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INVESTIGATION OF THE EFFICIENCY OF OLIVE OIL AS DIELECTRIC MATERIAL AND ITS ECONOMIC VALUE ON THE ENVIRONMENT USING ITS DIELECTRIC PROPERTIES.

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ABSTRACT

Most liquid insulators or dielectrics used all over the world today are mineral oil [Surya, 2008]. These substances are non-renewable and pose environmental challenges, hence a need for alternative sources. In this work, attempts have been made in other to evaluate some dielectric properties of olive oil so as to replace the existing dielectric substances by which environment stand at risk when spills occur. Thus we were able to calculate the dielectric constant, pH value, electrical conductivity, refractive index and viscocity of the olive sample. The results of the analysed parameters indicated that olive oil has a dielectric constant of 3.065, pH value of 6.8, electrical conductivity of zero micro-siemen (0µS), refractive index of 1.4656 at 30.2oC and 1.4657 at 29.9oC, viscocity of 83.89cP at 20oC. From the results it shows that olive oil is a bad conductor of electric charge and can be used in the fabrication of capacitors for effective capacitance, used as collant in transformers, used as insulators etc and its pose less enviromental danger when spill. Therfore olive oil is more efficient and economical to use than other mineral oil.

Key words: Olive oil, Dielectric Constant, Refractive Index, Viscocity, Electrical Conductivity, pH value and Efficiency.

I. Introduction

Matter can be describe or classified in terms of thier atoms been able to allow electrons move freely within them. Electrons of different types of atom have different degrees of fredom to move around. In some type of atoms, the outermost electrons in the atoms are loosely bound that they move in the space between the atoms of such material by just the influence of room temperature. Such types of materials, the atoms electrons have very litle freedom to move around**[Bhima, 2005].**

Olive oil: Is a fluid obtain from the olive (olea europaea; family oleaceae) a traditional tree crop of the mediterranean basin. It is mainly produced in three countries of the world namely spain, Italy and Greece.

In Africa however, olive oil is produce in South Africa, Egypt, Tunisia and Nigeria. It is commonly used for cooking, cosmetics, pharmaceuticals and also serves as a fuel for traditional oil lamps**[Clugston, 2000].**

Since olive oil is a fluid, it has fluid properties such as pressure, density, bioling points, freezing point etc. This research work however limits itself to the determination of few properties that make olive oil to be describe as a dielectric and its environmental effect. These include dielectric constant, refractive index, viscocity, pH value, acity and electrical conductivity.

Dielectric: Dielectrics are materials in which all the electrons are tightly bound to the nuclues of the atoms thus there are no free electrons to carry charges. It could also be defined as materials that do not conduct electric charges. This is as a result of the presence of electric dipoles within dielectric substances or material **[Edwin, 1990; Murugeshan, 1984].**

There are two(2) types of dielectrics namely polar and non-polar dielectrics. Since polarization of dielectrics is a molecular phenomenon, a molecule consists of atoms or ions and each molecule may possess a net dipole moment and charge. The spatial arrangement of charges in the molecule of different dielectrics may be different with all the positive and negative charge [**Bhima, 2005**].

A non-polar dielectric is therefore one in which the centre of gravity of the positive charge (proton) coincides with the centre of gravity of the negative charge (electron). They are symmetric and have zero dipole moment. Examples of non-polar dielectrics are hydrogen, nitrogen and benzene.

A polar dielectric is one in which the centre of gravity of the positive charges is seperated from the centre of gravity of the negative charges by a finite distance. Thus it is an electric dipole and has intrisic permanent dipole moment. Examples of such dielectrics are water(H_2O), HCl and $NH_{3.}$ [**Edwin, 1990**]..

When a dielectric is placed in an electric field, eletric charges do not flow through the materials but only slightly shift from thier average equilibrium position causing electric polarization of dielectric by an applied electric field and increases the capacitors surface charge **[Ohanian, 2007].**

Oil insulation: Oil insulation provides two main purposes in a machine in operation, as the insulation material and the cooling medium. There are several requirements for a machine insulating oil:

- To act as a coolant with the main task of absorbing the heat from the core and winding, then transmitting it to the outer surface of the transformer. At higher temperatures the viscosity of the oil decreases, thus facilitating the circulation of the oil.
- To insulate different parts at different electrical potential. Oil makes a good contribution to machine insulation by penetrating into and filling the spaces between wound insulation layers.
- In order to minimize the evaporation losses, the oil volatility should remain low. Oil temperature in service should be maintained below its flash point;

There are three factors that influence the chemical stability of oil: temperature, oxygen availability, and catalyst presence. The oil degradation process might be caused by decomposition of the hydrocarbon molecules in oil at high temperature. The oxygen contents in insulating oil might lead to a rise of the acidity number and to sludge formation [**Ohanian, 2007**]. Catalysts such as copper and iron are dissolved in oil during aging and might accelerate the aging process.

Mineral oil application in power system equipment can be potentially hazardous to the environment especially when there are any incidents during operational time like transformer explosion which may cause a spill of oil to the soil or water stream. Insulating oils should fulfill the following minimum health and environmental requirements:

- non-toxic;
- biodegradable;
- thermostable;
- recyclable, reconditionable, and readily disposable;
- not listed as a hazardous material.

Mineral oil was first introduced in 1892 by General Electric as a dielectric coolant. The main reason for using mineral oil was the high flash point characteristic and the widespread production around the world. As of today, mineral oil has been used as the main source of insulation material for several equipments, especially power transformers. But due to the poor biodegradability characteristics of mineral oil there is still environmental concern in case of leakages during operation or due to an incident. In the beginning of 1930 until mid 1970, many transformers were insulated by Askarel, a mixture of PCB (polychlorinated biphenyl) and chlorobenzenes. This material was chosen because of its non-flammable characteristics [**Fofana, 2001**]. Later, Askarel was no longer recommended as an insulation material anymore due to the environmental issues of this hazardous material. In order to settle down the environmental and sustainable issues, people started to look for alternative sources for insulating oil. The latest insulating oil implementation is vegetable oil-based fluid which is known as the most potential source to replace the mineral oil because of its biodegradability characteristic. The first vegetable oil was used for capacitor insulation in 1962 and gave a good match with cellulose due to its higher dielectric constants

[Oommen, 2002]. One of the vegetable oil variants is known as ester oil since the extraction process of ester oil uses the vegetable source.

II. Materials and Methods

The method used to determine the dielectric constant, refractive index, viscocity, pH value, acidity and electrical conductivity of the sample are **capacitance method**, **refractometer method**, **viscocity method, the roviband colour comparative method and the conductivity meter method** respectively. Before starting the accelerated process, the oil samples are preconditioned. First, the sample bottles or jars are cleaned before they are filled with olive oil. After taking some samples from the oil container, then the samples are vacumized. This procedure is intended to reduce the humidity of the oil that may have increased during the oil storage in the container. The imperfect bung closures and seals will allow the oil in the container to breathe air. Another reason is when we take the oil using the pump, it may introduce moisture to the oil too. The humidity content of the oil affects its dielectric properties, such as dielectric loss and breakdown stress. In order to study the dielectric properties, the humidity of the oil should be reduced as much as possible.

Table 1.0: The table below shows the result of the measured parameters mentioned above.

S/N	properties	Experimental values
1	Dielectric constant	3.07
2	Refractive index	1.4656 at 30.2^{o}C 1.4657 at 29.9^{o}C
3	viscocity	83.89cp at 20^{o}C
4	pH value	6.80
5	Electrical conductivity	0.00S(siemen)

III. Discussion

From the result obtained from the work, it shows that olive has a relatively high dielectric constant as compared to other mineral oil and materials such as Asphalt, Silicon oil Teflon etc and for that reason, a capacitor fabricated using olive oil as dielectric will store more charges than dielectrics with lesser dielectric constants.

It is also known that photons of light provide an electromagnetic field within a material **[Azaroff, 1963]**, hence the need for the determination of refractive index of olive oil. The values of refractive index obtained indicate that it varies with temperature.

Good liquid insulators should be chemically neutral [**Surya, 2008**]. From the pH value obtianed, it can be seen that olive oil falls within the range of good liquid insulator (from 6 to 8).

Also the value of electrical conductivity obtained indicates that olive oil is truely an insulator as compared to other liquid insulators. Meaning is highly resistive to flow of electric charge

Also transformers or machines oil, coolants etc using olive oil as dielectric will last longer. And pose less environmental danger due to the following advantages

- Low vapor pressure, low volatilities, high flash point
- Lubricity
- High solvency
- The high polarity of olive molecules causes a high solvency inside the fluid.
- Hygroscopic. Olive fluids are hygroscopic because water molecules easily attach to the polar bond.
- Hydrolytic stability

The above advantages are shown in viscocity of olive oil on table 1.0

Olive oil has a capability as the alternative source for transformer insulation. The biggest advantage of olive oil is the non-toxic material characteristic which will not produce any dioxin or toxic product during fire. Carbon dioxide and water are the only products that are formed during the biodegradation process. They are also less flammable liquids with a minimum flash point above 300°C. They resist oxidation and adsorb more moisture than mineral oil as is some times known as Triolein($C_{18}H_{33}O_2$).

Table 1.1: **Characteristic comparison between mineral oil and ester (Olive) oil**

Criteria	**Mineral oil characteristic**	**Ester (olive) oil characteristic**
Key properties	Produced from increasingly scarce and non-renewable special petroleum crude	Produced from domestically grown, renewable sources.
Environmental Properties	Contains compounds that do not readily biodegrade. May contain traces of a confirmed carcinogen (especially the hydrotreated light naphthenic petroleum distillate as the primary component)	Highly biodegradable; non-toxic; does not contain petroleum, silicone, or halogens
Leaks and Spills	Spill clean-ups are required by regulation and typically necessitate special equipment and material to help capture contaminated runoff	Relatively rapid biodegradation may eliminate the need for environmentally related clean-up operations
Fire Risk	Catches fire more easily, leading to higher probability of transformer(machine) fires	Higher fire point reduces the frequency and impact of transformer fires; virtually

		eliminates sustained fires
Transformer(machine) Performance	Does not slow down the standard insulation aging rate; requires special and expensive processing to dry out the paper insulation	Proven to slow down the aging rate of the insulation system, resulting in an increase in the expected life of a transformer(machine) by decades; also promotes automatic dry-out of paper insulation
Utility Cost	Smaller investment leads to shortened life of transformer(machine) and diminished economic returns; increases liability	Upfront investment promotes Transformer(machine) life and leads to longer-term economic benefits

[**ENDAH, 2010]**

On the other side, their high viscosity might cause a problem to the heat transfer system in the transformer [**Fofana, 2001**].
A research by Stockton et al has revealed the fact that natural olive oil has a higher solubility for water than mineral oil [**Eberhardt, 2008**]. This property is very helpful to eliminate any moisture from the insulating material.

IV. Conclusion

Although olive oil can be used as an insulator (liquid insulator) and as a coolant, it will give rise to rancidity due to the presence of free fatty acid (oleic acid in this case) in the oil. Olive oil can be said to be very bad conductor of electricity. Finally, due to its relatively high dielectric constant, olive oil can be used in the fabrication of capacitors in order to aid capacitance and is economically wise to use because of it less pollutant effect when spill or leak.

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