Effects of X-Rays on the Physico-Chemical Properties of Soybean Oil.

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ABSTRACT

Soybean oil was studied to investigate the effect of x-radiation on its physico-chemical properties. Different physico-chemical parameters were characterized. The density, refractive index, pH value, iodine value, viscosity, and free fatty acid values were recorded as .922, 1.425, 5.11, 140, 38.9 mPa and 140g/kg, respectively. The effect of radiation on the oil showed some modification of the density, pH value, iodine value, and free fatty acid value as .9106, 1.422, 4.87, 120, 36.6 mPa and 219g/kg for the soybean oil.

(Keywords: irradiation, food, density, refractive index, pH, iodine, viscosity, free fatty acid, biodiesel)

INTRODUCTION

Many vegetable oils have similar fuel properties to diesel fuel, except for higher viscosity and lower oxidative stability. If these differences can be overcome, vegetable oil may act as substitute for diesel fuel, most significantly as engine fuel or home heating oil [1]. Vegetable oils are also promising candidates as substitutes for petroleum base oils in lubricant applications, such as total loss lubrication, military applications, and outdoor activities. Although vegetable oils have some advantages, they also have poor oxidation and low temperature stability [2].

One of the vegetable oils of interest is soybean oil. There has been a lot of interest in soybean oil because of the potential of it being used as a lubricant [2, 3, and 4] and in biodiesel [5, 6]. Soybeans contain high levels of what is scientifically known as triglyceride molecules, which under a microscope look like the capital letter E [3]. These molecules are very similar in structure and contain multiple double bonds.

When these molecules containing double bonds are exposed to oxygen from the air and high temperatures, they readily condense together, oxidize, and sometimes break apart. At cold temperatures the molecules easily stack, forming little crystals that join together, eventually rendering the liquid oil a solidified mass.

What Adhvaryu [3] and his colleagues did is their research was to chemically alter the symmetrical structure of the molecules so that they no longer consisted of multiple double bonds and were also unable to stack together at cold temperatures.

The result was an inedible vegetable oil product that is more stable at both hot and cold temperatures, which is a key requirement for using it as a stand-alone engine oil, industrial fluid, and specialty grease. In addition, the chemical modification also improves the oil's lubricity.

Biodiesel is a cleaner burning alternative fuel that can be used in any diesel engine. This could be domestically produced renewable fuel made from soybean oil. The use of biodiesel in a conventional diesel engine results in a substantial reduction of unburned hydrocarbons, carbon monoxide, and particulate matter.

The present research work is designed to study different physico-chemical parameters of soybean oil, irradiate the soybean oil with x-rays, observe the effect of radiation on the physico-chemical parameters of the soybean oil, and investigate its suitability for industrial applications as either lubricant or biodiesel.

MATERIALS AND METHODS

The soybean oil used for this research was obtained from Taraku Mills Nigeria, Limited,

Benue State, Nigeria; makers of Golden Soya oil a brand of soybean oil. The soybean oil was then analyzed for density, viscosity, refractive index, iodine value, and free fatty acids by following their respective methods outlined in AOAC [7].

Refractive Index was measured at 30°C, using a Refractometer (Bellingham and Stanley Ltd. London, United Kingdom). The oil samples were then x-irradiated using a single phase Diagnostic x-ray machine, at the Federal Medical Center, Makurdi, Nigeria. The Model of the x-ray machine used is Roentgen 301 (GEC, England).

The following were the sample irradiation parameters: Tube Current, 56mA; Peak Tube voltage, 100KVp and source to sample distance (SSD) of 100cm. The sample underwent a repeated exposure and the total exposure time of 5s was used in order to obtain an appreciable effect on the physico-chemical properties of the soybean oil samples.

RESULTS AND DISCUSSION

The results of the physico-chemical characteristics of soybean oil are shown in Table 1. The results for all of the parameters studied showed that the values obtained for the samples before x-ray irradiation were consistent with those of other researchers [8, 9].

When the oil samples were x-irradiated, the molecular bonds were broken and more ions and free radicals were expected to be produced. This effect is observed in the decrease in the pH value which makes the oil more acidic, thereby increasing the free fatty acid value [10]. The report of Anwar et al. [11] who were looking at the assessment of oxidative deterioration of soybean oil at ambient and sunlight storage showed an increase in the free fatty acid value which indicates that the fatty acid has become saturated as the iodine value showed a decrease from the value of 138 to 120.

Low iodine value oils are more saturated with fewer double-bonds therefore have higher cetane values and are more efficient fuels than high iodine value oils, but they also have higher melting points and are usually solid at room-temperature.

Table 1: Physico-Chemical Characteristics of Soybean Oil.

Sample	Parameters	Values Before x-ray radiation	Values after x-ray radiation
1	Density	0.922	.916
2	Refractive index	1.425	1.422
3	Iodine value	138	120
4	pH value	5.1	4.9
5	Viscosity	38.9mPa.s	36.6mPa.s
6	Free fatty acid value	140g/kg	219g/kg

Biodiesel made from low iodine value oils also has a higher melting point and might only be suitable for use as summer fuel. The iodine value can be important because many Biodiesel fuel standards specify an upper limit for fuel that meets the specification. For example, Europe's EN 14214 specification allows a maximum of 120 for the iodine number, Germany's DIN 51606 tops out at 115. The USA ASTM D6751 does not specify an iodine value. It might be noted that the European and German specifications result in a *defacto* ban on Soy based biodiesel.

The iodine value does not necessarily make the best measurement for stability as it does not take into account the positions of the double bonds available for oxidation. In some cases, this can lead to iodine values that are misleading [12].

The modification of the iodine value in this work has shown that x-irradiation of the soybean oil has actually lead to a decrease in the iodine value therefore making it more usable as a biofuel. On the other hand, its use as a lubricant is based on introducing thickeners to hold the unsaturated fatty acid together [13].

CONCLUSION

The use of x-rays to irradiate soybean has shown that there are significant changes in the physico-chemical properties of the oil. The modification of oil properties due to these changes has resulted in the increased probability of the application of the soybean oil as a biofuel and grease.
It must be however pointed out that the use of x-ray on soybean oil renders it un-edible as it changes the free fatty acid value.

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