Petroleum and Chemical Engineering Department-College of Engineering-Sultan Qaboos University

Desulfurization of Liquid Fuel by Deep Eutectic Solvent Using Small Channels

Zainab AL Aani

Abstract

The various sulfuric compounds, which are found in different fuel types, have acute negative influence on the ecosystem and human beings in general. They can also deactivate catalysts and increase corrosion in process equipment. Due to these negative impacts, production of ultra-low sulfur content fuel in many parts of the world became an increasingly rigorous regulation. Many techniques are used for desulfurization; one of them is extractive desulfurization (EDS). This technique has high extraction efficiencies towards thiophenic compounds, can be applied at ambient operating conditions and without consumption of hydrogen. These advantages make EDS a much cheaper option compared to other techniques. Deep eutectic solvents (DESs) can be used in EDS, as they are efficient, biodegradable, which makes it an environmentally friendly process, and they are highly chemically and thermally stable. DESs are normally expensive; however, the high cost of these types of solvents can be overcome by using micro/small channels and regenerating the solvent.

The work presented in this thesis aims to investigate experimentally using DES as liquid fuel deep desulfurization solvents for continuous liquid-liquid microchannels-based extraction contactors. The aim is to enhance the sulfur removal and reduce the cost of using these fluids for practical applications. The investigation was carried out in a circular 1.22 mm ID glass small channel. The working fluids were simulated fuel with 200 ppm dibenzothiophene (DBT) and DES of tetra-n-butylammonium bromide (TBAB) and polyethylene glycol 200 with a molar ratio of 1:2 respectively. The DES density and viscosity are 1094 kg/m^3 and 0.2 Pa.s respectively, while those of simulated fuel are 739.4 kg/m^3 and 8x10-4 Pa.s respectively. The range of mixture velocity which was covered by the study varied from 0.033 to 0.5 m/s for different DES volume fractions. The effect of the inlet junction and initial channel saturation phase on the flow patterns and pressure drop was examined using Canon EOS 1100D camera and a digital monometer, respectively. Seven flow patterns were observed. These are stratified wavy, annular, intermittent, slug, plug, drop and dispersed flows. The pressure drop across the glass channel was found to increase gradually with increasing the DES velocity. Also, it was found that the pressure drop and flow patterns were not much affected by changing the saturation fluid. The influence of initial dibenzothiophene (DBT) concentration, mixture velocity, DES volume fractions and channel lengths on the extraction percentage (E%) was studied.

Initial DBT concentration did not have an effect on E%, while increasing the length of the channel and the volume fraction of the DES caused an increase in E%. The highest E% was achieved at a DES volume fraction of 0.5, 50 cm channel length and a mixture velocity of 0.2 m/s, which was 47%. This result shows that small channels have potential in DBT extraction

using DES. The overall mass transfer coefficient also determined. In addition, a correlation for each channel length was derived for predicting E%.

.