BIOdiesel Tech NOTES

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MOISTURE ABSORPTION IN BIODIESEL

Biodiesel has the ability to absorb more moisture than fossil diesel. The amount, approximately 1500 ppm, is still quite small. However, even this small amount could cause problems in handling, transportation, and storage.

There are two likely places this moisture can come from: the final washing stage during the manufacturing process or the absorption of moisture and contaminants during storage. Condensation and precipitation may occur if the moisture content in biodiesel moves beyond its saturation point as its storage temperature decreases. Microbial growth, storage container corrosion, and fuel contamination are examples of the consequences of high fuel moisture content. However, there is a lack of information on moisture absorbency in biodiesel and/or biodiesel-diesel blends, which is essential to biodiesel producers, distributors, and consumers.

The objective of this study is to explore the water absorbency and moisture saturation levels of different biodiesel fuels and biodiesel/diesel fuel blends.

MATERIALS AND METHODS

The biodiesel used was prepared from three different vegetable oils (soybean, canola and mustard) and two primary alcohols (methanol and ethanol). The initial moisture contents and all subsequent moisture contents of biodiesel were measured with an automatic Karl Fisher Coulometer. The equilibrium (saturation) moisture contents of the biodiesel samples were determined at three separate temperatures by contacting the biodiesel samples with an excess of water. Each sample was made in triplicate and placed in controlled temperatures of 4°C, 21°C (ambient temperature), and 35°C for thirteen days before being analyzed.

Samples of #2 petroleum diesel (D2) were used as references under the same conditions. The moisture content of biodiesel and petrodiesel blends were measured using a similar procedure. Blends of 20, 50, and 80% (by volume) biodiesel with D2 were prepared from saturated biodiesel and D2 samples. The dynamic moisture absorption of each type of biodiesel and D2 was measured in controlled humidity environments at the ambient temperature of 20°C to 22°C.

RESULTS AND DISCUSSION

Saturation Moisture in Biodiesel (B100)

Results at the three temperatures clearly showed that the capacity for moisture absorbency of the six types of biodiesel and petrodiesel increased as the temperature increased. Careful observations also revealed that the saturation moisture content levels were similar for the biodiesels made from different vegetable oils and alcohols.

Statistical analysis showed that there were no significant differences between the saturated moisture content data for methyl and ethyl esters at the given temperatures. Therefore, it was decided to represent the saturation moisture content data of biodiesel from different origins as one fuel. Over the temperature range of 4°C to 35°C, the saturation moisture level ranged from 1,000 to 1,700 ppm (0.10% to 0.17%) for biodiesel and from 40 to 117 ppm for #2 diesel fuel. For this temperature range the increase in moisture absorption as the temperature increased was 22.2 ppm/°C for biodiesel, which is more than 9 times higher than that of petrodiesel (2.4 ppm/°C). This shows that biodiesel, due to its unique oxygen-containing chemical structure of carboxyl groups, has a stronger tendency to absorb moisture.

SATURATION MOISTURE IN BIODIESEL/DIESEL BLENDS

One question raised regarding the moisture content in biodiesel/petrodiesel blends was: can water precipitate when saturated biodiesel is blended with petrodiesel? To answer this question, experiments were performed to evaluate the effects of three parameters (vegetable oil type, temperature, and level of blending) in two groups (methyl esters and ethyl esters) following a central composite design.

Sixteen experiments for each group were conducted. Measurements were conducted in triplicate and the averages were calculated. The predicted moisture content based on the contributions from the saturated biodiesel and petro-diesel blends are compared with the actual measured data in Figure 1.

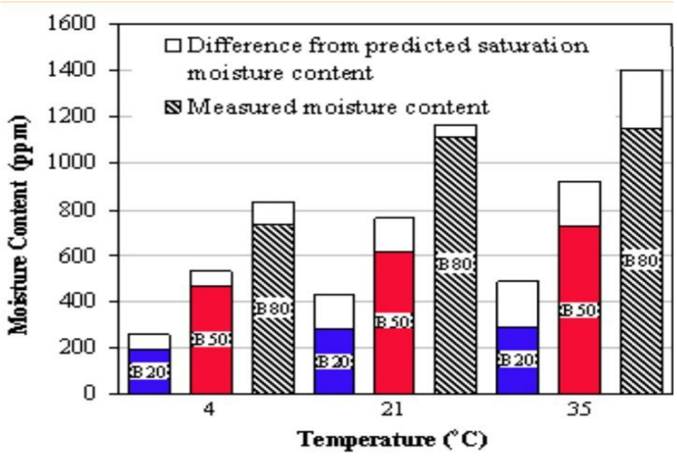

FIGURE 1. COMPARISON OF THE MEASURED MOISTURE CONTENT (LOWER SECTIONS) VS. DIFFERENCE FROM PREDICTED MOISTURE CONTENT.

It is evident that the predictions are always higher than the measured results. It was also observed that the moisture holding power of the biodiesel rapidly diminishes if the temperature drops. Saturated biodiesel samples at 35°C were put in a 4°C environment. After 24 hours, the moisture content in the samples decreased by 60%. There were no significant additional moisture content decreases even when the observations were extended to 240 h (Figure 2). The consequence of such a moisture content change as the temperature changes would be water precipitation in the storage vessels.

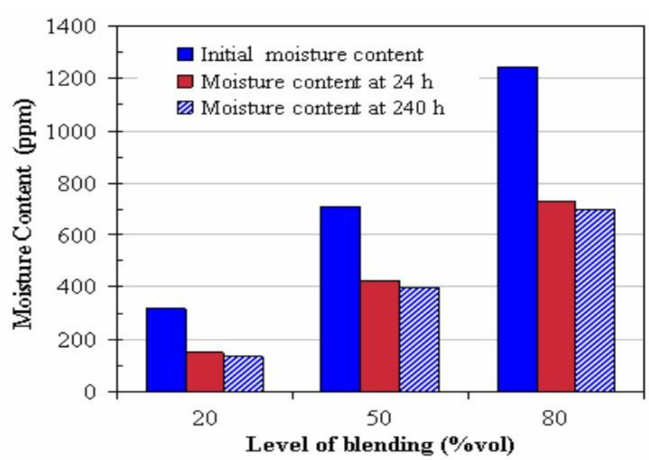

FIGURE 2. CHANGE OF SATURATE MOISTURE CONTENT IN BIODIESEL AFTER BEING COOLED FROM 35° TO 4 °C.

DYNAMIC MOISTURE ABSORPTION

The rate of moisture absorption was found to be very rapid when a biodiesel sample was exposed to ambient air. To quantify the rate of moisture absorption, biodiesel samples and a petrodiesel reference were put in desiccators of constant relative humidities at room temperature. The desiccators contained the saturated chemical solutions of CaCl2· 6H2O, NaON2, and Na2HPO4 ·10H2O, respectively.

Figure 3 is the summary of moisture content measurements at the three constant relative humidity conditions, in which the errors bars are the standard deviations. It was found that the moisture content of the biodiesel samples quickly increased when exposed to the constant relative humidity environments. After, 24 hours, the moisture content in the biodiesel samples reached their corresponding equilibria and leveled off. This is a strong indicator absorption into biodiesel is a rapid process.

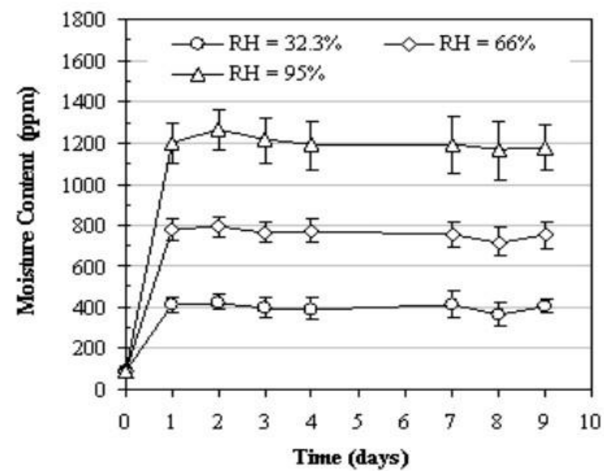

FIGURE 3. MOISTURE ABSORPTION THAT MOISTURE OF BIODIESEL AT CONSTANT RELATIVE HUMIDITIES.

CONCLUSIONS

Experimental results have shown that there were no significant differences in moisture absorbency for the biodiesel of different types at given temperatures, regardless of the origins of the vegetable oils or alcohols. As a clear contrast, biodiesel absorbed 1,000 to 1,700 ppm (or 0.1% to 0.17%) moisture from 4° to 35°C, which was 15 to 25 times higher than that of petrodiesel at the same temperatures. As the temperature increased, biodiesel had a 22.2 ppm/°C increase in moisture absorbing rate which is more than 9 times higher than that of petrodiesel with only 2.4 ppm/°C. This indicates that moisture may be absorbed by biodiesel at high temperature and then water could precipitate out as the temperature drops.

The results also showed that in biodiesel and petrodiesel blends, both the temperature and the level of blending affected the moisture absorbance. The moisture content of the blends was not a simple addition of the two moisture contents of biodiesel and petrodiesel. Blending created a mixture with a decreased tendency for moisture absorption, which can lead to water precipitating to the bottom of the storage container. Moisture absorption into biodiesel and its petrodiesel blends is a fast process. The moisture content in biodiesel reached equilibrium level under a constant relative humidity within 24 hours.