise to the Euro 5 level requirements, Sulphur <500ppm, by both Chloramine T and Synthesis PI, a complete sulphur removal was achieved using both adsorbents. The desulphurisation rate proved to be faster with Chloramine T as an adsorbent as compared to Synthesis PI. Modelled light oil adsorption obeyed the pseudo-first-order kinetics and the overall adsorption rate was controlled by the chemisorption process.
The diesel fuels study by Fadhel could not be desulphurised to the Euro 5 level. The diesel fuel 1 sulphur concentration was reduced from 12 354 to 11 200ppm and diesel fuel 2 from 1 900 to 800ppm. It was observed that the rate of desulphurisation proved to be faster with diesel fuel 1 as compared to that of diesel fuel 2.

The Freundlich isotherm was found to be a best fit in the adsorption of diesel fuel 1, the attained R square values was 0.881 and 0.435 for Freundlich and Langmuir, respectively. Also the obtained Langmuir separation factor, R_L , of 1 confirmed the that the Langmuir adsorption was unfavourable. This implies that the adsorption rate was controlled by a physisorption process. The diesel fuel 2 desulphurisation process did not fit the studied adsorption isotherms, the attained R square values was 0.433 and 0.218 for Freundlich and Langmuir, respectively. The Langmuir separation factor confirmed in-favourability at 1 and the Freundlich adsorption strength was 6.052, which is very low as compared to that pf diesel fuel 1 at 272.41. Diesel fuel 1 adsorption reaction obeyed the pseudo-second and pseudo-first order kinetics when reacted with Chloramine T and Synthesis PI, respectively. The obtained R squared values were 0.694 and 0.999 for pseudo-second and pseudo-first order, respectively. Diesel fuel 2 obeyed the third order kinetics with both Chloramine T and Synthesis PI, with R squared values calculated at 0.889 and 0.774 for Chloramine T and Synthesis PI reaction, respectively.