Enabling the active control of friction through layered silicate electro-responsive nanoparticles dispersions in castor oil

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We report preliminary results on the development of sustainable lubricating fluids for the active control of the lubrication process by application of electric fields. The effect of the electric potential on the friction coefficient was quantified by using a setup consisting of a ball-on-three plates electro-tribocell coupled to a strain-controlled rheometer. A reduction in the friction coefficient of up to 8 % at 100 V was observed in the mixed lubrication regime at 25 ºC with a 2 wt.% Cloisite 15A dispersion in castor oil.

Keywords: electrotribology, electrorheology, nanoclays, smart ecolubricants

1. Introduction

The newest generation of lubricants needs to adapt to stricter environmental policies. Simple and sustainable formulations with tunable rheological properties under the action of electric potentials may be the key. So far, very few studies have explored the potential interest of the so called “electro-viscous” effect in relation with the development of electro-sensitive lubricants [1]. We thereby report preliminary results on the development of environmentally friendly electro-rheological (ER) lubricating fluids, based on the montmorillonite Cloisite 15A and castor oil, which may assist in reducing the friction and wear through the application of controlled electric fields.

2. Methods

The organo-modified montmorillonite Cloisite 15A (cation exchange capacity: 125 meq/100 g clay; interlayer distance, d_{001}: 31.5 Å) was purchased from Southern Clay Products (USA). Castor oil from Guinama (Spain) 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 45º pitched stainless steel plates (1.4301 AISI 304), coupled to the rotational rheometer ARES-G2 (TA Instrument).

3. Discussion

Under the action of electric fields, the Newtonian behavior of a 2 wt.% Cloisite 15A in castor oil dispersion turned into the so-called “Bingham” fluid, characterized by a yield stress. The observed behavior was attributed to the formation of organized chain-like structures from interacted plates. Moreover, a clear relaxation shoulder in ε´´ at ca. 5 kHz was found when the dispersion was subjected to dielectric spectroscopy characterization, which was related to interfacial polarization [3] and assigned to be the origin of the ER phenomenon. As a consequence of the nanoparticles’ electro-sensitive capacity, a reduction in the coefficient of friction (COF) of ca. 8 % was obtained with the application of electric potentials up to 10 V using the above formulation (Figure 1).

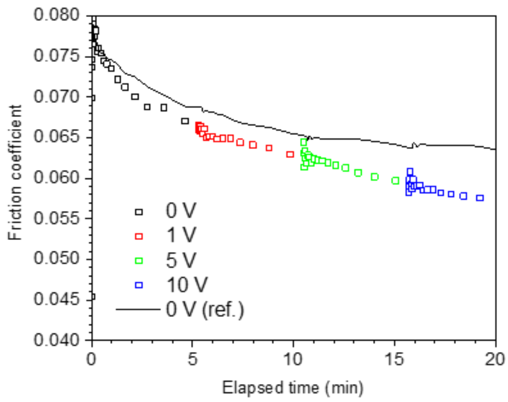

Figure 1: Evolution of the friction coefficient with time in a sequence of 4 consecutive steps with increasing electric potentials up to 10 V.

A more effective entrance of clay into the contact point as a consequence of the attraction caused by the electric field on the polarized particles (with the consequent benefit derived from layers that may be possibly causing an enhanced sliding effect) along with the electro-viscous effect (increased viscosity) might be the reasons behind the observed decrease in the COF.

4. References

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