Concentration measurement on preparation of blending SiO_2 nano biodiesel

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Abstract. Biodiesel is an important renewable energy candidate for the future energy. To improve the fuel properties, many experimental works and trial for the fuel blend. The fuel enrichment method by addition of nano-additives is widely accepted by numerous researchers. The nano-additives are used to achieve specific fuel properties and to improve the performance characteristics and to attain a good emission control of the Compression Ignition (CI) engine without any modification. It is important to blend in right concentration in order to avoid the effect on fuel properties. This paper reports the calculation on how to measure concentration of blending biodiesel fuel with nanoparticles with the appropriate method which is mass concentration method. This paper investigates the details of concentration measurements of blending biodiesel (B7) with SiO_2 nanoparticle by using the mass fraction method for only 0.5 liter of fuel. This method also can use for other types of fuel and nanoparticles.Thus, by using the correct method of mass concentration would not be affect to its fuel properties, engine performance and also exhaust emissions.

1. Introduction

Growing energy desires, depletion of fossil fuels and rigorous emission standard forced the scientific society to search for alternative fuels such as biodiesel for diesel engine applications in order to decrease the gap between demand and energy source for automotive sector [1-3]. Biodiesels are readily available, bio-degradable, portable, nontoxic and renewable source. It can be produced from a variety of natural feedstock sources and globally around 350 crops are accepted as the potential feedstock for biodiesel production [4]. Energy supply and demand is always a priority for the current energy balance and energy research communities [5-7]. Renewable energy is one of the answers to this energy security and future energy supply [8-11]. Biodiesel is one of the prominent renewable fuel for the potential to replace fossil fuel [12-15].

However, the viscosity of the biodiesel is considered the main problem which hinders to use it directly in diesel engines. Therefore, to tackle this issue, transesterification process is a widely used technique to reduce biodiesel viscosity which considers the most feasible and viable approach. By using this technique, all edible oil can be brought down to similar diesel characteristics. Palm oil and its derivatives have a great potential to be utilized in biodiesel production and in many other applications [16]. There are numbers of research studies that were examined on diesel engines with palm oil biodiesel as fuel under different operating conditions. Although it is considered as a promising alternative source for diesel engines, it still has an adverse effect on exhaust emissions, particularly NO_x emission [17]. In recent decades, there are several studies have focused on nanoparticle additives to biodiesel fuels because these additives have considerable impacts on the combustion characteristics of biodiesel fuels [18][5,6]. In order to improve the biodiesel fuel properties, the fuel can be added and blended into the biodiesel [19-23].

The influence of adding nanoparticle additives with diesel, biodiesel and diesel-biodiesel blends on a diesel engine performance and emission parameters was surveyed by Fangsuwannarak et al. [24]. They concluded that the TiO_2 additive have been demonstrated promising in terms of their impacts on engine performance and emission characteristics. Their positive attributes have been related with reducing ignition delay and the highly reactive surfaces of TiO_2 resulting in a cleaner combustion. These additives act as a catalyst in the combustion zone, resulting in a significant reduction in emissions [25]. Such additives were also found to improve the heat transfer between the fuel and air, which shorted ignition delay and promoted the combustion process [20].

The main objective of this paper is to distribute the knowledge and information among budding engineers, industry people, research scholars and students who are interested in the field of nano fuel additives for CI engine fueled with biodiesel blend with nano additive. This review paper provides the information about the concentration measurement on preparation of blending SiO_2 nano biodiesel.

2. Methodology

Nano-sized particles that have larger surface area to volume ratio produce higher surface tension preventing the particles to separate and therefore agglomerate to form micro-sized particles which next start to sediment. The nanoparticles used in this experiment SiO_2 (diameter 20–30 nm), supplied from Sigma-Aldrich Corporation. Biodiesel use in this preparation is commercializing biodiesel which is Petron Turbo Diesel Euro 5; is a premium plus diesel fuel with 7% of Palm Oil Methyl Ester (POME) known as B7. Table 1 lists the properties (such as density, flash point, cetane number, total sulfur, cloud point, total acid number, conductivity, oxidation stability and kinematic viscosity) of B7 fuel used in the present investigation. The preparation of 25, 50, 75 and 100 ppm in weight of nanoparticle-biodiesel fuel blends were done by measuring nanoparticles of 25mg, 50mg, 75mg and 100 mg on an analytical balance.

Table 1. Properties of the fuel (B7) [26].

Fuel Properties	B7
Density @ 15 (ºC, kg/l)	0.8326
Flash point (ºC, PMCC)	77.0
Cetane number	57.5
Total sulfur (ppm)	6.0
Cloud point (ºC)	-3
Total acid number (mg KOH/g)	0.03
Conductivity (pS/m)	680
Oxidation stability (mg/100ml)	0.6
Kinematic viscosity @ 40ºC (cSt)	3.100

Then nanoparticles are weighed separately for quantities 25mg, 50mg, 75mg and 100mg accurately. The nanoparticles blended biodiesel fuel (B7) is prepared by mixing the biodiesel and SiO_2 nano particles with the aid of homogenizer mixer (Figure 1) at 700 rpm within 15 minutes.

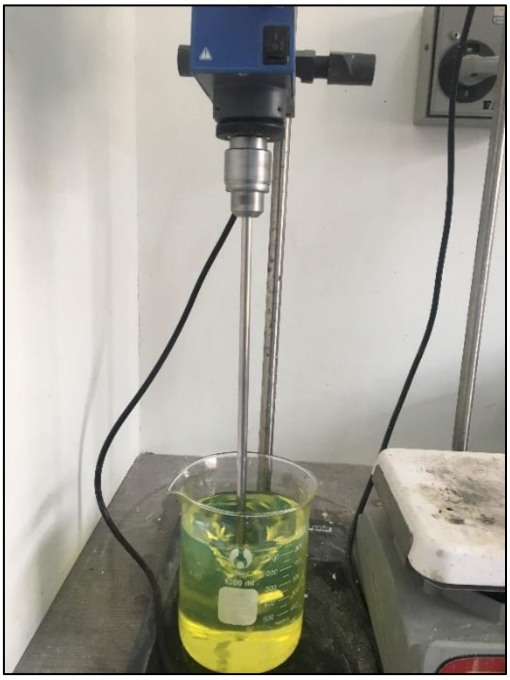

Figure 1. Homogenizer mixer used for biodiesel and SiO_2 nano particles blend.

Then, it mixes by using an ultrasonicator (Figure 2) at amplitude of 60% within 30 minutes. The ultrasonicator technique is the best suited method to disperse the SiO_2 nanoparticles in a fluid, as it facilitates possible agglomerate nanoparticles back to nanometre range.

Figure 2. Ultrasonicator.

The nanoparticles are weighed to a predefined mass fraction say 25ppm and dispersed in the biodiesel fuel that prepared is called BSiO+25ppm labelled as BSiO25 (Figure 3). The same procedure is carried out for the mass fraction of 50ppm (BSiO+50ppm; labelled as BSiO50), 75 ppm (BSiO+75ppm; labelled as BSiO75) and 100ppm (BSiO+100ppm; labelled as BSiO100) to prepare the SiO2 nanoparticles blended biodiesel fuel. Repeat procedure for 50ppm, 75ppm and 100ppm.

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Figure 3. SiO_2 nanoparticle-biodiesel fuel blends after preparation.

Below is the formula that relate with measurements.

$$1\ l = 0.001\ m^3 \quad (1)$$

It needs 0.5 liter of biodiesel fuel in solution, thus;

$$0.5\ l = 5\ x\ 10^{-4}\ m^3 \quad (2)$$

In this investigation, it uses 0.5 liter of fuel because the beaker can fill up to the 0.5 liter only. This beaker will put in the cabin of ultrasonicator to mix with the nanoparticle after mixing using homogenizer mixer (Figure 1). Based on the formula of density below.

$$\rho = \frac{m}{v} \quad (3)$$

$$m = \rho v \quad (4)$$

Where;
m = mass [kg]
v = volume [m^3]
$\rho = de$nsity [$\frac{kg}{m^3}$]

Take the density of biodiesel (B7) which is $832.6\ \frac{kg}{m^3}$; it is from the properties of biodiesel itself (Table 1). Based on equation (3), it can find the mass of the biodiesel fuel.

$m = (832.6\ \frac{kg}{m^3})(5\ x\ 10^{-4}\ m^3)$
m = 0.4163 kg

0.4163 kg of B7 = 0.5 liter of B7

Thus, 0.4163 kg of biodiesel fuel (B7) need to blend with SiO_2 nanoparticles. Then, below are the steps or procedure to find the mass of nanoparticle that need in fuel blends. It uses example of 25 mg of nanoparticle. For 25 mg of nano particle = 0.025 g. One ppm is equivalent to 1 milligram of something per liter of water (mg/l) or 1 milligram of something per kilogram soil (mg/kg). It needs to use the equation (5) to find the mass fraction of nanoparticle.

$$Mass\ fraction\ x_i,\ = \frac{mass\ component,i}{total\ mass, x_t} = \frac{mass\ of\ nanoparticle}{total\ mass\ of\ fuel\ and\ nanoparticle} \quad (5)$$

$$= \frac{0.025\ g}{1000\ g + 0.025}\ X\ 100 = 0.0025\ wt\ \%$$

Based on equation (5), it is using the mass of B7 which is 0.4163 g.

$$\frac{100x_{nano}}{0.4163 +\ x_{nano}} = 0.0025\ wt\ \%$$

$$x_{nano} =\ 1.0408\ x\ 10^{-3} kg = 0.010408\ g = 10.408\ mg$$

Then, it gets the value of 10.408 mg of of SiO_2 nanoparticle that will be used to blend with B7. Thus, 0.4163 kg of biodiesel fuel (B7) need to blend with 10.408 mg of SiO_2 nanoparticles.

3. Results and discussion

First and foremost, concentration, in chemistry, measure of the relative proportions of two or more quantities in a mixture. Concentration also can be expressed in several ways. The simplest statement of the concentrations of the components of a mixture is in terms of their percentages by weight or volume. In this paper, the proportion of biodiesel which is B7 and SiO_2 nanoparticle; two quantities in a mixture. Then, these mixtures of liquids specified by weight percentage concentrations. These solution of nanobiodesel blend also describe as molarity, molality, mole fraction, formality, and normality [27]. The concentration of a solute is very important in studying chemical reactions because it determines how often molecules collide in solution and thus indirectly determines the rates of reactions and the conditions at equilibrium (see chemical equilibrium).

Thus, it is very important to measure the mass concentration of blending because if measure incorrectly, it will affect the properties of fuel itself [28]. To improve the performance of the biodiesel, addition of SiO_2 nano particle study has been conducted. The addition of nanofluids decreased the emission parameter and there was an improvement in combustion efficiency as describe by Nanthagopal et al. [29]. It is showed that thermal efficiency was improved by approximately 17% whereas the engine emissions of NO_x, CO, UHC, and soot were decreased significantly by 29%, 40%, 40%, and 30%, respectively. Furthermore, Nanthagopal et al. [29] analyzed the impacts of adding zinc oxide nanoparticles and Ethanox, which is an antioxidant, into biodiesel fuel on a diesel engine performance and emission characteristics. The results illustrated that the thermal efficiency was enhanced by approximately 25% whereas the NO_x emission was decreased by approximately 18%. However, the CO and UHC emissions were increased by approximately 20% and 15%, respectively. This paper investigates the concentration measurement on preparation of blending SiO_2 nano biodiesel also called as solution [30, 31].

Based on the preparation of fuel blend, it uses 0.5 liter of fuel due to the limitation of beaker that can fill up to the 0.5 liter only. From results, it gets the value of 10.408 mg of of SiO_2 nanoparticle that will be used to blend with B7. Lastly, it can find the amount of biodiesel fuel (B7) which is 0.4163 kg that required to blend with 10.408 mg of SiO_2 nanoparticles.

4. Conclusions

Among the recent additives used in diesel and biodiesel fuels, the nanoparticles have emerged as a novel and promising additive which results in the reduction of exhaust emissions and enhancement in engine performance. Many researchers have focused their attention on fuel modification methods by using the nano-additives for achieving improved performance and emission characteristics. Incorrectly blended fuel can result in fuel properties, engine problems and warranty issues and may affect the tax credits associated with blending biodiesel. The myriad of blending methods, biodiesel feedstocks, and analysis techniques can all add to the uncertainty of the fuel blend. Understanding the issues involved with blending and determining blend ratios will help to reduce inaccuracies and in turn will reduce the frequency of problems associated with incorrect blends. Thus, the method used to blend the fuel is the most important factor contributing to blend accuracy in terms of mass concentration. This paper investigates the details of concentration measurements of blending biodiesel (B7) with SiO_2 nanoparticle by using the mass fraction method for only 0.5 liter of fuel. This method also can use for other types of fuel and nanoparticles.

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