Insights into the nanocellulose-based ecolubricant for electro-tribological applications

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This research study aims to explore the development of functional nanocellulose-based ecolubricants, which allow for an electro-active control of the friction behavior. With this purpose both nanofibrillar (CNF) and monocrystalline (CNC) celluloses were studied as polarizable particulate phase to castor oil-based lubricant at weight fractions ranging 0-6 wt.%. The main goal of this research works has been to demonstrate that both CNF and CNC nanoparticles endow castor oil with significant ER properties, which remarkably reduced the friction coefficient within the boundary and mixed lubrication regions at electric field strengths lower than 40 V.

Keywords: electrotribology, electrorheology, nanocellulose, smart ecolubricants

1. Introduction

Viscosity and low temperature dependence are two of the fundamental properties that a lubricant must own [1]. In this sense, the most innovative technological approach in the lubrication sector may be aimed to achieving a suitable viscosity or rheological behavior from the development of lubricants with electro-rheological (ER) properties. The main objective of the present research was to study the effect of both particle concentration and electric field strength on the electro-rheological potential of nanocellulose-based ecofriendly lubricants, in order to promote an electro-active control of the friction behavior of a new generation of ecolubricants.

2. Methods

Commercial nanocrystalline (CNC) (D: 10-20 nm; L: 0.3-0.9 µm) and nanofibrillar (CNF) (D: 10-20 nm; L: 2-3 µm) celluloses. Castor oil was selected as dispersing medium. The ER fluids were prepared according to the two-step protocol reported by Maheswaran and Sunil [2] Electro-tribological measurements were done by using a ball-on-three plates tribology cell consisting of a stainless steel ball (1.4401 grade 100) with 6.35 mm radius contacting with three 45 º pitched stainless steel plates (1.4301 AISI 304), coupled to the rotational rheometer ARES-G2 (TA Instrument).

3. Discussion

The electro-rheological behavior of CNC and CNF-based dispersions in castor oil was attributed to an induced interfacial polarization mechanism [3]. It was observed that the chaining between the dipoles of the polarized CNC or CNF particles at an imposed electric field was mainly affected by their orientation mechanism induced by both dielectrophoretic (related with the electric field strength) and hydrodynamic (related with shear rate) forces. Thus, two sort of alignment in the electric field direction was detected, chain-like or column structures. The orientation and chaining was affected at different extents depending on weight fraction, electric field and shear rate. In addition, an optimal balance of the highest yield stress values with the lowest leak current intensities was achieved at concentration higher than 2 wt.%.

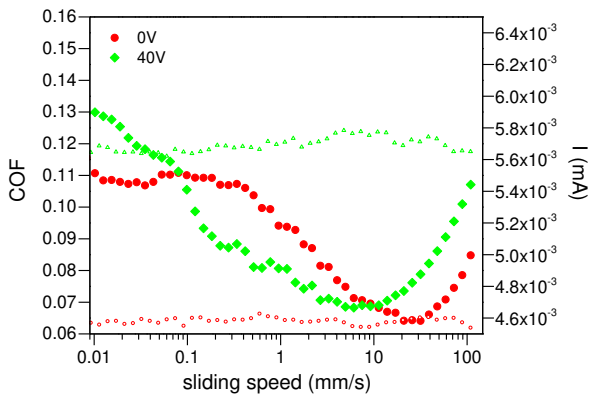

Figure 1: Friction coefficient (COF) and current intensity (mA) with sliding speed for 4 wt.% CNF-based dispersion at 0 and 40 V.

In conclusion, the ecolubricants studied have demonstrated noticeable ER properties, which significantly reduced the friction coefficient within the mixed lubrication region (0.1 and 8 mm/s) using an electric field strength of 40 V.

4. References

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