Green diesel for the road ahead

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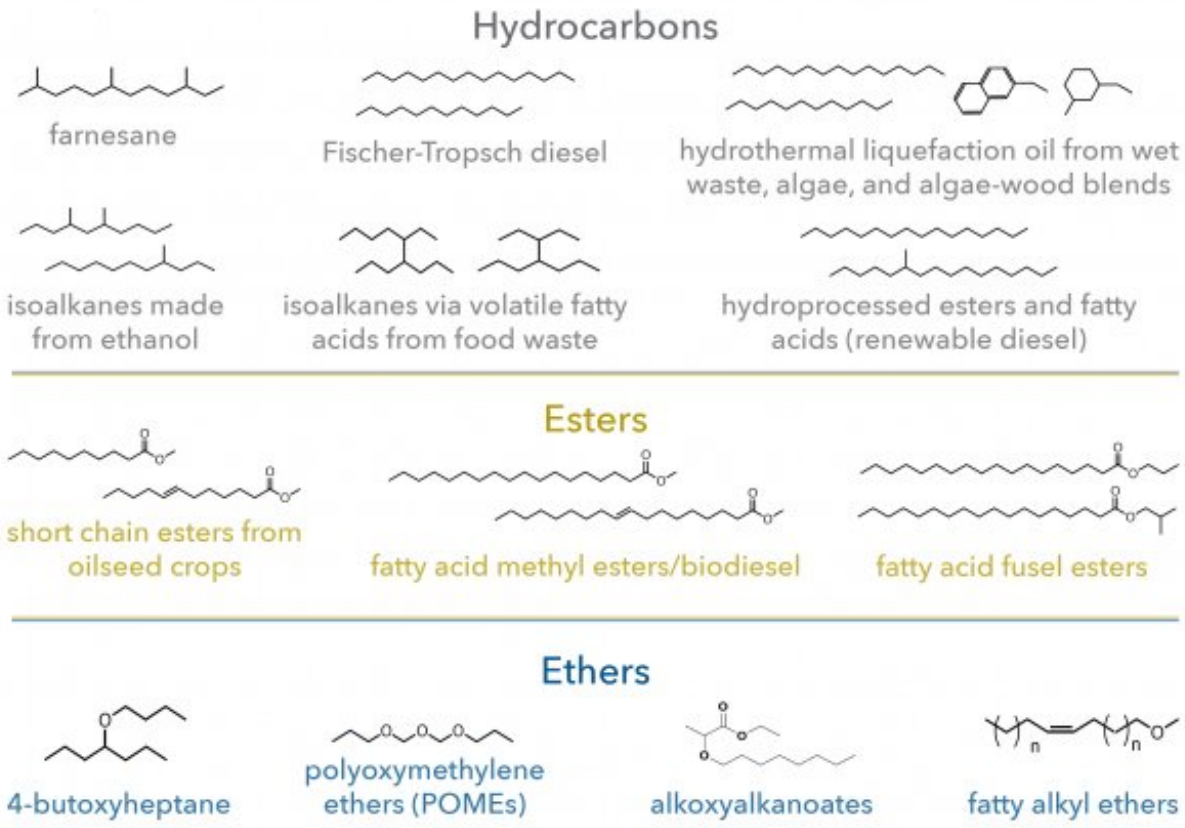

The 13 top-performing blendstocks with the potential to reduce criteria and GHG emissions comprise 6 hydrocarbons, 3 esters, and 4 ethers. Credit: Dan Gaspar, Pacific Northwest National Laboratory

Diesel engines far outpace gasoline engines when it comes to miles-per-gallon for freight-hauling heavy-duty trucks. And thanks to advances in

technology, today's diesel engines emit far lower levels of pollutants, including soot and nitrogen oxides (NO_x), than they used to.

Because heavy-duty trucks are harder to electrify than passenger vehicles, further reducing emissions—including greenhouse gases (GHGs)—from diesel engines will help improve air quality and the carbon intensity of medium- and heavy-duty transportation.

A new report from the U.S. Department of Energy (DOE) Co-Optima initiative identifies the top 13 diesel fuel blendstocks from biomass resources that could reduce harmful emissions from medium- to heavy-duty diesel vehicles. The top 13 blendstocks include hydrocarbons, esters, and ethers that have the potential to reduce GHG emissions by at least 60% and be produced at a competitive cost.

The blendstocks could also make the emissions control system simpler and less expensive to operate. Together, the improvements could translate to lower costs for industry and consumers.

"Lower engine-out emissions can be cheaper to operate and potentially a little more efficient, and using blendstocks made from biomass and waste means lower well-to-wheels GHG emissions," said Dan Gaspar, a bioenergy researcher at Pacific Northwest National Laboratory (PNNL) and lead author of the report.

Co-Optima stands for Co-Optimization of Fuels & Engines and is a collaboration among multiple DOE national laboratories, universities, and industry to accelerate the development of affordable, scalable, and sustainable biofuels along with high-efficiency, low-emission vehicle engines. The work is sponsored by DOE's Vehicle Technologies Office and Bioenergy Technologies Office.

Analyzing the alternatives

Gaspar, who leads the Co-Optima initiative, coordinated development of the report, merging contributions from more than three dozen researchers from nine national laboratories, including PNNL. The team focused on blendstocks to improve cold-weather operability, ensure good combustion performance, reduce GHG emissions, and reduce soot.

Soot and NO_x are two criteria emissions regulated by the U.S. Environmental Protection Agency. Along with minor engine operation adjustments, reducing soot produced in the engine can also decrease production of NO_x.

To determine their top 13 blendstocks, the researchers first conducted modeling, small-scale experiments, and single-cylinder testing to establish target values of key fuel properties for reducing soot production and improving engine operability. These properties include the cetane number—a measure of how quickly fuel ignites; the propensity to generate soot related to criteria emissions; cold- weather operations—a key limitation of current biodiesel mixtures; and energy density—more energy per gallon means less volume needed.

Researchers then used computational and experimental methods to screen thousands of blendstocks against the target values to determine which of them had the greatest potential to improve performance and reduce emissions. To evaluate the potential of different classes of molecules to reduce soot and NO_x, the team conducted tests in single-cylinder engines, including conventional and a new type of engine called ducted fuel injection. Next, the team conducted technoeconomic and life cycle analyses on the most promising candidates to evaluate their market potential, scalability, and sustainability.

The results provide a solid scientific basis for exploring larger-scale production of the most promising blendstocks for testing in multicylinder engines.

More information: Daniel Gaspar et al, Top 13 Blendstocks Derived from Biomass for Mixing-Controlled Compression-Ignition (Diesel) Engines: Bioblendstocks with Potential for Decreased Emissions and Improved Operability, (2021). DOI: 10.2172/1806564

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