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Investigation on Parameters of Vegetable Oil and Blends Used as Alternative Liquid Insulation

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Abstract
In a variety of application industries, petroleum products have long dominated the world's energy demands. When looking for a suitable alternative to normal mineral oil, natural-based ester oil is offered as an alternative liquid insulation. In order to evaluate the typical characteristics of blended liquid as liquid insulation, several ratios of vegetable ester oil were blended in this study. Research is being done on the oils from safflower, sunflower and Palm oil. Standards state that several combinations of viscosity, breakdown voltage, and pour point are tested. The investigation suggests that individual oil samples may eventually take the place of conventional mineral oil samples. Additionally, the blended varieties show that changes happen as a result of mixing the samples, which calls for further research.

Key Words: vegetable oil; blending; liquid insulation; transformers

1. INTRODUCTION

In fact, the insulating fluid utilized in electrical power transformers is transformer oil. It is produced through fractional distillation and further processing of crude petroleum. Every time a powerful electric field is applied, heat is produced inside the transformer. As a result, the main purposes of transformer oil are to suppress corona and arc discharges, cool the transformer, lessen pyrolysis, and avoid direct contact between the insulation anD ambient oxygen. The majority of the molecules in mineral oil are composed of the elements carbon and hydrogen, and it is a complex mixture of hundreds of different chemical compounds. There are three different kinds of mineral oil. Paraffinic crudes, which are divided into ordinary paraffin and o-paraffins, include a trace quantity of naphthenic hydrocarbons. When compared to these three oils, naphthenic crudes have a number Of advantages, like as Mineral oils continue to be an excellent technological and economical solution, but it is important to take into account their environmental impact. They also stand out as a suitable substitute for mineral oil because of their toxicity and biodegradability. Tri-alcohol glycerol is etherified with three fatty acids in vegetable oil to produce triglycerides. Ester-based liquid dielectrics, both produced and naturally occurring, have gained popularity among academic organizations and businesses around the world. Particularly for ester-based dielectric fluids, biodegradability is a crucial component. As a result, there is a pressing need for and chance to increase knowledge of these innovative insulating fluids. Blended oil, which is formed by mixing two insulating liquids, has recently been suggested as an alternative.

1.1 Oil samples

Based on the literature, this study set out to examine the characteristics of both pure natural ester oil and mixed natural ester oil samples. Sunflower Oil (SUO), Safflower Oil (SAO), and Palm oil (PO) were selected as vegetable oil samples for analysis based on their geographic availability, cost, and prior study. Raw vegetable oil samples are collected from a nearby factory.

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Table -1: SAMPLEOILS

Base oil sample1	100% SUO
Base oil sample2	100% SAO
Base oil sample3	100% PO

1.2 Blended oil samples preparation

In a 500mL glass spherical reactor with a thermostat and mechanical stirring, the sample preparation is carried out. The reactor is warmed to 75°C before each vegetable oil sample is added in accordance with the suggested samples in order to remove moisture. The stirring system is turned on when the reactor achieves the reaction temperature, designating this as the reaction's start time.

Table2 : Blended oil samples

Sample	Oil quantity	Oil quantity	Oil quantity
Blended Sample1	250	250	-
Blended Sample2	250	125	125
Blended Sample3	250	125	250
Blended Sample4	125	125	250

1.3 Measurements and properties of oil samples

This section discusses the significance of key factors such breakdown voltage, viscosity and pour point as well as experimental testing techniques. By applying a voltage across the electrode at a rising rate of 2kV/s across the electrode, the breakdown voltage of oil samples is measured at a specific voltage that causes breakdown between electrodes under specified test conditions. To ascertain the dielectric breakdown voltage of oil samples, the test is carried out five to six times.

Fig1 : Breakdown voltage kit

Viscosity can affect cooling and how cooling-related equipment functions. Viscosity may have an impact on cooling and the performance of cooling-related machinery. According to IEEE Standard C57.14 from 2018, a liquid's viscosity is a measurement of how resistant it is to flow. According to ASTM D445, the viscosity of liquid insulation is computed in a redwood viscometer. It is determined by timing the passage of 50 ml of oil samples through an aperture in a viscometer under carefully regulated conditions. A redwood viscometer is depicted in Figure 2.

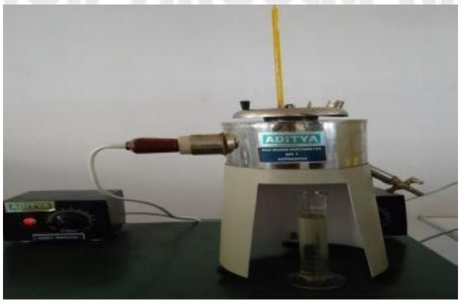

Fig2: Redwood viscomter

The pour point of liquid insulation is the lowest temperature at which liquid flows in a certain circumstance. Below the pour point, oil flow can be challenging, as viscosity restricts flow.

Fig 3: Pour point Apparatus kit

2. Properties of Base oil

For preliminary analysis on a few oils, breakdown voltage, viscosity, flash point, fire point, and pour point are tested in accordance with standards. Tables 3, respectively, contain values for the attributes of base oil sample and blended oil sample samples.

Table 3 : Properties of oil samples

Properties	SUO	SAO	PO
Breakdown voltage(kv)	39	39	35
Viscosity(cst)	70	80	75
Pour Point(^{0}c)	-6	-3	-6

Table 4 : Properties of Blended Oil Samples

Oil samples	Breakdown voltage(kv)	Viscosity(cst)	Pour Point(^{0}c)
Blended sample 1	35	75	-6
Blended sample 2	36	74	-6
Blended sample 3	37	73	-9
Blended sample 4	35	75	-6

A crucial factor in evaluating a liquid insulation's ability to withstand the electrical stress produced inside a transformer during operation is the breakdown voltage of the insulation. According to IEEE recommendations, the minimum breakdown voltage should be 30 kV. All oil samples (base oil samples and blended oil samples), according to the primary examination of characteristics of selected oil samples for this investigation, had a breakdown voltage of greater than 30 kV. These findings lead to the conclusion that a crucial property of breakdown voltage makes some natural esters promising candidates for use as liquid insulation in transformers.

Fig -4: **oil sample**

The performance of liquid insulation as a coolant and other liquid insulation-related components in the transformer are significantly influenced by the viscosity of the liquid. The maximum range for the viscosity value of natural esters specified in the IEEE guidance for absorbing liquid insulation is 50 cSt. Vegetable oil-based liquid insulations frequently have higher viscosities than the typical mineral oil used in transformers. This investigation shows that the measured viscosity values for samples of vegetable oil are also higher than the established standard value. If utilized directly, natural esters could impair cooling performance.

• A crucial characteristic that identifies a range of temperatures where unrestricted circulation is allowed is the liquid insulation's pour point. The minimum pour point temperature for accepting liquid insulation is -100C, per IEEE recommendations. All of the samples have more notable pour point temperatures. These findings suggest that oil samples could freeze or form crystals at temperatures close to zero. The results demonstrate that fatty acid components have an effect on pour point values. For application in cold areas, the pour point temperature of investigated natural esters should be lower than the values obtained. Several methods for lowering the pour point from its anticipated value to a certain range should be adopted, according to the literature that is now accessible.

3. CONCLUSIONS

The world is currently transitioning away from petroleum-based products, which are environmentally harmful and polluting, and toward renewable and environmentally benign vegetable-based oils. These renewable resources can be used without risk and have good dielectric properties. The characteristics of natural ester oil-based blended oils are therefore investigated in this study. When compared to raw oil samples, the qualities of blended oil combinations are superior. Depending on the application area and key qualities, this mixed oil may be utilized in any electrical equipment. The blended sample under research might make a good substitute for regular mineral oil. There is simply one drawback: Natural esters cost more than mineral oil.

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