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Microfluidics applied to the study of the formation of insoluble hydrocarbons for automobile fuels and biofuels.

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The oxidation of fuels and biofuels is a major concern to the transport industry. Failure of engine or components can be caused by the formation of insoluble deposits. To prevent this kind of issues, we develop a system able to detect early oxidation of fuels using a microfluidic system. Actual fuels are complex mixtures of hundreds of chemical components from multiple chemical classes. The fuels and biofuels degradation generate other hundreds of oxidation products which can modify the physical chemical properties of the fuels. The main challenge is to identify these products and/or physical chemical changes early in the process to prevent insoluble issues. A microfluidic system compatible with fuels and biofuels flow has been developed in order to identify the different levels of oxidation. The approach presented here is to study a simpler fuel representative of a real fuel, made of a small number of pure chemical compounds, called a surrogate fuel. In this study, seven different components have been investigated: ethanol, ETBE, fatty acid methyl ester, iso-dodecane, n-dodecane, toluene, methyl cyclohexane as well as their blends. An autoclave was used to perform an intense controlled accelerated oxidation. Then, the main oxidized compounds have been identified by GC-MS in these different mixtures. In order to find tracers to follow fuel degradation, infrared (see Figure 1), fluorescence and UV-visible spectroscopies have been investigated. Viscosity, density, refractive index and heat capacity of surrogates have also been measured. Depending on the composition of the established surrogates, changes on these physicochemical and optical properties were significant enough to be easily detected, before and after the oxidation step. This innovative approach using a microfluidic system should improve the online detection of the oxidation of the new alternative biofuels.

Figure 1: Differential flow rates of model fuels after and before a step of artificial oxidation in a microfluidic system with an inlet pressure of 1.5 atm at 25 °C.

Recent Publications

1. Edwards T and Maurice L Q (2001) Surrogate mixtures to represent complex aviation and rocket fuels. Journal of Propulsion and Power 17:461–466.
2. Tomić M, Đurišić-Mladenović N, Mićić R, Simikić M and Savin L (2019) Effects of accelerated oxidation on the selected fuel properties and composition of biodiesel. Fuel 235:269–276.
3. Ben Amara A, Kaoubi S and Starck L (2016) Toward an optimal formulation of alternative jet fuels: Enhanced oxidation and thermal stability by the addition of cyclic molecules. Fuel 173:98–105.

Biography

Émilie Bordes is a Postdoctoral scholar at *IFP Énergies Nouvelles* since April 2018. Her research focuses on the evolution of the physicochemical properties of fuels and biofuels during oxidation process. She is currently working between two departments: Mobility and Systems and Physicochemistry of complex materials and fluids. In 2017, she graduated from the University Clermont Auvergne in the Institut de Chimie de Clermont-Ferrand. Her PhD was about the understanding of the production of carbon nanomaterials in ionic solvents. She is a Physico Chemist using molecular dynamic calculations, thermodynamics, interfacial energies and materials characterizations, for her studies.

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