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Effect of epoxidation and nanoparticle addition on the rheological and tribological properties of canola oil

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Abstract

The paper investigates the lubricating properties of epoxidised canola oil. The epoxidation is carried out to decrease the unsaturated bonds present in canola oil. Further, metal dichalcogenide nanoparticles (molybdenum disulphide and tungsten disulphide) are mixed in modified canola oil and their effect on rheological and tribological properties is evaluated. The tribological investigation is carried out on a pin-on-disc tribometer with aluminium alloy and steel as tribopairs. The rheological properties of nanofluids have been studied. It is observed that the modification of the canola oil improves the tribological properties of virgin canola oil. The addition of nanoparticles into the modified canola increases the viscosity of the oil with a 1 wt% concentration of nanoparticles. Further, enhancement in the tribological properties is observed with the addition of nanoparticles. A maximum of 54.6% and 30% decrease in coefficient of friction is observed with the use of tungsten disulphide and molybdenum disulphide nanoparticles, respectively.

Keywords

Rheology, epoxidation, canola oil, lubrication, nanofluids

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Introduction

Global warming is a serious concern to human health, human settlements, production of crops, terrestrial ecology and the physical environment. The major causes responsible for global warming are the greenhouse gases such as carbon dioxide (CO_2), nitrogen dioxide and methane.[1] The harmful gases released by the burning of petroleum oils are major contributors to the greenhouse gases such as CO_2. Also, the amount of greenhouse gases in the environment is continuously increasing due to the excessive use of automobiles.[1] Consequently, the need for the replacement of mineral and synthetic oils is indispensable. Vegetable oils are evolving as a suitable replacement due to the excellent biodegradability, high-viscosity indices, low toxicity and good tribological properties.[2] However, the presence of unsaturated C=C double bonds limits their use as industrial lubricants. Higher content of polyunsaturated fatty acids is responsible for poor oxidative and thermal stability, thereby resulting in the formation of oxidation products and decreasing their effectiveness in boundary and mixed lubrication regimes.[3]

Consequently, various reports have suggested that the chemical modification of vegetable oils can improve their oxidative properties, hence making them suitable for industrial applications.[2,4] Wu et al.[5] conducted a comparative investigation on the tribological properties of rapeseed oil and epoxidised rapeseed oil on a four-ball tester. The authors observed that the coefficient of friction (COF) and extreme pressure (EP) properties of epoxidised oil are better than rapeseed oil. The authors have attributed the reduction in friction after running in the period to the formation of tribochemical film on the surfaces. Kashyap and Harsha[6] conducted a similar investigation on the lubricating properties of rapeseed oil and epoxidised rapeseed oil. The authors observed that the epoxidised rapeseed oil reduces the friction and wear of the tribosurfaces in comparison with the rapeseed oil. The reduction in friction and wear is attributed to the better protective film formation due to the higher adsorption of polar groups on the tribosurfaces.

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