American Journal of Electrical and Computer Engineering
2019; 3(1): 20-29
http://www.sciencepublishinggroup.com/j/ajece
doi: 10.11648/j.ajece.20190301.13
ISSN: 2640-0480 (Print); ISSN: 2640-0502 (Online)

Examining the Properties of Neem Oil, Sunflower Oil and Mahua Oil with Antioxidants and Nano Powders for Power Transformer

Uma Devi Sankarasubbu, Senthil Kumar Suburaj*

Department of EEE, National Engineering Collge, Kovilpatti, India

Email address:
senthilkumarneceee@gmail.com (S. K. Suburaj), malathiumadevi@gmail.com (U. D. Sankarasubbu)

*Corresponding author

To cite this article:
Uma Devi Sankarasubbu, Senthil Kumar Suburaj. Examining the Properties of Neem Oil, Sunflower Oil and Mahua Oil with Antioxidants and Nano Powders for Power Transformer. *American Journal of Electrical and Computer Engineering.* Vol. 3, No. 1, 2019, pp. 20-29.
doi: 10.11648/j.ajece.20190301.13

Received: April 6, 2019; **Accepted**: May 14, 2019; **Published**: June 20, 2019

Abstract: In the newfangled world, electrical energy is the most important thing, and we cannot live without it. The recent research has predominated that petroleum by-products are available only for a few hundred years. This paper is especially clear to meet out that. After some years, the mineral oil in the transformer needs to be changed due to its degradation of insulation. The mineral oil used in the transformer acts as insulation as well as cooling purpose. The used mineral oil can be recycled by adding some additives for reuse purpose. In this paper, the oil chosen is neem oil, sunflower oil and mahua oil and it is treated with antioxidants and nano powders. "Breakdown voltage, flash point, fire point, acidity, and viscosity are measured in consonance with standards". To reduce the oxidation stability natural and synthetic antioxidants are preferred, and Nano powders are also used for improving the properties of the oil. Synthetic antioxidants such as Beta Carotene and TBHQ and selenium are preferred as natural antioxidants. Selenium is used. Before and after the addition of antioxidants and nano powders the measurements were done. By doing this analysis, the transformer oil is used for reuse purpose and it has a longer lifetime. After antioxidants and Nano powders are added, the property of the transformer oil is increased.

Keywords: Nano Powders, Antioxidants, Break Down Voltage, Flash Point, Fire Point, Viscosity, Acidity

1. Introduction

1.1. Background

Transformer oil is used for insulation purpose. It is obtained by petroleum by-products and so it is named as mineral insulating oil. Transformer oil serves mainly two purposes one it is liquid insulation in electrical power transformer and two it dissipates heat of the transformer that is it acts as a coolant. It also helps in another two reasons, one to preserve the core and winding as these are fully immersed inside oil, and next preventing the direct contact of atmospheric oxygen [1].

In the transformer there are two types of transformer oil are used. They are

i. Paraffin-based transformer oil
ii. Naphtha-based transformer oil

Naphtha oil gets more easily oxidized than Paraffin oil. Sludge formation present in the naphtha oil is more when compared to paraffin oil [2]. Thus sludge is not formed in the bottom of the transformer and does not disturb the cooling system of the transformer. But in the case of Paraffin oil although the oxidation rate is lower. Although Paraffin-based oil has a disadvantage because we use it because of its easy availability. High pour point problem is found in paraffinic oil due to the wax content, but this does not affect its use due to warm climate condition of India [3-5].

1.2. Compound Description

1.2.1. Antioxidants

An Antioxidant is the chemical compounds which can delay the start or slow the rate of lipid oxidation reaction in food systems both natural and synthetic antioxidants are used in the food industry as food additives. Oxidative

degeneration is stated to have been caused by harmful molecules called free radicals. Free radicals are molecular fragments having one (or) more unpaired electrons [6-8].

1.2.2. Nanopowders

Nanopowders are defined as powdered materials with individual particles having sizes fewer than 100 nanometers. The particles present in the nanopowders are very smaller when compared with the wavelength of visible light [9, 10]. The smaller size of nanopowders gives them an extremely high surface area to volume ratio that results in extraordinary properties like extreme strength. Below formula is used to calculate the number of nanoparticles to be added with the oil for preparation of nanofluids:

$$\text{Weight of the nanoparticles} = (\text{density} * \text{Volume}) / (\text{Volume Fraction}) \quad (1)$$

The above euation A represents the equation for calculating the nano power weight added to the oil samples.

2. Methodology

The methodology includes standards, measurements, sample description and sample preparation. Sample description and sample preparation are done for neem oil, sunflower oil and mahua oil.

2.1. Standards

The measurement of oil properties like Viscosity, Breakdown Voltage, Acidity, Flash and Fire pointis carried out according to IEC and ASTM standards [11-13]. The method standard used and standard values are given in Table 1.

Table 1. *Standards and Methodology for Measurement.*

Parameters	Method/Equipment	Standard
Breakdown Voltage	Breakdown Voltage Kit	IEC 60156
Viscosity	Redwood Viscometer	ASTM D-445
Flash Point and Fire Point	Pensky Martin Closed Cup Method	ASTM D-93
Acidity	Color Chart	-

2.2. Measurement of Breakdown Voltage

The dielectric strength of transformer oil is also known as the Breakdown voltage of transformer oil. The low value of BDV indicates the presence of moisture content and conducting substance in the oil. In BDV kit, oil is kept in a pot in which one pair of the electrode is fixed with a gap of 2.5mm between them [14]. By raising the voltage measurement is taken 3 to 5 times in the same sample of oil. The breakdown Voltage testing kit is shown in Figure 1.

Figure 1. *BDV Test Kit.*

2.3. Measurement of Viscosity

Technically the viscosity of the oil is a measure of the oil resistance to shear. Viscosity is more commonly known as resistance flow. The measurement of viscosity the resistance to flow between the individual layers [15]. A high viscosity implies high resistance to flow while a low viscosity indicates a low resistance to flow. Viscosity varies inversely with temperature [21]. The Redwood viscometer is shown in Figure 2.

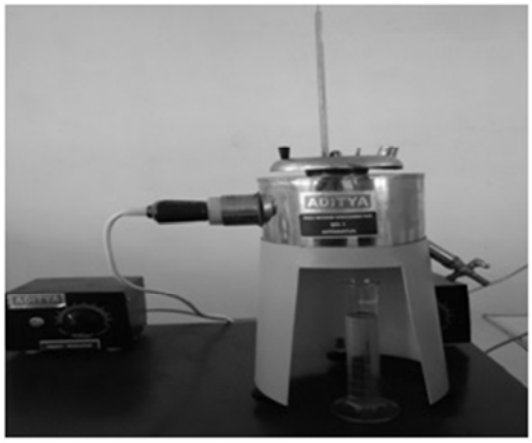

Figure 2. *Redwood Viscometer.*

2.4. Measurement of Flash and Fire Point

Flashpoint of a volatile liquid is the lowest temperature at which it can vaporize to form an ignitable mixture in air. Measuring a liquid's flashpoint requires an ignition source [16]. The flash point is often used as one descriptive characteristic of liquid fuel, but it also used to describe liquids that are not used intentionally as fuels [22].

The temperature at which the vapor continues to burn after being ignited is called fire point. It is the lowest temperature at which, on further heating beyond the flash point the sample will support combustion for 5 seconds. The Pensky Martins Closed Cup apparatus is shown in Figure 3.

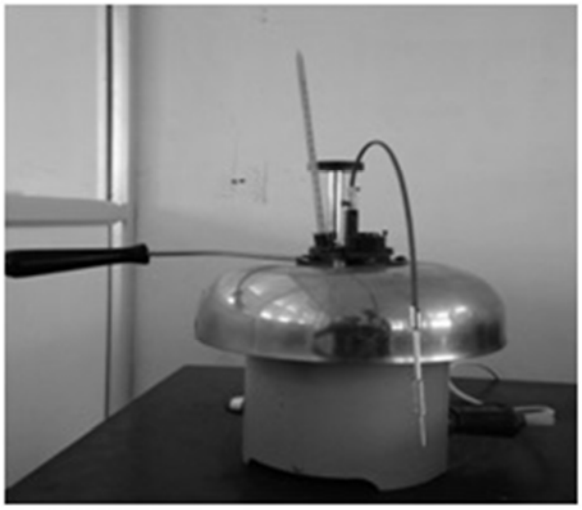

Figure 3. *Pensky Martin Closed Cup Apparatus.*

2.5. Measurement of Acidity

The acidity is calculated by using colour chart method. The colour code for determining the acidity is shown in figure 4. 1.1mlof the oil sample and 1ml of ethyl alcohol are mixed and after shaking well 1ml of sodium carbonate is added [17]. After re shaking well 5 drops of universal indicator solution is added and mixed well. By using the colour chart acid content in oil sample is found in KoH/g.

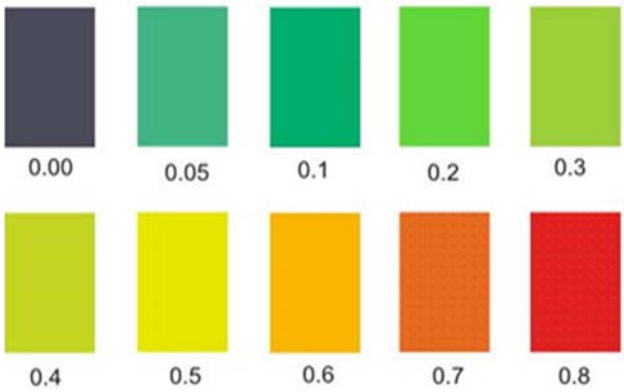

Figure 4. *Acidity Test color chart.*

2.6. Sample Description

The vegetable oil is mixed in different proportions like neem oil, sunflower oil and mahua oil with different antioxidants and nanopowders [18-20]. Samples prepared using neem oil with antioxidants and nanopowders are shown in Table 2.

Table 2. *Sample Combination Using Neem Oil.*

Samples	Sample Name
Sample 1	500 ml of neem oil
Sample 2	500 ml of neem oil+1g TBHQ
Sample 3	500 ml of neem oil+1g Selenium
Sample 4	500 ml of neem oil+1g Beta Carotene
Sample 5	500 ml of neem oil+0.5g Selenium +0.5g Beta Carotene
Sample 6	500 ml of neem oil0.5g Selenium +0.5g TBHQ
Sample 7	500 ml of neem oil0.5g TBHQ +0.5g Beta Carotene
Sample 8	500 ml of neem oil0.3g Selenium +0.3g Beta Carotene+0.3g TBHQ
Sample 9	500 ml of neem oil+2.5g Aluminium Nitride
Sample 10	500 ml of neem oil+1.06g Carbon Nano Powder
Sample 11	500 ml of neem oil+0.96g Carbon Nano Powder+0.96g Aluminium Nitride

Samples prepared using sunflower oil with antioxidants and nanopowders are shown in Table 3.

Table 3. *Sample Combination Using Sunflower Oil.*

Samples	Sample Name
Sample 1	500 ml of sunflower oil
Sample 2	500 ml of sunflower oil+1g TBHQ
Sample 3	500 ml of sunflower oil+1g Selenium
Sample 4	500 ml of sunflower oil+1g Beta Carotene
Sample 5	500 ml of sunflower oil+0.5g Selenium +0.5g Beta Carotene
Sample 6	500 ml of sunflower oil0.5g Selenium +0.5g TBHQ
Sample 7	500 ml of sunflower oil0.5g TBHQ +0.5g Beta Carotene
Sample 8	500 ml of sunflower oil0.3g Selenium +0.3g Beta Carotene+0.3g TBHQ
Sample 9	500 ml of sunflower oil+2.5g Aluminium Nitride
Sample 10	500 ml of sunflower oil+1.06g Carbon Nano Powder
Sample 11	500 ml of sunflower oil+0.96g Carbon Nano Powder+0.96g Aluminium Nitride

Samples prepared using mahua oil with antioxidants and nanopowders are shown in Table 4.

Table 4. *Sample Combination Using Mahua Oil.*

Samples	Sample Name
Sample 1	500 ml of mahua oil
Sample 2	500 ml of mahua oil+1g TBHQ
Sample 3	500 ml of mahua oil+1g Selenium
Sample 4	500 ml of mahua oil+1g Beta Carotene
Sample 5	500 ml of mahua oil+0.5g Selenium +0.5g Beta Carotene
Sample 6	500 ml of mahua oil0.5g Selenium +0.5g TBHQ
Sample 7	500 ml of mahua oil0.5g TBHQ +0.5g Beta Carotene
Sample 8	500 ml of mahua oil0.3g Selenium +0.3g Beta Carotene+0.3g TBHQ
Sample 9	500 ml of mahua oil+2.5g Aluminium Nitride
Sample 10	500 ml of mahua oil+1.06g Carbon Nano Powder
Sample 11	of mahua oil+0.96g Carbon Nano Powder+0.96g Aluminium Nitride

2.7. Sample Preparation

The neem oil, sunflower oil and mahua oil of 500 ml is mixed with the single and combination antioxidants like TBHQ, selenium and beta carotene and nanopowders like aluminium nitride and carbon nanopowder and mixed using magnetic stirrer unit for 20 to 30 minutes under 750 RPM.

3. Result and Discussion

The results are obtained from the combination of neem oil, sunflower oil and mahua oil blended with regenerative materials. The critical parameters of the samples are improved by using this.

3.1. The Blending of Neem Oil with Regenerative Materials

The results are obtained from the experiment are presented here in Table 5. The evaluation of critical parameters of Neem Oil by way of different proportions through the addition of regenerative materials like TBHQ, Selenium, Beta Carotene, Aluminium Nitride and Carbon Nanopowder were made.

Table 5. *Results of Neem oil with Regenerative Materials.*

Samples	BDV(kV)	Viscosity at 40°C(cSt)	Viscosity at 90°C (cSt)	Flash Point (°C)	Fire Point(°C)	Acidity (KoH/g)
Sample 1	20	145.8	41.05	230	250	0.6
Sample 2	22.1	113.2	34.10	260	283	0.1
Sample 3	23.8	94.95	34.10	238	257	0.1
Sample 4	22.3	110.1	34.90	243	259	0.4
Sample 5	27.8	82.40	28.40	218	238	0.6
Sample 6	25.1	48.50	14.52	232	248	0.3
Sample 7	21.5	87.11	28.40	243	261	0.4
Sample 8	18.4	94.43	30.58	253	274	0.3
Sample 9	26.3	86.3	28.13	283	313	0.4
Sample 10	29	97.04	26.49	279	296	0.05
Sample 11	26.2	74.81	24.28	273	295	0.1

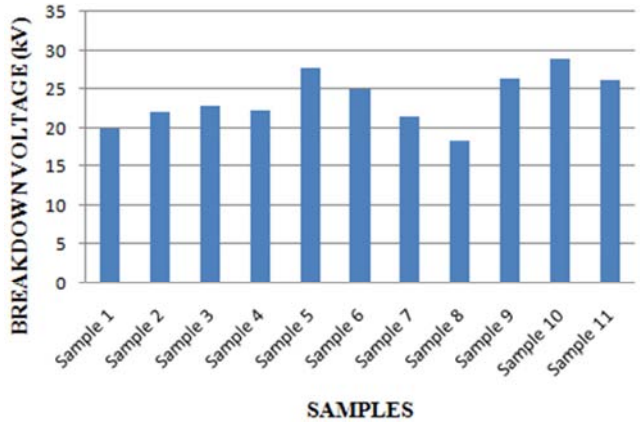

Figure 5. *Comparison of Breakdown Voltage values of samples using neem oil.*

Figure 5 shows the comparison graph of breakdown voltage for different samples using neem oil.

From the Investigations of the breakdown Voltage of the neem oil sample the following inference were made:

1. Breakdown Voltage of the neemoil sample increases when Antioxidants and nano powders are added.
2. When Carbon nano powder is added the breakdown Voltage (Sample 10) is higher when compared with other.
3. The breakdown voltage is increased from 18.4kV to 29kV.

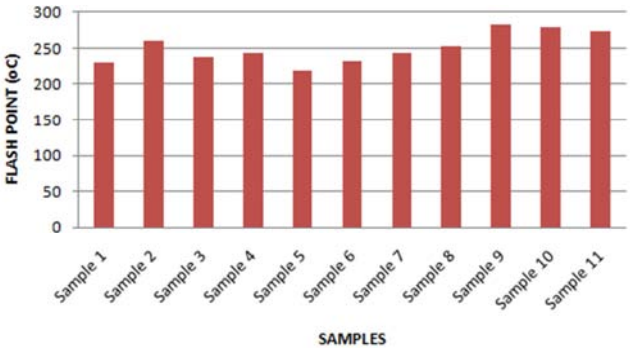

Figure 6. *Comparison of Flash point values of samples using neem oil.*

Figure 6 shows the comparison graph of Flash point for different samples using neem oil.

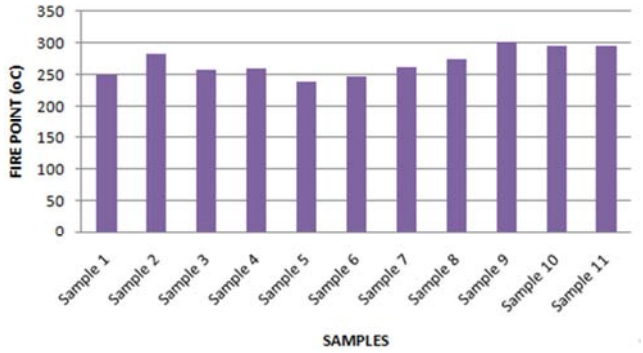

Figure 7. *Acidity Comparison of Fire point values of samples using neem oil.*

Figure 7 shows the comparison graph of Fire point for different samples using neem oil.

From the Investigations of the Flash Point and Fire Point of the neem oil sample the following inference were made:

1. The flash point is increased from 218°C to 283°C.
2. The fire point is the withstand temperature of the oil sample.
3. The flash point and Fire point for Sample 10 that is when carbon nano powder is very high.

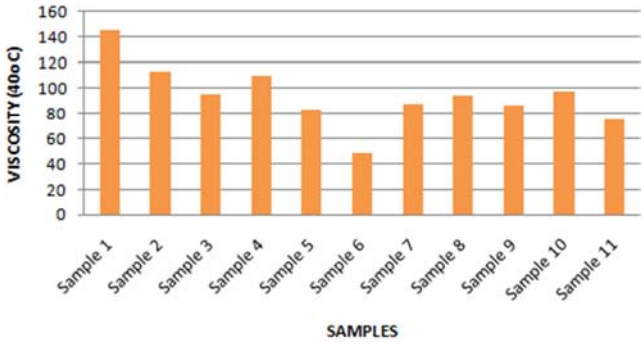

Figure 8. *Comparison of Viscosity values of samples using neem oil at 40°C.*

Figure 8 shows the comparison graph of Viscosities for different samples using neem oil at 40°C.

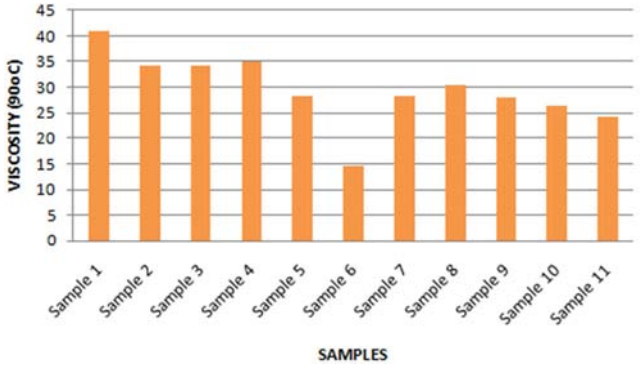

Figure 9. *Comparison of Viscosity values of samples using neem oil at 90°C.*

Figure 9 shows the comparison graph of Viscosities for different samples using neem oil at 90°C.

From the Investigations of the Viscosity values of the neem oil sample the following inference were made:

1. At 40°C, the viscosity of the oil sample gets reduced from 145.81cSt to 48.50cSt.
2. At 90°C, the viscosity of the oil sample gets reduced from 41.05cSt to 14.52cSt.
3. The viscosity values of sample 6 that is when neemoil is mixed with selenium and TBHQ is very low.
4. Usually lower the viscosity value gives the better oil sample.

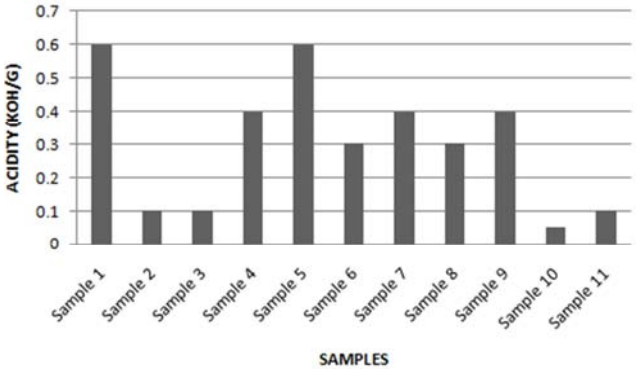

Figure 10. *Comparison of Acidity values of samples using neem oil.*

Figure 10 shows the comparison graph of Acidity for different samples using neem oil.

From the Investigations of the Acidity values of the neem oil sample the following inference were made:

1. The acidity of the oil sample gets reduced from 0.6KoH/g to 0.05KoH/g.
2. The acidity value for Sample 10 that is when carbon nano powder is low.

3.2. The Blending of Sunflower Oil with Regenerative Materials

The results are obtained from the experiment are presented here in Table 6. The evaluation of critical parameters of Neem Oil by way of different proportions through the addition of regenerative materials like TBHQ, Selenium, Beta Carotene, Aluminium Nitride and Carbon Nanopowder were made.

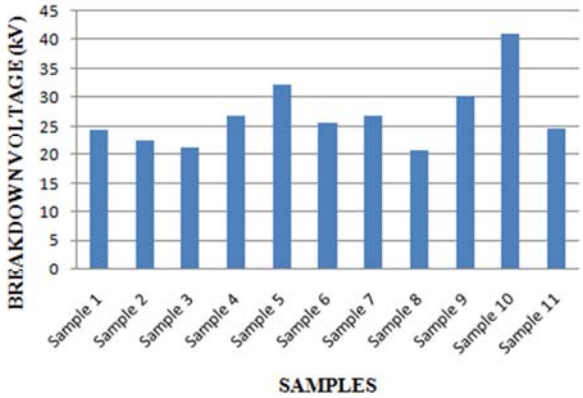

Figure 11. *Comparison of Breakdown Voltage values of samples using sunflower oil.*

Table 6. *Results of Sunflower oil with Regenerative Materials.*

Samples	BDV (kV)	Viscosity at 40°C(cSt)	Viscosity at 90°C (cSt)	Flash Point (°C)	Fire Point(°C)	Acidity (KoH/g)
Sample 1	24.5	42.66	26.21	311	331	0.05
Sample 2	22.4	115.3	52.46	321	346	0.05
Sample 3	21.3	90.51	25.66	316	331	0.1
Sample 4	26.9	75.85	26.21	306	324	0
Sample 5	32.4	84.49	30.04	317	330	0
Sample 6	25.6	90.25	26.21	329	352	0.05
Sample 7	27	48.50	23.72	324	347	0.7
Sample 8	20.9	90.51	55.1	339	362	0.4
Sample 9	30.3	70.87	25.94	335	357	0.1
Sample 10	41	66.15	20.93	346	364	0.05
Sample 11	24.8	91.55	23.17	336	353	0

Figure 11 shows the comparison graph of breakdown voltage for different samples using sunflower oil.

From the Investigations of the breakdown Voltage of the sunflower oil sample the following inference were made:

1. Breakdown Voltage of the sunflower oil sample increases when Antioxidants and nano powders are added.
2. When Carbon nano powder is added the Breakdown Voltage (Sample 10) is higher when compared with other.
3. The breakdown voltage is increased from 21.3kV to 41kV.

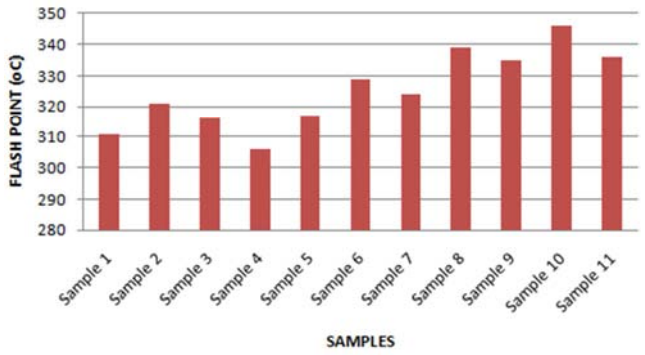

Figure 12. *Comparison of Flash point values of samples using sunflower oil.*

Figure 12 shows the comparison graph of Flash point for different samples using sunflower oil.

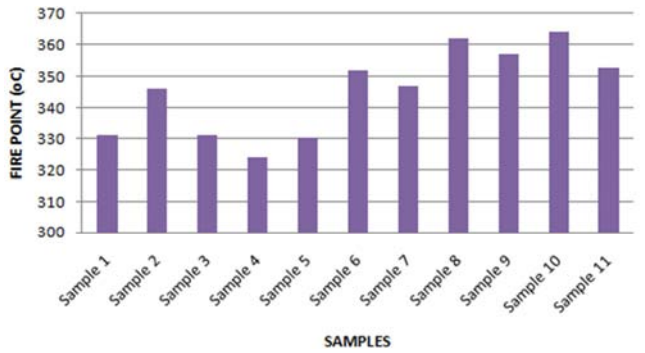

Figure 13. *Acidity Comparison of Fire point values of samples using sunflower oil.*

Figure 13 shows the comparison graph of Fire point for different samples using sunflower oil.

From the Investigations of the Flash Point and Fire Point of the sunflower oil sample the following inference were made:

1. The flash point is increased from 306°C to 346°C.
2. The fire point is the withstand temperature of the oil sample.
3. The flash point and Fire point for Sample 10 that is when carbon nano powder is very high.

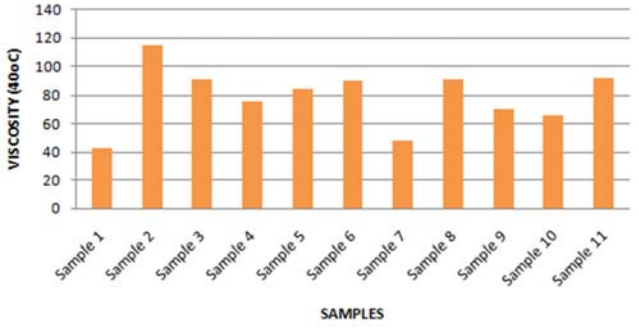

Figure 14. *Comparison of Viscosity values of samples using sunflower oil at 40°C.*

Figure 14 Comparison of Viscosity values of samples using sunflower oil at 40°C.

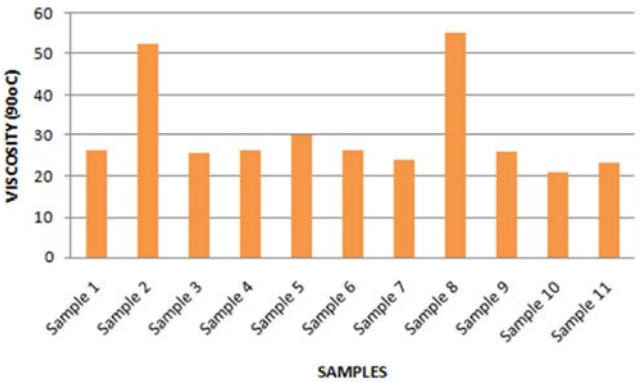

Figure 15. *Comparison of Viscosity values of samples using sunflower oil at 90°C.*

Figure 15 shows the comparison graph of Viscosities for different samples using sunflower oil at 90°C.

From the Investigations of the Viscosity values of the sunflower oil sample the following inference were made:

1. At 40°C, the viscosity of the oil sample gets reduced from 115.31cSt to 42.66cSt.
2. At 90°C, the viscosity of the oil sample gets reduced from 55.1cSt to 20.93cSt.
3. The viscosity values of sample 10 that is when mahua oil is mixed with selenium and TBHQ is very low.
4. Usually lower the viscosity value gives the better oil sample.

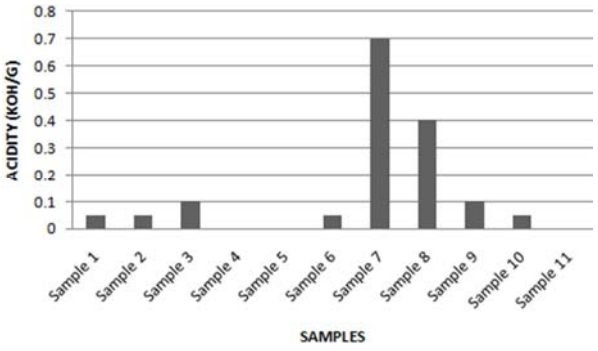

Figure 16. *Comparison of Acidity values of samples using sunflower oil.*

Figure 16 shows the comparison graph of Acidity for different samples using sunflower oil.

From the Investigations of the Acidity values of the sunflower oil sample the following inference were made:

1. The acidity of the oil sample gets reduced from 0.7KoH/g to 0KoH/g.
2. The acidity value for Sample 4, 5 and 11 that is when beta carotene, selenium and beta carotene andwhen carbon and aluminium nano powder is added is low.

3.3. The Blending of MahuaOil with Regenerative Materials

The results are obtained from the experiment are presented here in Table 7. The evaluation of critical parameters of Neem Oil by way of different proportions through the addition of regenerative materials like TBHQ, Selenium, Beta Carotene, Aluminium Nitride and Carbon Nanopowder were made.

Table 7. *Results of Mahua oil with Regenerative Materials.*

Samples	BDV (kV)	Viscosity at 40°C(cSt)	Viscosity at 90°C (cSt)	Flash Point (°C)	Fire Point(°C)	Acidity (KoH/g)
Sample 1	24.9	298.5	30.85	270	290	0.1
Sample 2	15.4	80.83	30.58	240	260	0.4
Sample 3	23.1	81.88	37.85	250	268	0.05
Sample 4	26.6	96.52	27.04	258	273	0.6
Sample 5	18.6	115.0	28.13	252	269	0.4
Sample 6	16.9	103.5	30.04	280	298	0.3
Sample 7	26.4	98.35	27.04	275	294	0.4
Sample 8	28.6	123.3	31.39	310	325	0.1
Sample 9	29.4	109.3	46.37	290	313	0.05
Sample 10	27.9	108.2	22.89	268	291	0.1
Sample 11	25.3	183.2	56.42	285	309	0.2

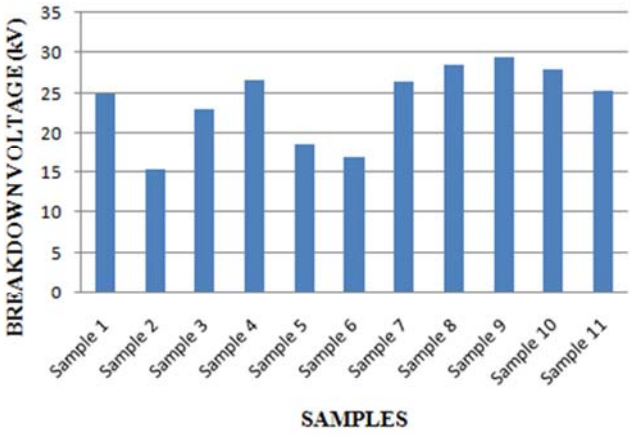

Figure 17. *Comparison of Breakdown Voltage values of samples using mahua oil.*

Figure 17 shows the comparison graph of breakdown voltage for different samples using mahua oil.

From the Investigations of the breakdown Voltage of the mahua oil sample the following inference were made:

1. Breakdown Voltage of the mahua oil sample increases when Antioxidants and nano powders are added.
2. When Aluminium Nitride nano powder is added the Breakdown Voltage (Sample 9) is higher when compared with other.
3. The breakdown voltage is increased from 15.4kV to 29.4kV.

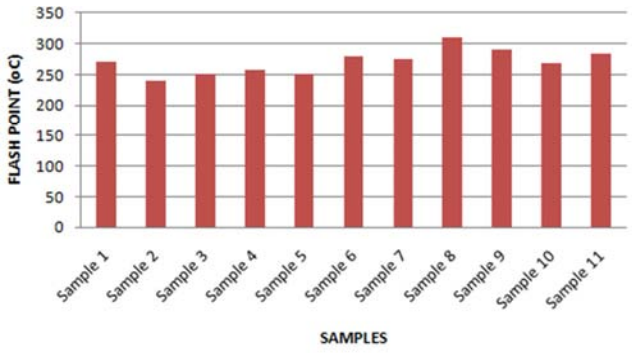

Figure 18. *Comparison of Flash point values of samples using mahua oil.*

Figure 18 shows the comparison graph of Flash point for

different samples using mahua oil.

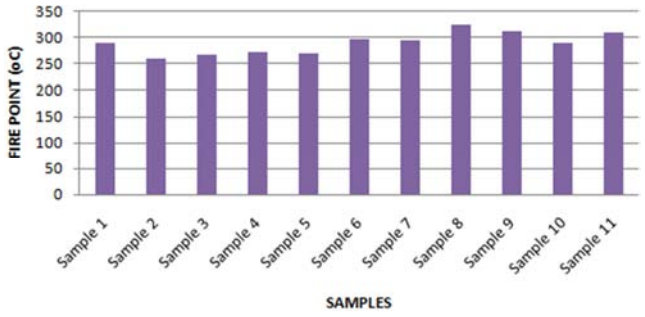

Figure 19. *Acidity Comparison of Fire point values of samples using mahua oil.*

Figure 19 shows the comparison graph of Fire point for different samples using mahua oil.

1. From the Investigations of the Flash Point and Fire Point of the mahua oil sample the following inference were made:
2. The flash point is increased from 240°C to 310°C.
3. The fire point is the withstand temperature of the oil sample.
4. The flash point and Fire point for Sample 8 that is when carbon nano powder is very high.

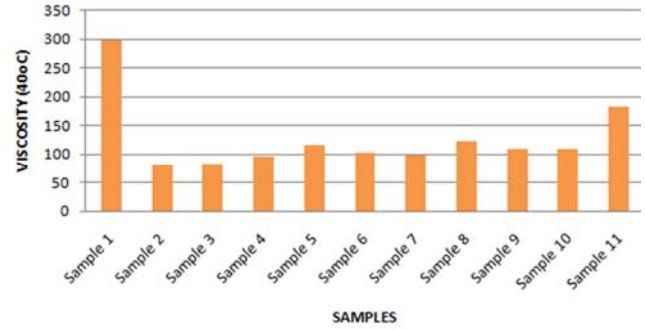

Figure 20. *Comparison of Viscosity values of samples using mahua oil at 40°C.*

Figure 20 shows the comparison graph of Viscosities for different samples using mahua oil at 40°C.

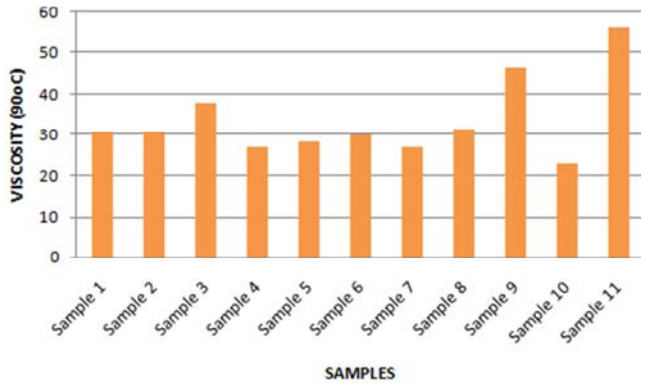

Figure 21. *Comparison of Viscosity values of samples using mahua oil at 90°C.*

Figure 21 shows the comparison graph of Viscosities for different samples using mahua oil at 90°C.

From the Investigations of the Viscosity values of the sunflower oil sample the following inference were made:

1. At 40°C, the viscosity of the oil sample gets reduced from 298.53.81cSt to 80.83cSt.
2. At 90°C, The viscosity of the oil sample gets reduced from 56.42cSt to 22.89cSt.
3. The viscosity value of sample 10 that is when mahua oil is mixed with Carbon nano powder is very low.
4. Usually lower the viscosity value gives the better oil sample.

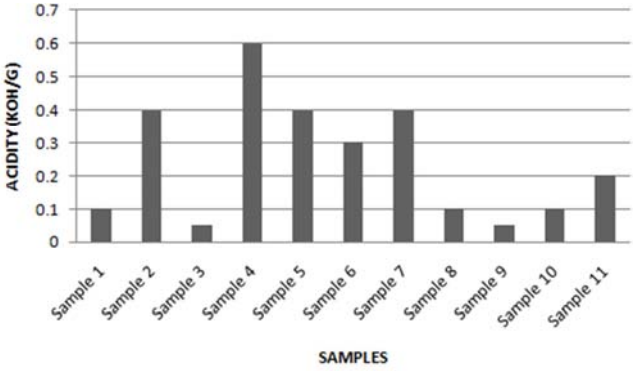

Figure 22. *Comparison of Acidity values of samples using neem oil.*

Figure 22 shows the comparison graph of Acidity for different samples using mahua oil.

From the Investigations of the Acidity values of the mahua oil sample the following inference were made:

1. The acidity of the oil sample gets reduced from 0.6KoH/g to 0.05KoH/g.
2. The acidity value for Sample 3 and 9 that is when selenium and when beta carotene, selenium and TBHQ is added is low.

3.4 Comparison of the Blending of Three Oils with Regenerative Materials

The evaluation of critical parameters of the three oils by way of different proportions through the addition of regenerative materials like TBHQ, Selenium, Beta Carotene, Aluminium Nitride and Carbon Nanopowder were made are discussed below.

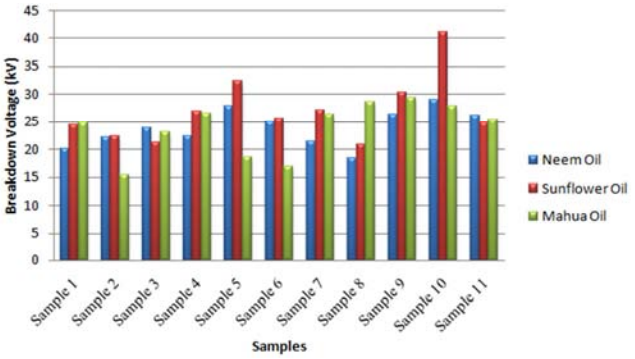

Figure 23. *Comparison of Breakdown Voltage values of samples using three oils.*

Figure 23 shows the comparison graph of breakdown voltage for different samples using three oils.

From the Investigations of the breakdown Voltage of the three oil sample the following inference were made:

1. Breakdown Voltage of the sunflower oil when mixed with carbon nano powder is high.
2. For all the oils the breakdown voltage is higher when antioxidants and nano powder is added.

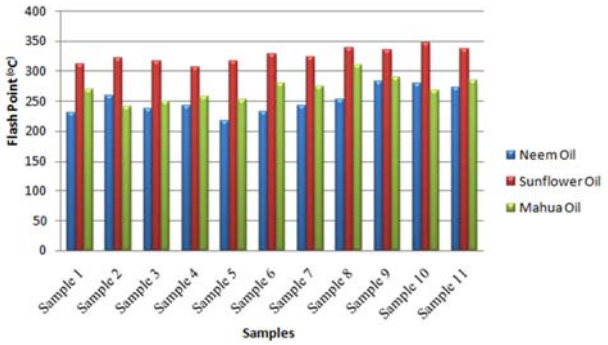

Figure 24. *Comparison of Flash Point values of samples using three oils.*

Figure 24 shows the comparison graph of Flash Point for different samples using three oils.

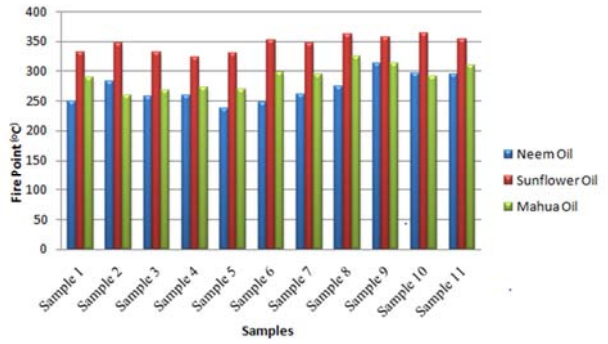

Figure 25. *Comparison of Fire Point values of samples using three oils.*

Figure 25 shows the comparison graph of Fire Point for different samples using three oils.

From the Investigations of the Flash Point and Fire Point of the three oil sample the following inference were made:

1. The flash point is high in sample 10 when sunflower oil is added.
2. The fire point is high in sample 10 when sunflower oil is added.
3. The flash point and Fire point for the entire sample increases when antioxidants and nano powder is added.

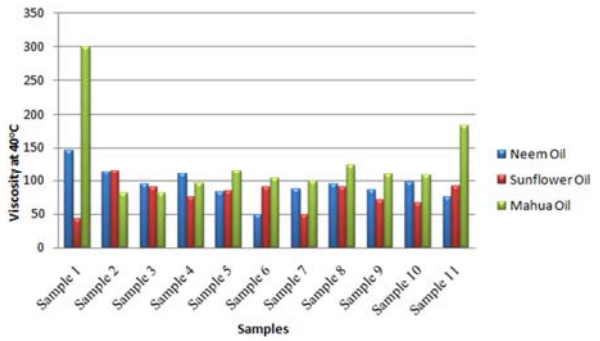

Figure 26. *Comparison of Viscosity values of samples using three oils at 40°C.*

Figure 26 shows the comparison graph of Viscosity at for different samples using three oils at 40°C.

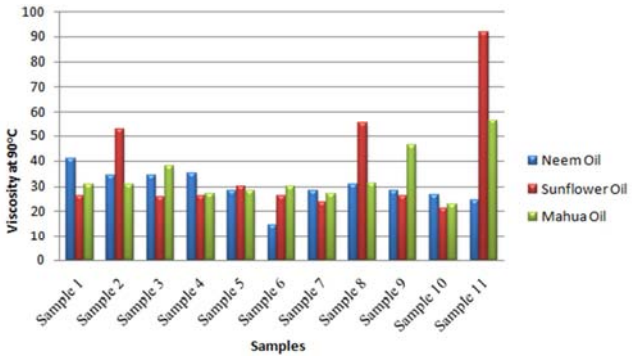

Figure 27. *Comparison of Viscosity values of samples using three oils at 90°C.*

Figure 27 shows the comparison graph of Viscosity for different samples using three oils at 90°C.

From the Investigations of the Viscosity values of the three oil sample the following inference were made:

1. At 40°C, the sample 10 when carbon nano powder is added the viscosity value reduces.
2. At 90°C, the sample 10 when carbon nano powder is added the viscosity value reduces.
3. Usually lower the viscosity value gives the better oil sample.

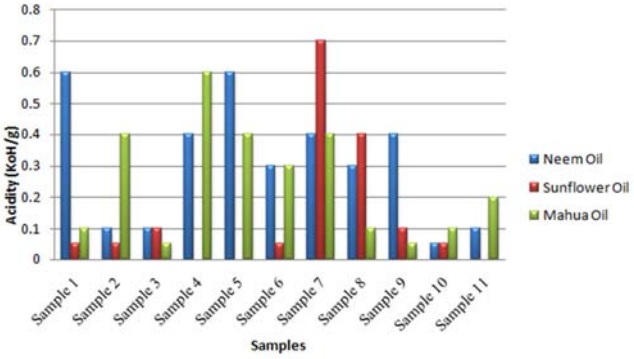

Figure 28. *Comparison of Viscosity at Acidity values of samples using three oils.*

Figure 28 shows the comparison graph of Acidity values for different samples using three oils.

From the Investigations of the Acidity values of the three oil sample the following inference were made:

1. The acidity of the oil sample of 4, 5 and 11 is very low for sunflower oil.
2. Usually sunflower oil has lower acidity value.

4. Conclusion

Transformers are the most important component in the electrical power system. The analysis is used to establish the reclamation of vegetable oil. Moreover, the combination of antioxidants (TBHQ, Selenium and Beta Carotene) and Nano Powders (Aluminium Nitride and Carbon Nano Powder) is a proven technique for enhancing the properties of vegetable

oil. The important features of using antioxidants and nanopowders combination during experimentation apart from enhancement property are very less carbon content during the breakdown. After the addition of regenerative materials, the parameters such as BDV, Viscosity, Flash point and Fire point gets increased. This approach is also useful in avoiding harmful disposal of used transformer oil to the environment. The overall investigation concludes that the enhanced oils using regenerative materials, nanopowders and antioxidant is an appropriate solution for potential reuse in power transformer.

References

[1] IEEE. Guide for Loading Mineral Oil Immersed Transformer, AnnexI: Transformer Insulation Life, IEEE Standard C57.91, 1995.

[2] Vishal, Saurabh, Vikas and Prashant, "Transformer's History and itsInsulating Oil", 5th National Conf., INDIACom, Computing for Nation Development, 2011.

[3] K. Sindhuja, M. Srinivasan and N. Niveditha, "Natural Esters as an alternative to Mineral Oil in Transformer Applications," InternationalJournal of Pure and Applied Mathematics, vol. 118 No.20, pp. 723–732, 2018.

[4] Pavel Totzauer, Pavel Trnka, Jaroslav Hornak, Petr Kadlec, Josef Pihera, "Antioxidant variation in the ester oil," IEEE Conference, 2017.

[5] M. Thanga Rathna, R. V. Maheswari, P. Samuvel Pakkianathan, "Enhancing the properties of used mineral oil by Regeneration process," IEEE Conference, 2017.

[6] 'M. Karthik, M. Willjuice Iruthayarajan and M. Bakrutheen, "Investigation of Vegetable oil blended with Antioxidant," IEEE conference, 2015'.

[7] 'Arun Ram Prasath. R. T, Willjuice Iruthayarajan. M. S, Radha. K, "Performance studies on dielectric and physical properties of eco - friendly based natural ester oils using semi-conductive nanocomposites for power transformer application," Institution of Engineering and Journals, 2017'.

[8] Senthil Kumar. S, Willjuice Iruthayarajan. M, Bakrutheen. M, "Effect of Antioxidants on critical Properties of Natural Esters for Liquid Insulations," IEEE Transactions on Dielectric and Electrical Insulation, 2016.

[9] Pavel Totzauer, Pavel Trnka, Vaclav Mentlik, Jaroslav Hornak, PetrKadlec, Jiri Ulrych, Josef Pihera, "A study of various inhibitors mixtures in Natural ester oil," IEEE conference, 2017.

[10] 'Raymon. A, Karthik. R, "Reclaiming Aged Transformer Oil with Activated Bentonite and Enhancing Reclaimed and Fresh Transformerr Oils with Antioxidants," IEEE Transactions on Dielectric and Electrical Insulation, 2015'.

[11] Raymon. A, Samuel Pakianathan. P, Rajamani. M. P. E, Karthik. R, "Enhancing the Critical Characteristics of Natural Esters with Antioxidants for Power Transformer Applications," IEEE Transactions on Dielectric and Electrical Insulation, 2013.

[12] Krishna Kumar. P, Senthil Kumar. S, Ravindran. M, "Investigationon Mixed Insulating Fluids with Nano Fluids and Antioxidants", IEEE Conference 2014.

[13] Samuel Pakianathan. P, Rajamani. M. P. E, "Enhancing the Critical Characteristics of Vegetable Oil and used Mineral Oil of Power Transformer," IEEE Conference, 2013.

[14] R. Madhavan, S. Senthil Kumar, M. Willjuice Iruthayarajan, "A Comparative investigation on the effects of nanoparticles on characteristics of natural ester based nano fluids," Elsevier Journal, Colloids and Surfaces A 556, 2018.

[15] S. Senthil Kumar, M. Willjuice Iruthayarajan, M. Bakrutheen, "Investigation on the suitability of Rice Bran Oil and Corn Oil as Alternative Insulating Fluids for Transformer," IEEJ Transactions on Electrical and Electronic Engineering, 2016.

[16] S. Senthil Kumar, M. Willjuice Iruthayarajan, M. Bakrutheen, "Performance Of Activated Bentonite And Carbon In Reclaiming The Properties Of Used Mineral Oil," Journal of Electrical Engineering, 2017.

[17] P. Joeljoshuva, A. Prabhu, R. Arun Kumar, S. Senthil Kumar, "Investigation of various Natural Esters Insulating Medium for the Applications in High Voltage Machinery," International Journal of Advanced Research in Basic Engineering Sciences and Technology, 2018.

[18] R. Karthik, T. S. R. Raja, S. S. Shanmugam and T. Sudhakar, *Performance Evaluation of Ester oil and Mixed Insulating Fluids*, J. Institute of Eng., India, Series B, Springer, Vol. 93, No. 3, pp.173-178, 2012.

[19] R. Karthik and SreeRenga Raja. T, "Investigations of Transformer Oil Characteristics", IEEJ-Trans. Electr. Electronics Eng., Vol. 7, pp. 369-374, 2012.

[20] M. Bakrutheen, R. Karthik and R. Madavan, "Investigation of Critical Parameters of Insulating Mineral Oil Using Semiconductive Nanoparticles", IEEE Int'l. Conf. Circuits, Power and Computing Technologies - ICCPCT, pp. 294-299, 2013.

[21] ASTM D 93. Standard Test Methods for Flash Point by Pensky-Martens Closed Cup Tester, 2012.

[22] ASTM D 3828. Standard Test Method for Kinematic Viscosity of Transparent and Opaque Liquids (and the Calculation of Dynamic Viscosity), Annual book of ASTM standard 10.03, 2006.