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### **Effects of non-thermal plasmas and electric field on hydrocarbon/air flames**

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Need to improve fuel efficiency, and reduce emission from hydrocarbon combustor in automotive and gas turbine engines have reinvigorated interest in reducing combustion instability of a lean flame. The heat generation rate in a binary reaction is  $H_Q = N^2 c_1 c_2 Q \exp(-E/RT)$ , where  $N$  is the density,  $c_1$  and  $c_2$  are mol fractions of the reactants,  $Q$  is the reaction heat release,  $E$  is the activation energy,  $R$  is the gas constant and  $T$  is the average temperature. For hydrocarbon-air reactions, the typical value of  $E/R \sim 20$ , so most heat release reactions are confined to a thin reaction sheet at  $T \geq 1400$  K. The lean flame burning condition is susceptible to combustion instability due to a critical balance between heat generation and heat loss rates, especially at high gas flow rate. Radical injection can increase flame speed by reducing the hydrocarbon oxidation reaction activation barrier and it can improve flame stability. Advances in nonequilibrium plasma generation at high pressure have prompted its application for energy efficient radical production to enhance hydrocarbon-air combustion. Dielectric barrier discharges and short pulse excited corona discharges have been used to enhance combustion stability. Direct electron impact dissociation of hydrocarbon and  $O_2$  produces radicals with lower fuel oxidation reaction activation barriers, initiating heat release reaction  $C_n H_m + O \rightleftharpoons C_n H_{m-1} + OH$  (and other similar sets of reactions with partially dissociated fuel) below the typical cross-over temperature. Also,  $N_2(A)$  produced in air discharge at a moderate  $E/n$  can dissociate  $O_2$  leading to oxidation of fuel at lower gas temperature. Low activation energy reactions are also possible by dissociation of hydrocarbon  $C_n H_m + e \rightarrow C_n H_{m-2} + H_2 + e$ , where a chain propagation reaction  $H_2 + O \rightleftharpoons OH + H$  can be initiated at lower gas temperature than possible under thermal equilibrium kinetics. Most of heat release comes from the reaction  $CO + OH \rightarrow CO_2 + H$ , nonthermal OH production seem to improve combustion stability. The effect of applied voltage in a flame below self-sustained plasma generation is known to enhance flame holding through induced turbulence. Review of recent results will be presented to show future research opportunities in quantitative measurements and modeling of hydrocarbon/air plasma enhanced combustion.