A PARAMETRIC STUDY SHOWING THE EFFECT OF TEMPERATURE AND HYDROCARBON SPECIES ON THE PRODUCT DISTRIBUTION FROM A NON-THERMAL PLASMA REACTOR

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In an attempt to better understand how the performance of a plasma reactor varies in actual diesel exhaust, its ability to (1) convert NO-to-NO_2 and (2) create chemically active oxygenates (e.g., acetaldehyde) was evaluated as a function of variables, such as gas temperature, hydrocarbon species, and hydrocarbon concentration. Simulated diesel exhaust conditions including O_2, CO_2, H_2O, CO, NO, and hydrocarbons were employed together with a single-cell plasma reactor in a bench system. The source of reductant species was one of nine lighter weight saturated or unsaturated hydrocarbons ranging in carbon number from 2 to 5. The gas temperature was varied between 125° C and 475° C. The resulting product distribution was then examined with an FTIR and a chemical ionization mass spectrometer (CIMS) to better clarify the role of hydrocarbon speciation in forming NO_2 and oxygenates.

In general, we find that higher hydrocarbon concentrations are essential at all gas temperatures to optimize NO-to-NO_2 formation. Unsaturated straight chain hydrocarbons appear superior at low temperatures, while saturated straight chain hydrocarbons perform better at higher temperatures. Longer chain hydrocarbons outperform shorter chain hydrocarbons at any temperature on a molar basis. A combination of saturated and unsaturated hydrocarbons can provide a broad temperature window for good NO_2 formation.

To maximize formation of oxygenates, like acetaldehyde, higher concentrations of longer chain hydrocarbons are superior. Unsaturated hydrocarbons show little temperature dependence, while saturated hydrocarbons work better at high temperatures. Some additional work was also done to examine the reactor performance as a function of NO concentration, reactor power, and space velocity. Modeling of the gas-phase chemistry in a plasma reactor supports many of these findings. Extensions of this work, using mixtures of gases present in actual exhaust, should allow for the determination of the optimal conditions at which to run a plasma reactor, depending on its application.