JET FUELS AND BITUMEN EMULSIONS STABILIZED BY CARBOXYMETHYLATED LIGNINS: EFFECT ON COMBUSTION EFFICIENCY AND EMISSIONS

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Abstract

We summarize the results of a Sun Grant project that focused on the upgrading of technical Kraft lignins to produce carboxymethylated derivatives that were water-soluble. The obtained carboxymethylated lignins (CML) presented characteristics typical of polymeric amphiphiles and had a high calorific value. The CML was used to synthesize high-internal-phase, oil-in-water fuel emulsions. The hydrophilicity of the molecule was adjusted depending on the target pH to facilitate a tunable balance of affinities with oil and water. The CML fractions was characterized by elemental analysis, molecular weight (GPC), and degree of substitution (^{31}P NMR). Surface tension analyses confirmed the suitability of CML as far as its surface activity, which presented a pseudo-Critical Aggregation Concentration with low minimum surface tension. Salinity and pH scans of the CML were carried out in kerosene/water (1:1) systems in the presence of CML with different degrees of substitution. Kerosene, diesel, jet fuel and an ultra-high viscosity bitumen from the Canadian oil sands, were used to prepare oil-in-water fuel emulsions with varying water-to-oil ratio (WOR), from 3:7 to 7:3. The properties of the fuel emulsions were determined including drop size and distribution (particle sizing and cryo-SEM), stability, and rheological behavior. All types of emulsions presented long term stability with normal size distribution (typically diameter between 1 and 10 μm). Emulsions with shear thinning behavior enabled the high viscous fuels to be burnt in a diesel engine operated at high shear rates. Moreover, the fuel emulsions were evaluated based on combustion analyses: heating value, spray test, and exhaust gas emissions. Emulsions burned effectively and displayed a relative high HHV. Compared with based fuels and in given conditions, O/W emulsions presented better combustion efficiently, lower NO_x and CO emissions.