The Development of Surrogate Fuel Mixtures for Bio-Based and Petroleum-Based Fuels Using Thermophysical Property Measurements

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The chemical composition of bio-based and petroleum-based fuels influences their physical and chemical properties and how they combust in diesel engines. Some fuels are composed of complex mixtures, while other fuels contain only a few hydrocarbon components. One approach to develop an improved understanding of the diesel engine combustion process is to link thermophysical properties to the combustion process using both the complex fuel mixtures and representative mixtures prepared with fewer well-defined and characterized components, which are called surrogate mixtures. In our work we have successfully used density, viscosity, speed of sound, bulk modulus, surface tension, flash point, and compositional information determined by gas chromatography/mass spectrometry to develop surrogate mixtures for hydroprocessed esters and fatty acid (HEFA) fuel from algae, alcohol-to-jet synthetic paraffinic kerosene (ATJ-SPK) derived from isobutanol, hydrodepolymerized cellulose-based fuels, and catalytic hydrothermal conversion fuels. During the surrogate development process, we have found interesting trends in thermophysical property behavior for binary and ternary mixtures. Some of the mixtures we have tested have viscosity, speed of sound, and bulk modulus values that are below those of the individual components. Results will be presented for both binary and ternary surrogate mixtures. Furthermore, the results of combustion experiments will be presented that provide validation for the use of thermophysical properties to design surrogate mixtures for bio-based fuels.