NREL Highlights RESEARCH & DEVELOPMENT

Low-Temperature Biodiesel Research Reveals Potential Key to Successful Blend Performance

Relatively low-cost solutions could improve reliability while making biodiesel blends an affordable option.

While biodiesel has very low production costs and the potential to displace up to 10% of petroleum diesel, until now, issues with cold weather performance have prevented biodiesel blends from being widely adopted. Some biodiesel blends have exhibited unexplained low-temperature performance problems even at blend levels as low as 2% by volume.

The most common low-temperature performance issue is vehicle stalling caused by fuel filter clogging, which prevents fuel from reaching the engine. Research at the National Renewable Energy Laboratory (NREL) reveals the properties responsible for these problems, clearing a path for the development of solutions and expanded use of energy-conserving and low-emissions alternative fuel.

NREL researchers set out to study the unpredictable nature of biodiesel crystallization, the condition that impedes the flow of fuel in cold weather. Their research revealed for the first time that saturated monoglyceride impurities common to the biodiesel manufacturing process create crystals that can cause fuel filter clogging and other problems when cooling at slow rates.

Biodiesel low-temperature operational problems are commonly referred to as "precipitates above the cloud point (CP)." NREL's Advanced Biofuels team spiked distilled soy and animal fat-derived B100, as well as B20, B10, and B5 biodiesel blends with three saturated monoglycerides (SMGs) at concentration levels comparable to those of real-world fuels. Above a threshold or eutectic concentration, the SMGs (monomyristin, monopalmitin, and monostearin) were shown to significantly raise the biodiesel CP, and had an even greater impact on the final melting temperature.

Researchers discovered that upon cooling, monoglyceride initially precipitates as a metastable crystal, but it transforms over time or upon slight heating into a more stable crystal with a much lower solubility and higher melting temperature—and with increased potential to cause vehicle performance issues. This explains why fuel-filter clogging typically occurs over the course of long, repeated diurnal cooling cycles. The elevated final melting points mean that restarting vehicles with clogged filters can be difficult even after ambient temperatures have warmed to well above CP.

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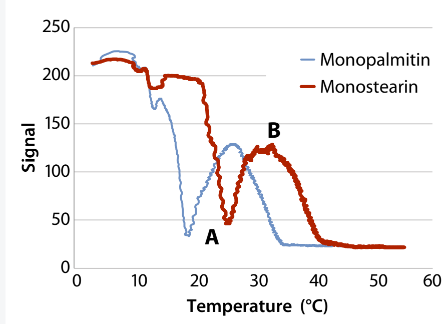
Reference: Chupka, G.M., Yanowitz, J., Chiu, G., Alleman, T.A., McCormick, R.L. (2011). "Effect of Saturated Monoglyceride Polymorphism on Low-Temperature Performance of Biodiesel." *Energy & Fuels* 25 (1) 398–405.



0.6% monostearin and 0.6% monopalmitin in tallow B100. *The size and shape of the crystals change as the temperature is raised. These changes take place concurrently in the regions marked A and B.*

Key Research Results

Achievement

By examining how biodiesel impurities affect filtration and crystallization during warming and cooling cycles, NREL researchers uncovered an explanation for poor biodiesel performance at low temperatures.

Key Result

The observation of a eutectic point, or a concentration below which SMGs have no effect, indicates that SMGs do not have to be completely removed from biodiesel to solve low-temperature performance problems.

Potential Impact

Biodiesel is a critical element in the overall strategy to reduce transportation-related petroleum use and greenhouse gas emissions. This discovery means that biodiesel producers will not need to rely on expensive vacuum distillation operations, but can instead use much less expensive process modifications, reducing manufacturer and consumer costs.

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