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WASTE COOKING OIL (WCO) ADDED WITH CATIONIC CELLULOSE NANOCRYSTALS (cCNC) AS A GREEN LUBRICANT

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ABSTRACT

Friction and wear are primary factors contributing to material loss and energy loss in all of the mechanical machinery, necessitating the need for a high-performing lubricant. Conventional lubricants, primarily derived from mineral and synthetic oils, contain hazardous substances such as polycyclic aromatic hydrocarbons, cadmium, and phosphorus, posing significant environmental risks during disposal. Waste cooking oil (WCO) has emerged as a promising eco-friendly alternative, supporting waste management and the circular economy. However, challenges such as poor tribological characteristics and cold-flow properties limit their industrial applicability.

A promising strategy to enhance the performance of WCO-based lubricants is the incorporation of cellulose nanocrystals (CNC), which are renewable, biodegradable, and possess superior mechanical properties. However, the natural hydrophilicity and surface charge of CNC hinder their dispersion in non-polar oils. This study explores the use of cationic CNC (cCNC) as an additive for WCO-based lubricants. cCNC is used instead of CNC because the cationization of CNC can help in improving the interaction with the negatively charged fatty acids in WCO, thus giving the suspension stability.

A novel technique was developed to formulate cCNC suspensions in WCO. It was observed that the formulated suspensions show high stable at wide ranges of concentration, thus suitable for industrial applications. The tribological performance was evaluated using pin-on-disc tests, revealing a lower coefficient of friction (COF) for WCO compared to Mobil1 industrial automotive lubricant. The addition of cCNCs further reduced the COF, especially at concentration ranges of 1-2 wt.% cCNC. Wear analysis confirmed that the WCO-based lubricant exhibited superior wear resistance compared to standard mineral oils. Differential scanning calorimetry (DSC) was used to assess the cold-flow property, demonstrating that cCNCs effectively decreased the pour point due to colligative effects, enhancing the low-temperature performance of the lubricant.

These findings demonstrate that WCO-based lubricants with cCNCs provide a sustainable, high-performance alternative to mineral oil-based lubricants. This approach not only enhances energy efficiency and reduces wear but also promotes a carbon-neutral solution, supporting environmental sustainability and reducing reliance on petroleum-derived products.