Mechanism of plasma-assisted ignition for H$_2$ and C$_1$–C$_5$ hydrocarbons

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Nonequilibrium plasma demonstrates ability to control ultra-lean, ultra-fast, low-temperature flames and appears to be an extremely promising technology for a wide range of applications, including aviation gas turbine engines, piston engines, ramjets, scramjets and detonation initiation for pulsed detonation engines. To use nonequilibrium plasma for ignition and combustion in real energetic systems, one must understand the mechanisms of plasma-assisted ignition and combustion and be able to numerically simulate the discharge and combustion processes under various conditions. Numerical simulations of the discharge processes are generally based on the solution of the Boltzmann equation for electrons and on the balanced equations for the active particles. The input data are electron-molecule cross sections and the rate constants for reactions with excited and charged particles. These data are available for simple molecules such as N$_2$, O$_2$, H$_2$, and, to a smaller extent, for simple hydrocarbons till C$_5$. A new, validated mechanism for high-temperature hydrocarbon plasma assisted combustion based on these data was built and allows to qualitatively describing plasma-assisted combustion close and above the self-ignition threshold. The principal mechanisms of plasma-assisted ignition and combustion have been established and validated for a wide range of plasma and gas parameters. These results provide a basis for improving various energy-conversion combustion systems, from automobile to aircraft engines, using nonequilibrium plasma methods.