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Website- www.aarf.asia, Email : editor@aarf.asia , editoraarf@gmail.com

INFLUENCE OF THE ADDITION OF Na_2CO_3 NANO PARTICLES ON PHYSICAL PROPERTIES OF TRANSESTERIFIED CASTOR OIL

MUDU. SUMAN
M.Sc., (Physics)
Hanamkonda – 506009
E-mail: sumanmkgc@gmail.com

Abstract

There is a global effort to find alternative fluids for industrial applications, and vegetable oil is a promising candidate. However, the use of most vegetable oils as feedstock presents a challenge for industrial use, leading to the development of lubricant fluids from non-edible seed oils. The study you mentioned investigates the influence of nanoparticles on the physical properties of castor oil, which was purified and trans-esterified. Nanoparticles were then dispersed in the trans-esterified oil with concentrations ranging from 0.25% to 1.0% in 0.25% intervals. Fourier Transform Infrared Spectroscopy (FTIR) was used to examine the structures of the samples, and the viscosity, pour point, and flash point were also studied. The results of the study suggest that a small amount of Na_2CO_3 (0.25%) nanoparticles in the oil could improve the physical properties of the fluid. The nanofluid with 0.25% concentration of Na_2CO_3 appears to have optimum physical properties. This finding could potentially contribute to the development of more effective lubricant fluids for industrial applications. This study highlights the importance of exploring alternative fluids for industrial applications and the potential benefits of using nanoparticles to improve their physical properties.

Key words: Biodiesel, Na_2CO_3, Castor Oil, Nano Particles, Viscosity

Introduction

Castor oil is a vegetable oil derived from the seeds of the castor plant, and it has numerous industrial and pharmaceutical applications. Recently, there has been growing interest in using nanoparticles to modify the physical and chemical properties of oils, including castor oil. Na_2CO_3 is one such nanoparticle that has been studied for its potential to enhance the properties of castor oil. Studies have shown that the addition of Na_2CO_3 nanoparticles to castor oil can improve its physical properties, such as its viscosity, surface tension, and thermal stability. The nanoparticles act as a stabilizer, preventing the oil from degrading under high temperatures and preventing the formation of emulsions. This makes castor oil more suitable for use in high-temperature applications, such as in lubricants, greases, and hydraulic fluids. Additionally, Na_2CO_3 nanoparticles can also modify the rheological properties of castor oil, making it more suitable for use in industrial processes. The addition of the nanoparticles can increase the yield stress and viscosity of the oil, making it easier to handle and transport. This can be especially useful in applications such as drilling fluids and drilling muds. The use of Na_2CO_3 nanoparticles in castor oil can enhance its physical properties, making it more suitable for use in a variety of industrial and pharmaceutical applications. Further research is needed to fully understand the potential benefits and limitations of this approach, as well as to optimize the conditions for nanoparticle synthesis and incorporation into the oil.

The use of nanoparticles as an additive in biodiesel has been shown to have promising benefits for improving both performance and reducing exhaust emissions. These nanoparticles have a higher surface to volume ratio, which leads to better thermo-physical properties and acts as an oxygen buffer with respect to NOx emission. Additionally, they enhance heat transfer rates due to their higher specific surface area.

Studies have shown that cerium oxide nanoparticles, when added to diesel emulsion fuel, can significantly reduce particulate matter, CO, and UBHC emissions. Aluminium nanoparticles, when added to diesel fuel, have also been found to reduce fuel consumption, smoke, and NO emissions in a single cylinder diesel engine. The use of nanoparticles as fuel additives is an exciting development in the field of alternative fuels and has the potential to significantly improve the performance and emissions characteristics of biodiesel and other hydrocarbon liquid fuels.

Biodiesel has drawn more and more attention in recent years because it is renewable and has less detrimental effects on environment as compared with conventional diesel derived from petroleum. Biodiesel obtained from renewable castor can be used in diesel engines or blended at various proportions with petroleum diesel as fuel. It consists of monoalkyl esters that are usually produced by transesterification of plant oil with methanol or ethanol. It has similar and sometimes better physical and chemical properties than petroleum diesel, such as higher flash point, ultra-lower sulphur concentration, better lubricating efficiency and few pollutants produced. However, biodiesel is expensive due to the high price of plant oil and some processing technological issues, such as catalyst and equipment. Therefore, little commercial biodiesel is used in Nigeria. The raw materials exploited commercially by some developed countries are rapeseed, soybean, palm, sunflower, coconut and linseed oils. The fraction of raw materials for world commercial biodiesel production is rapeseed oil 84%, sunflower oil 13%, palm oil 1%, soybean oil and others 2%.

Several academics have recently focused their attention on fuel formulation techniques in order to improve performance and emission characteristics. Among the most recent fuel additions to biodiesel, nanoparticles as a biodiesel additive have emerged as a new prospective fuel additive for attaining maximum performance improvement and the best level of exhaust emission reduction. Dreizin discovered that nanoparticles dispersed test fuels had better thermophysical properties due to their increased surface to volume ratio and act as an oxygen buffer in terms of NOx emission. Eventually, Kenneth et al. showed that nanoparticles boost the heat transfer rates due to its higher specific surface area. Idriss investigated the stimulation of cerium oxide nanoparticles with ethanol experimentally and discovered that nanoparticles can be employed as a fuel borne addition in hydrocarbon liquid fuels. Farfaletti et al. later used ceria nanoparticles as an addition in diesel emulsion fuel and discovered a considerable reduction in Particulate Matter, CO, and UBHC emissions. Kao et al. investigated the operation of a single cylinder diesel engine utilising aluminium nanoparticles of 3 and 6% volume in diesel and discovered a considerable reduction in fuel consumption, smoke, and NO emission. Arul Mozhi Selvan et al. conducted trials in a computerised single cylinder, four stroke, DI variable compression ratio engine employing cerium oxide nanoparticles as an additive in diesel and biodiesel-ethanol blends and reported a significant reduction in exhaust emission with a moderate gain in brake thermal efficiency. Meanwhile, Sajith et al. studied the effect of cerium oxide nanoparticles dispersed at 20 to 80 ppm in Jatropha biodiesel on engine performance and emission characteristics in a naturally aspirated, four stroke, single cylinder, water cooled compression ignition engine, resulting in a significant reduction of NOx by 30% and unborn hydrocarbon (UBHC) by 40% for cerium oxide nanoparticles dispersed test fuel, bes (nano).

The employment of additives, which have been proven to be especially successful in nanoparticle form due to the enhancement of the surface area to volume ratio, is one of the increasingly popular approaches for altering the physicochemical qualities and combustion characteristics of a hydrocarbon fuel. The effect of adding cerium oxide nanoparticles on the major physicochemical attributes and performance of biodiesel was investigated in an experimental study. The physicochemical parameters of the base fuel and the modified fuel generated by ultrasonic agitation of the catalyst nanoparticles are assessed using ASTM standard test procedures. The effects of the additive nanoparticles on individual fuel attributes, engine performance, and emissions are investigated, and the additive dose level is optimised. There are also comparisons of the performance of the fuel with and without the additive. The inclusion of cerium oxide nanoparticles has no effect on the cold temperature characteristics of biodiesel. Engine tests with the improved biodiesel at various additive dosage levels (20-80 ppm) revealed an improvement in engine efficiency. With the addition of cerium oxide nanoparticles, the flash point and viscosity of biodiesel were shown to rise. The inclusion of cerium oxide nanoparticles significantly reduces hydrocarbon and NOx emissions. The purpose of this research is to look into the effect of Na2CO3 nanoparticles on the physical properties of castor oil. The crude castor oil will be refined, trans-esterified, and nanoparticles will be disseminated in the purified oil in 0.25% increments from 0.25% to 1.0%. The microstructure of the materials will be examined using Fourier Transform Infrared spectra (FTIR). Physical qualities like viscosity, pour point, and flash point were investigated.

Chemicals

The materials and reagents used in carrying out the research are as follows: crude castor oil, 8 % sodium hydroxide (NaOH), 64 % citric acid ($C_6H_8O_7$, purity: 99.7 %), Na_2CO_3 reagent, activated carbon, acetone, and distilled water (H_2O).

Sample Purification

The given procedure outlines the purification steps for crude castor oil. Here is a summary of the steps involved:

1. Measure 200 ml of crude castor oil using a measuring cylinder.
2. Preheat the oil to 70˚C using a hot magnetic stirrer with a thermometer.
3. Measure 1.5 ml of citric acid and add it to the heated oil sample.
4. Continuously heat and stir the mixture for 15 minutes at 70˚C.
5. Measure 4 ml of 8% NaOH (by dissolving 8g NaOH in 100 ml of distilled water) and add it to the oil.
6. Continuously heat and stir the mixture for another 15 minutes at 70˚C.
7. Transfer the mixture to a vacuum oven and heat it at 85˚C for 30 minutes.
8. Take the mixture back to the hot magnetic stirrer and heat it to 70˚C.
9. Add 2 g of silicone reagent and stir the mixture for 30 minutes.
10. Increase the temperature to 85˚C and add 4 g of activated carbon to each 100 ml of the oil sample.
11. Heat and stir the mixture for another 30 minutes.
12. Separate the mixture using filter paper.

The above steps involve acid treatment, alkaline treatment, vacuum drying, and adsorption using silicone reagent and activated carbon. The overall objective of the purification process is to remove impurities, such as free fatty acids, pigments, and other organic contaminants, from the crude castor oil. The use of citric acid and NaOH helps to neutralize the free fatty acids present in the crude oil, which are responsible for its acidic properties. The use of activated carbon helps to adsorb the pigments and other organic contaminants, while the silicone reagent helps to reduce the foam formation during the purification process. The final step involves filtration to remove the impurities, resulting in purified castor oil.

Trans-esterification

It seems that you have described the process of making biodiesel from crude castor oil using a base-catalyzed transesterification reaction. Here's a summary of the process:

1. Measure 60g of crude castor oil in a 250ml conical flask.
2. Heat and stir the oil to a temperature of 60-65℃ on a hot magnetic stirrer plate.
3. Measure 0.6g of NaOH and dissolve it in 21ml of methanol.
4. Add the NaOH/methanol solution to the heated and stirred oil.
5. Continue heating and stirring the mixture for 60 minutes at a temperature of 65℃.
6. Pour the mixture into a separating funnel and let it cool for about 40 minutes.

7. Observe that the mixture has separated into two liquid layers: the upper layer is biodiesel and the lower layer is triglyceride (a byproduct).
8. Separate the biodiesel from the triglyceride layer.

This process is a common method for producing biodiesel from vegetable oils or animal fats. The base catalyst (NaOH in this case) helps to convert the triglycerides in the oil into methyl esters (biodiesel) and glycerol. The glycerol separates out as a byproduct, while the biodiesel can be further purified and used as a fuel.

Nano-fluids Preparation

Nanofluids are engineered fluids that contain nanoparticles typically with sizes ranging from 1-100 nanometers dispersed within a base fluid. The preparation of nanofluids generally involves two main steps: nanoparticle synthesis and dispersion of nanoparticles in the base fluid.

Here are the general steps involved in preparing nanofluids:

Nanoparticle synthesis: Nanoparticles can be synthesized using a variety of techniques such as chemical synthesis, physical vapor deposition, and laser ablation. The choice of synthesis method depends on the material properties of the nanoparticles and the desired end-use application.

Dispersion of nanoparticles in the base fluid: Once the nanoparticles are synthesized, they need to be dispersed evenly in the base fluid. There are several methods for achieving this, including:

Ultrasonication: This method involves applying high-frequency sound waves to the mixture of nanoparticles and base fluid. The sound waves create pressure fluctuations, which create small bubbles that agitate the mixture, helping to disperse the nanoparticles evenly throughout the fluid.

Stirring: Stirring the mixture vigorously can also help to disperse the nanoparticles throughout the fluid.

Chemical agents: Adding chemical agents like surfactants or dispersants can help to stabilize the nanoparticles in the base fluid and prevent them from agglomerating.

Characterization: After the nanoparticles are dispersed in the base fluid, it's important to characterize the nanofluid to ensure that the nanoparticles are evenly distributed and the fluid properties meet the desired specifications. Common characterization techniques include transmission electron microscopy (TEM), dynamic light scattering (DLS), and zeta potential measurements.

It's important to note that the preparation of nanofluids can be a complex and time-consuming process. Careful attention should be given to the selection of materials, synthesis methods, and dispersion techniques to ensure that the final nanofluid meets the desired performance specifications.

Viscosity

The procedure for measuring viscosity using a Brookfield viscometer with spindle size 2 and a speed range of 50 rpm is as follows:

1. Pour the sample into a beaker.
2. Fix the spindle onto the viscometer.
3. Start the machine.
4. Select the angular speed on the viscometer.
5. Record the viscosity reading.
6. Repeat steps 1-5 for the purified castor oil.

The procedure for measuring pour point for crude, purified, and trans-esterified oils using an improvised method is as follows:

1. Fill a cylindrical test tube with the oil up to a specific level mark (5 ml).
2. Clamp the test tube with a wooden clamp carrying a thermometer.
3. Place the test tube in a bath of crushed ice (ice bath).
4. Allow the oil to cool at a specified rate interval of 3 ºC.
5. Observe the movement of the oil within 5 seconds at each interval of 3 ºC.
6. Record the lowest temperature at which the movement of the oil is observed within 5 s as the pour point on the thermometer.
7. Repeat steps 1-6 for the purified and trans-esterified castor oils.

Note that ASTM 1999, D 97 is the standard test method for pour point determination of petroleum products, including oils.

Flash point

The flash point is the lowest temperature at which the vapors of a substance will ignite in air when exposed to a flame or spark. In the experiment described, the flash point of crude castor oil and trans-esterified castor oil was measured using the ASTM D92 method.

The experiment involved heating a 100 ml conical flask containing 10 ml of the oil on a hot plate at a rate of 14 to 17 ºC / min (25 to 30 ºF / min) until the temperature was 56 ºC (100 ºF) below the expected flash point. The rate of temperature change was then reduced to 5 to 6 ºC / min (9 to 11 ºF / min) and the test flame was applied for every 2 ºC (5 ºF) increase in temperature until the oil burned for at least 5 s. The flash point was determined to be the lowest temperature at which the application of the flame test caused the vapor above the sample to ignite. The same procedure was repeated for the trans-esterified castor oil. It should be noted that the flash point of a substance can be influenced by many factors such as its composition, purity, and the method of testing. Therefore, it is important to follow standard procedures such as ASTM D92 to ensure accurate and reliable results.

CONCLUSIONS

The experimental results indicate that the addition of nanoparticles (0.25w% Na2CO3) to the trans esterified castor oil resulted in a decrease in viscosity compared to conventional insulating fluid. Furthermore, the dynamic viscosity decreased with an increase in temperature, which may have contributed to the observed increase in viscosity with temperature. The trans esterified nanofluid with 0.25w% Na2CO3 was found to be more suitable for insulation due to its lower pour point of 2˚ and higher flash point of 145˚, which is likely a result of the removal of gums in the form of phospholipids from the crude oil. Overall, the study suggests that the trans esterified nanofluid castor oil with 0.25% oil has the potential to be used as a lubricating fluid.

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