The impact of blending techniques, feedstock choice, and analytical techniques on biodiesel blend accuracy

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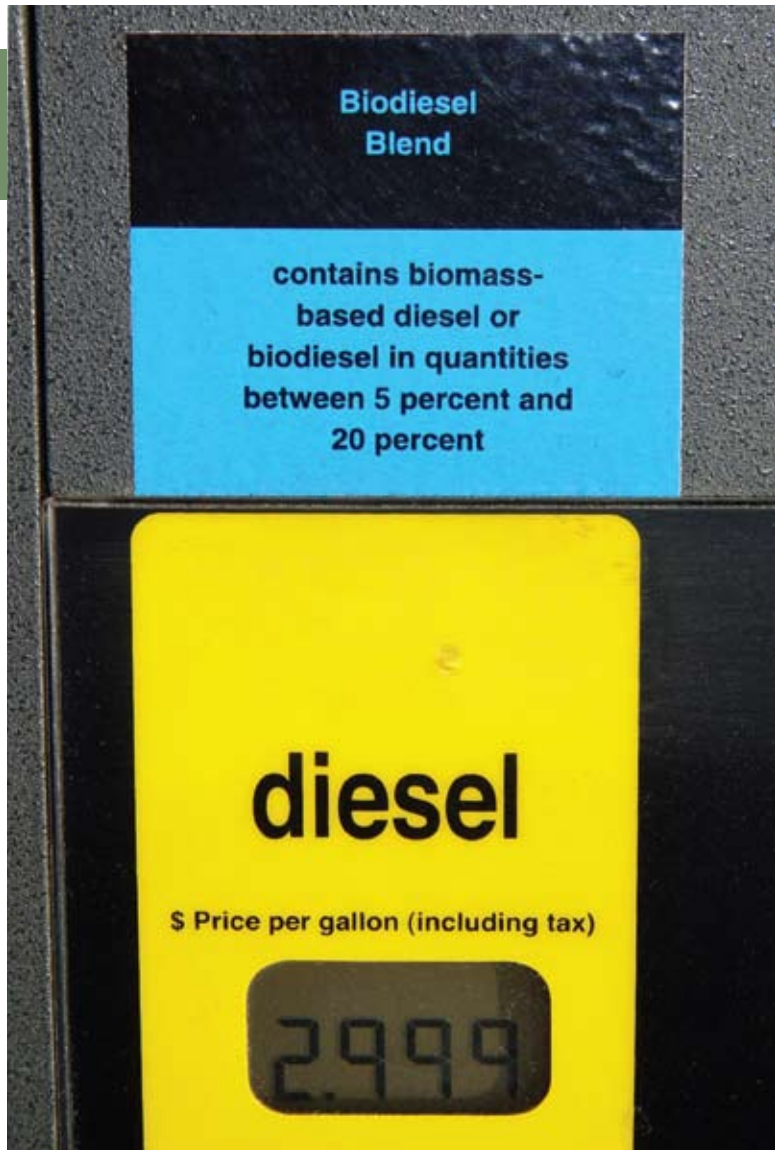
Dylan Wilks

The National Renewable Energy Laboratory in Golden, Colorado, USA, conducted a nationwide study released in 2005 that compared the actual content of biodiesel in biodiesel/petroleum diesel blends vs. the nominal content. Results showed that 36% of the samples were incorrectly labeled. Inaccurately blended biofuels can have a negative impact throughout the supply chain, affecting distributors, regulators, and the end consumer, in addition to giving the biodiesel industry a bad name. Although much interest has been directed toward ensuring biodiesel meets quality standards, not much attention has been paid to biodiesel blend accuracy. Blended fuel is emerging as an area of concern as biodiesel enters mainstream fuel supplies.

Incorrectly blended fuel can result in engine problems and warranty issues and also 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.

Biodiesel has been blended with diesel for many years; however, recent consumer demand coupled with government tax incentives and environmental pressures has resulted in a dramatic increase in production volume. The majority of blends found in the United States are B5 (5% biodiesel, 95% diesel) and B20. Recently the ASTM specification for diesel fuel, D 975, has been modified to include up to a 5% blend of biodiesel (see *inform 19*:545–546, 2008). An ASTM specification for B6–B20 is also being drafted.

Before analyzing the issues that impact biodiesel blend accuracy, the question "Why is an accurate blend important?" must first be answered. Table 1 examines potential problems with a fuel blend that is higher or lower than specified and clearly shows why a correct blend is important.



A sticker found on a gas station's diesel pump giving information related to the biodiesel's blend. Wilks suggests that this sticker could be more informative if biodiesel blends were tested more often.

The method used to blend the fuel is the most important factor contributing to blend accuracy. The two major blending techniques used are *splash blending* and *in-line (injection) blending*. Currently, the most widely implemented technique is splash blending. This blending process involves adding biodiesel to a

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TABLE 1. Potential problems with out-of-specification blends

Blend is below specification	Blend is above specification
Customer does not get the fuel paid for (biodiesel is considered a premium fuel).	Cloud point can be reached, clogging fuel filters and stopping engines.
Manufacturer could lose biodiesel tax incentive money.	Engine warranties may be invalidated.
Engine emissions may be higher than expected.	Cold weather performance may be decreased.
Tax rebates may not be correctly applied, resulting in a loss of tax revenue.	Other possible engine problems (gasket damage, sludge buildup, oil dilution, etc.) can occur.

fuel truck that is partially filled with diesel fuel. The blending occurs as the truck drives and the fuel splashes around in the tank. Unfortunately, in many cases, the truck does not drive far enough for the two fuels to blend uniformly. In addition, environmental factors such as temperature and humidity can affect the speed at which the fuels blend.

A recent analysis, carried out jointly by Wilks Enterprise, Inc. (South Norwalk, Connecticut, USA) and Pacific Biodiesel (Santa Cruz, California, USA), on a fuel truck using the splash-blending technique that supposedly had a B20 blend, showed approximately 12% biodiesel at the top of the tank, and 24% at the bottom. Clearly this is not an ideal biodiesel blending method; however, with little biodiesel infrastructure in place, this method is the cheapest and easiest blend method for a fuel distributor to use.

The best way to ensure that the fuel is correctly blended regardless of blending technique is to test the fuel along the supply chain. The assumption that a tank containing 200 gallons of biodiesel and 800 gallons of diesel will be B20 must be replaced by proper blend analysis in order to integrate biodiesel successfully into fuel supplies.

A second, more accurate blending method is in-line blending. This type of blending occurs at a fuel rack, where dedicated blending equipment delivers a metered amount of fuel into a waiting truck. Ethanol and other fuel additives are commonly blended using this method. With in-line blending, the correct ratio of biodiesel is metered with automated control valves into the diesel fuel before it is dispensed into a truck. Since the resulting fuel is blended prior to entering the truck, the mixing problem associated with splash blending is eliminated.

Although in-line blending offers a more accurate blending method than splash blending, any mechanical system is subject to wear and/or failures. The need to test the biodiesel blend ratio after final mixing is necessary regardless of the blending method. An accurate method to determine the biodiesel blend is just as important as an accurate blending method.

Infrared (IR) spectroscopic analysis is currently the most popular method for measuring biodiesel blend composition owing to its short analysis time and accuracy. Both the EN 14078 method and the recently passed ASTM D 7371 method specify mid-IR for the measurement of the biodiesel blend ratio. Both methods call for an FTIR (Fourier transform IR) spectrometer for the analysis. Whereas FTIR spectrometers are excellent laboratory analyzers, their cost, size, and delicate parts make them difficult to bring to the field.

In cases where on-site analysis is required, portable analyzers as shown in Figure 1 are capable of rapid blend analysis. Most portable analyzers use fixed filters that measure IR light specific to biodiesel, thus eliminating any moving parts and reducing instrument size. Portable instruments provide the easy and fast on-site analysis required by regulatory agencies, blenders, and fleet managers. The data they can provide are comparable in accuracy with accepted laboratory methods.

One factor that has recently become an issue for biodiesel blend determination is that of the feedstock used to make the biodiesel. As concern over food versus fuel increases, less biodiesel will be created using the typical feedstocks of soybean and rapeseed oils and more will be created from waste products or nonfood feedstocks. Since feedstocks can vary significantly in chemical makeup, the resulting biodiesel may also vary.

The key difference between feedstock varieties is the range of their component molecular weights. Oils with lower molecular weights will have a larger number of molecules for a given sample



FIG. 1. *Portable biodiesel blend analyzer.*

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weight. Since the IR methods essentially measure the number of molecules, a lower molecular weight sample will provide a larger signal. In the case of biodiesel blends, this means that biodiesel with lower molecular weight will return a higher blend percentage than actually present if the analyzer has been calibrated with a higher molecular weight biodiesel. Table 2 illustrates that in most cases, this problem is not significant. In the case of coconut oil, however, the molecular weight is significantly lower and therefore the resulting blend will read higher than the actual fuel blend unless an instrument is calibrated specifically for this feedstock. Coconut biodiesel is extremely rare in the United States and is not used extensively worldwide.

Another issue with lower molecular weight biodiesels is their higher cloud points. Because fuel that has reached its cloud point will clog fuel filters, high blend percentages or biodiesel made from low molecular weight feedstocks cannot be used in colder climates. Understanding the climate to which engines will be subjected and the feedstocks available will allow a distributor to determine the optimal blend ratio to deliver to customers. In many cases the optimal blend will change depending on the season.

Ensuring a correct blend is an important part of ensuring a biodiesel-blended fuel performs at its best. Clearly the blending technique plays a significant role in how accurate the blend is. As biodiesel becomes more integrated into the fuel supply, it will increasingly be blended using the in-line methods, eliminating most blending problems.

TABLE 2. Effect of feedstock on B20 blend determination

Feedstock	B20 result (%)	Feedstock	B20 result (%)
Soybean oil	20.4	Animal fat	20.5
Yellow grease	20.1	Coconut oil	26.3
Palm oil	20.5	Rapeseed oil	20.4

In the meantime, ensuring that distributors understand the caveats of splash blending will help to improve the blend accuracy. As blending techniques often are unknown once the fuel has been blended, the best way to ensure that the fuel is correctly blended regardless of blending technique is to test the fuel along the supply chain. The assumption that a tank containing 200 gallons of biodiesel and 800 gallons of diesel will be B20 must be replaced by proper blend analysis in order to integrate biodiesel successfully into fuel supplies.



Dylan Wilks is product development engineer for Wilks Enterprise, Inc., which is headquartered in South Norwalk, Connecticut, USA. He may be contacted by telephone at +1-831-338-7459 or by e-mail at dwilks@wilksir.com.



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