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FULL LENGTH ARTICLE

Comparative study between prepared electrical grease and the imported one

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ABSTRACT

Grease lubrication is a complex mixture of science and engineering, requiring an interdisciplinary approach, and is applied to the majority of bearings worldwide. Grease can be more than a lubricant; it is often expected to perform as a seal, corrosion inhibitor in electrical joints, electrical insulator and electrical connection improver. This work is concerned, therefore, with the comparative study between prepared electrical grease and the imported one. Physicochemical and electrical properties for the prepared grease and the imported one were evaluated. The results of dropping point, penetration, dynamic viscosity, corrosion inhibition, evaporation loss, total acid number and oil separation for the prepared grease under investigation are mostly the same compared with the imported grease. In addition, the results interpreted in terms of the physical and chemical properties of both greases revealed that no remarkable differences. In this respect, calorimetric study shows that the prepared grease, like the imported one, is thermally stable up to about 200 °C then decomposition and degradation started slightly faster and higher than that of the imported one. The electrical and dielectric parameters are very close at and around room temperature then the increase of charge carriers' mobility at higher temperatures explains the deviation from stability in case of the prepared grease. One can conclude that the prepared electrical grease could replace efficiently the imported electrical grease especially in isothermal application at and around room temperature.

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1. Introduction

The search for alternative natural sources of base stocks for lubricants has gathered momentum in recent years [1–4] with results, which can be considered positive. Amongst the various alternative lubricants, however, a challenge remains for the researcher in the field of lubricating greases. Mineral oils will continue to be the fluids employed in the manufacture of the great bulk of lubricating greases. This is true because of the availability and low cost of these mineral oils. Primary components of grease are mineral oil and soaps. The mineral oils consist of varying proportions of paraffinic, naphthenic and aromatic hydrocarbons. The trend in lubricating oil refinement is to produce oils which are more selective in composition to certain applications [5]. The study on the preparation and evaluation of silicone greases using two grades from silicone oil as fluid and Polyethylene, fumed silica, silicone rubber, and styrene butadiene rubber was investigated. Five

formulations from silicone greases were prepared with different proportions of these compounds [6].

Many patents reported [7–9] the compositions of silicone greases. These patents relate to lubricating compositions and methods for their preparations. In general, silicone grease composition comprising organopolysilixane as thermal fluid and a thickening agent such as finely divided silica filler. The optimal preparation method for each application is dependent upon type of technology and its methodology. The electrical grease or jointing compound or seals electrical connection compounds are imported. The main objective of the present investigation is concerned with the preparation and evaluation electrical grease and compared it with imported one.

The electrical or dielectric grease is in general an insulating material of remarkably high dielectric strength (breakdown voltage). It is usually used in high-voltage connections associated with gasoline engine spark plugs. Actually, the dielectric grease is called conductive or electrical grease when powdered metal is suspended by insulating grease. However, it is still insulator. Dielectric spectroscopy has been applied for a long time to study the effect of

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the structure components on the dielectric and electrical behavior of grease lubricants [10–14].

When AC-field is applied on a real dielectrics, the capacitance is expressed as complex parameter:

$$C^*(\omega, T) = C_0 \varepsilon^*(\omega, T) \quad (1)$$

in which ω is the radial frequency and C_0 the capacity of the empty measuring cell, usually called the geometrical constant of the cell, given by:

$$\varepsilon_0 \frac{A}{d} \quad (2)$$

The complex permittivity ε^* can be written as:

$$\varepsilon^* = \varepsilon' - j\varepsilon'' \quad (3)$$

The real part ε' is considered as the conventional relative permittivity, the imaginary part ε'' is a loss factor. The ratio between imaginary and real parts of the dielectric constant is an important parameter referred as the loss tangent:

$$\tan \delta = \frac{\varepsilon''}{\varepsilon'} = \frac{1}{\omega RC} = \frac{\sigma}{\omega \varepsilon' \varepsilon_0} \quad (4)$$

where σ is the electrical conductivity of the material.

Combining Eqs. (2) and (3), Dyson et al. [15], calculated the thickness of the lubricants at various pressures and studied the effect of the oil and soap on the dielectric constant of the grease. The results revealed that there is a significant role of the pressure on the thickness of the lubricant.

According to the objective of this work, we will study the electrical and dielectric properties of the prepared electric grease over a broad range of frequencies and temperatures in comparison with the commercial (imported) one.

2. Experimental

2.1. Materials

2.1.1. Prepared grease-G1

The prepared electrical grease in this study was comprise from heavy base mineral oil, stearic acid, hydrogenated castor oil, lithium hydroxide, octyl amine, natural polymer, aluminum powder and silicon oxide. This achieved according to a procedure described as reported elsewhere [1,2,5]. The obtained grease from this method was designated G1. The prepared grease was made in batches of one liter in an open kettle with a capacity of 2 l, fitted with a mechanical stirrer. The saponification process was performed on a mixture of stearic acid and castor oil (1:1 vol ratio) with lithium hydroxide, at 150–170 °C. The reaction time for each saponification process to achieve a soap structure was found to be dependent on the type of constituent. After the completion of the reaction, the reaction mixture was cooled gradually while the base mineral oil, aluminum powder and silicon oxide ratios were added to adjust and get consistency grade NLGI-1.

2.1.2. Imported grease-G2

The imported grease under study is commercial grease used, at El-Sewedy-Sedco Company, in cables industry to prevent galvanic corrosion and to enhance connections in electrical joints. This grease is designated as G2.

2.2. Grease evaluation

Physicochemical properties for the prepared grease (G1) and commercial grease (G2) were carried out using ASTM and IP standard methods as presented in Table 1. Thermal analysis (TGA & DSC) and phase transition for both greases under explored was

carried out in the temperature range 30 °C–999 °C at a heating rate of 10 °C/min under a flow of air using SDT Q600 V20.5 Build 15.

2.3. Electrical investigation

Broadband Dielectric Spectroscopy (BDS) is the more suitable technique for probing molecular dynamics as well as the charge carriers' transportations in many advanced materials according to its wide range of frequency and temperatures [16–20]. The electrical and dielectric investigations were carried out on a wide frequency ranging from 20 Hz up to 2 MHz using Agilent LCR meter A E4980 A. The gelatin texture samples were pressed between two stainless steel parallel plates separated by 2 mm Teflon spacer ring of diameter 20 mm as measuring cell as shown in Fig. 1. Similar measuring cell was used previously in order to study hyper branched polymers of gelatin texture [21–23]. A guard ring type NFM/5T Wiss. Tech. Werkstätten (WTW) GMBH Germany was used as sample holder. The sample holder has metal jacket that connected to an ultra-thermostat as temperature controller system. The experimental error in temperature controlling was ± 0.1 °C.

3. Results and discussion

The physicochemical characterizations of the prepared electrical grease (G1) and its commercial one have been carried out and presented in Table 1. It is clear that the consistency, dropping point, solubility in water and corrosion efficiency in the two greases under investigation are nearly the same result. The dynamic viscosity, oxidation stability and evaporation loss of prepared grease are found to be slightly higher compared with commercial grease. The result of corrosion measurement showed that the octyl amine is compatible with selected ingredients of prepared grease and act as good corrosion inhibitor.

Inspection of the data of physicochemical properties of the investigated greases had shown in Table 1 reveal the possibilities for development of the local materials under investigation and their suitability to produce electrical greases instead of imported electrical grease.

Experimental data concerning the ratio of ingredients of the prepared grease are excellent selected. Accordingly, the obtained results showed that the prepared grease is very close with the commercial grease. It was conclude that the prepared grease could be classified as equivalent for commercial grease.

The thermal stability and phase transitions of lubricating greases have attracted the attention of several researchers [2,24]. It was therefore of interest to investigate the thermal behavior of greases under study. The heat flow in watt per gram as well as the weight percent of the sample were determined and illustrated graphically against temperature that increases at a rate 10 °C/min for the two greases under investigations as given in Fig. 2 as DSC and TGA thermogram. This figure shows that both samples have high thermal stability until about 200 °C where the weight of the prepared sample G1, started to decrease remarkably. It is clear from the figure that the commercial sample G2 has more thermal stability since it does not suffer remarkable weight loss until about 250. Further increase of temperature shows that the range of thermal stability of both greases followed by a drastically multi-dispersion steps increase of the weight loss. This indicates that the two greases under investigation have a comparable thermal decomposition behavior although the rate of the weight loss seems to be much faster in the case of the prepared grease. The thermal degradation and decomposition of both greases pass through different dispersions of different rate of weight loss during the temperature range 200–600 °C for G1 and 250–500 °C for the

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