Mid-Infrared Fuel Analysis

A new technology allows blenders to accurately analyze biodiesel blends. Designed for laboratory or field use, Cetane 2000 provides important diesel fuel quality information wherever it is needed.

By Dr. G. Patrick Ritz and Dr. Michael Croudace

It is now possible to determine the volume of biodesel and the renewable fuel's precursor fatty oils simultaneously through infrared (IR) analysis to an accuracy of 0.1 volume percent. This, along with ascertaining the fuel's cetane number, its cetane improver volume and its density is made possible by advanced spectroscopy.

In the United States, most biodiesel blends are produced accurately, but in rare cases, B2 has been found to contain both lower and higher percentages of biodiesel. The introduction of PetroSpec's Cetane 2000 now allows distributors to verify the precise volume of biodiesel in diesel/biodiesel blends.

The technology also allows distributors to determine the fuel's cetane number. Most diesel customers currently use a "cetane index" (a mathematical model using distillation and density as a correlation to the cetane number) instead of a cetane number to evaluate their fuel's combustion quality. However, because biodiesel dramatically changes the distillation qualities of the blended diesel fuel, the current cetane index equation is unusable for the estimation of a cetane number. Therefore, the blender is forced to use "cetane engines" or correlative cetane methods and analytical instruments such as the Cetane 2000.

The Cetane 2000 analytical instrument is the result of a two-year co-development project between BP, Shell and PetroSpec. Cetane 2000 is the first analytical tool that includes analyses for density, cetane number and cetane index plus cetane improver, total aromatics, polynuclear aromatic and biodiesel content in the same portable instrument.

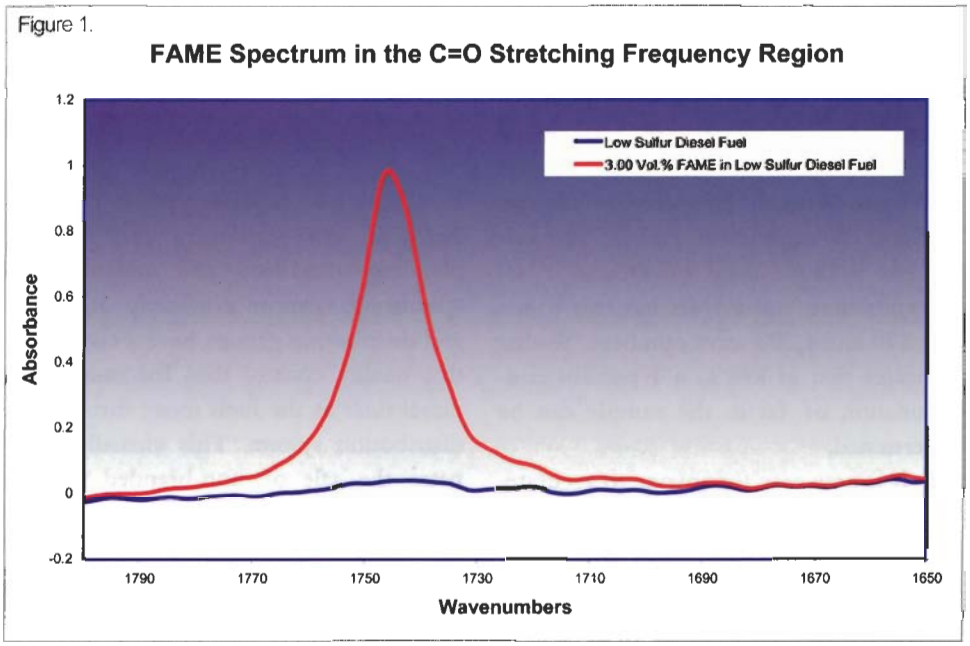
Cetane 2000 is an analytical method that utilizes this diesel fuel analyzer.

In an effort to produce a cost effective and accurate instrument that would allow BP and Shell to monitor diesel quality worldwide, BP and Shell Research approached PetroSpec with an idea for determining cetane numbers through the detailed analysis of mid- and near-infrared spectra. Hundreds of fuels were provided to produce a European calibration set in which each of the diesel samples included a minimum of three independent cetane engine ratings. Many samples were rated by 17 independent laboratories. The cetane number was the average of the multi-rated results, optimizing the chance of an accurate cetane number. The Ethyl Corporation calibration set included over 600 samples from all over the United States with varying amounts of cetane improver. The correlation between the measured cetane number and the spectral data obtained using Cetane 2000 is outstanding.

How does mid-IR detect the biodiesel?

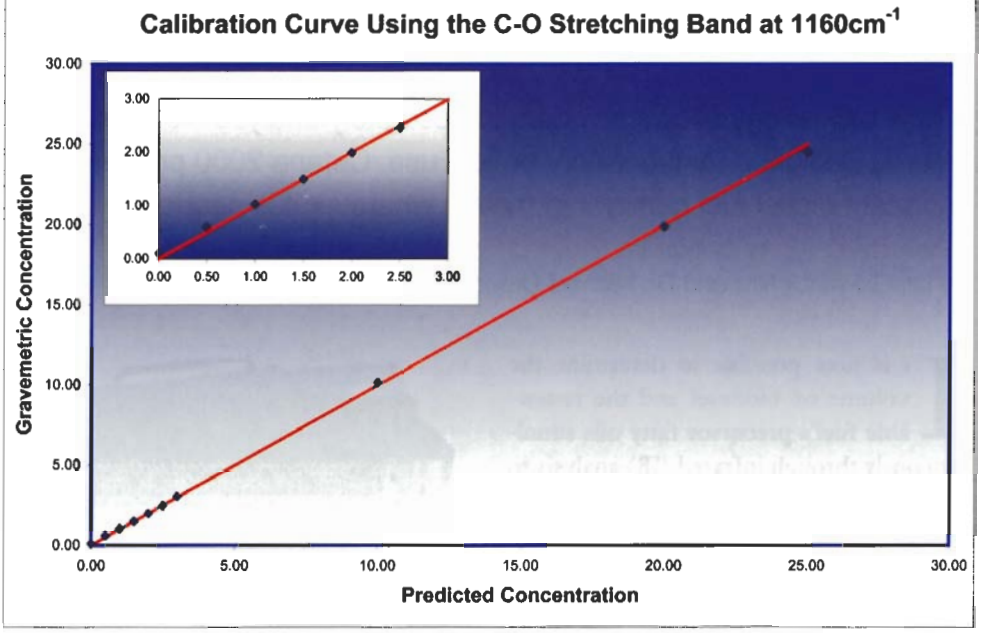
In the mid-IR spectral range, there are two spectral positions that uniquely identify biodiesel in diesel fuel. The level of absorbency (large or medium) is a function of spectral positioning (see Figure 1).

Figure 1.



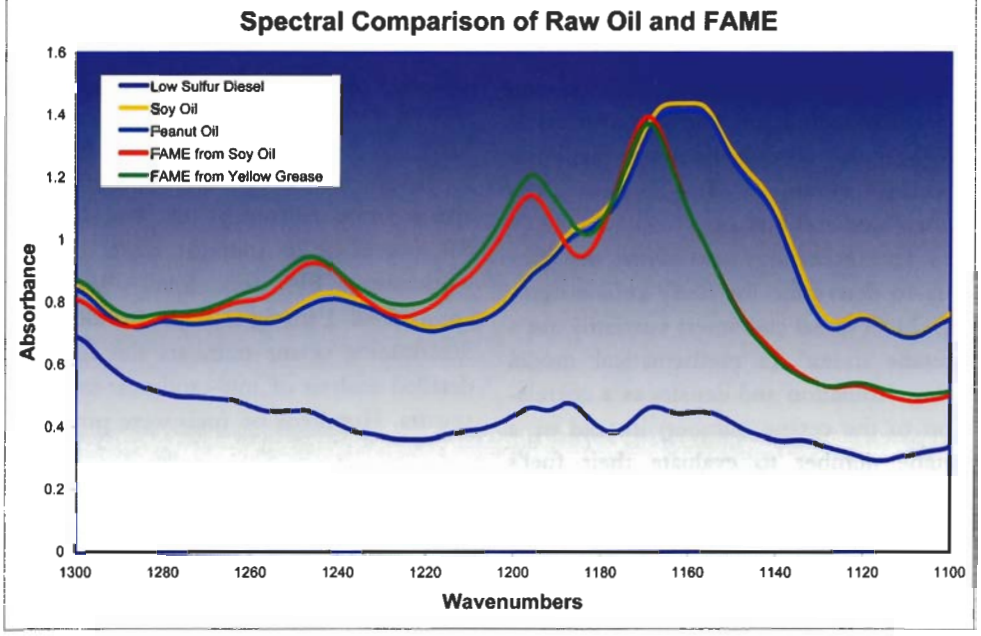
The absorbencies in the mid-IR region for biodiesel, being unique, are separated from other component absorbencies in the fuel. The absorption of light is directly proportional to the quantity of biodiesel. Thus, by using a gravimetrically-produced calibration set of biodiesel in diesel, the amount of biodiesel in the fuel can be quantified. This spectroscopic separation allows for the characterization and quantification of biodiesel in much the same way as the physical separation that is produced on a gas chromatograph. The accuracy of this method is exceptional (see Figure 2). Over the range, the instrument has been calibrated, (0 percent to 30 percent biodiesel) the standard error for the calibration is 0.09 percent.

Figure 2.



Another question that has been asked of this method is do the results vary with different types of biodiesels made from different types of oils? An experiment was performed to show that ester concentration predictions do not vary with biodiesel produced from different sources. As expected, all fatty acid methyl esters gave similar concentration results. All fatty acid methyl esters have very similar molecular weights being produced with fats that average 18 carbons in length.

Figure 3.



Finally, this analysis can distinguish between the methyl ester fatty acid (biodiesel) and the raw fat, which is an ester of trigylcol. Figure 3 shows the infrared spectrum between 1,000-1,300 wavenumbers for two raw fats (canola and peanut oil) and two FAME samples (methyl derivatives of lard and yellow grease). It is clear that there is a significant difference between the spectra of the raw fats and the samples of FAME. The raw fat has a single band of around 1,160 wavenumbers, and FAME has two bands at 1,170 and 1,200 wave numbers. Testing indicates that as low as a 1 percent contamination of fat in the sample can be determined.

It is now easy for anyone to accurately analyze biodiesel blends. Designed for laboratory or field use, Cetane 2000 quickly provides important diesel fuel quality information wherever it is needed. Refiners and regulators can monitor blending operations and measure final specifications more efficiently. Marketers and distribution groups have a cost-effective quality control tool for monitoring diesel fuels as the fuels move through the distribution system. This virtually eliminates the sale of non-branded product throughout the distribution system and the liability of selling product that is off specification. ■

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