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Combustion Characteristics of Ionized Fuels for Battery System Safety

Authors : Hyeuk Ju Ko, Eui Ju Lee

Abstract : Many electronic devices are powered by various rechargeable batteries such as lithium-ion today, but occasionally the batteries undergo thermal runaway and cause fire, explosion, and other hazards. If a battery fire should occur in an electronic device of vehicle and aircraft cabin, it is important to quickly extinguish the fire and cool the batteries to minimize safety risks. Attempts to minimize these risks have been carried out by many researchers but the number of study on the successful extinguishment is limited. Because most rechargeable batteries are operated on the ion state with electron during charge and discharge of electricity, and the reaction of this electrolyte has a big difference with normal combustion. Here, we focused on the effect of ions on reaction stability and pollutant emissions during combustion process. The other importance for understanding ionized fuel combustion could be found in high efficient and environment-friendly combustion technologies, which are used to be operated an extreme condition and hence results in unintended flame instability such as extinction and oscillation. The use of electromagnetic energy and non-equilibrium plasma is one of the way to solve the problems, but the application has been still limited because of lack of excited ion effects in the combustion process. Therefore, the understanding of ion role during combustion might be promised to the energy safety society including the battery safety. In this study, the effects of an ionized fuel on the flame stability and pollutant emissions were experimentally investigated in the hydrocarbon jet diffusion flames. The burner used in this experiment consisted of 7.5 mm diameter tube for fuel and the gaseous fuels were ionized with the ionizer (SUNJE, SPN-11). Methane (99.9% purity) and propane (commercial grade) were used as a fuel and open ambient air was used as an oxidizer. As the performance of ionizer used in the experiment was evaluated at first, ion densities of both propane and methane increased linearly with volume flow rate but the ion density of propane is slightly higher than that of methane. The results show that the overall flame stability and shape such as flame length has no significant difference even in the higher ion concentration. However, the fuel ionization affects to the pollutant emissions such as NOx and soot. NOx and CO emissions measured in post flame region decreased with increasing fuel ionization, especially at high fuel velocity, i.e. high ion density. TGA analysis and morphology of soot by TEM indicates that the fuel ionization makes soot to be matured.

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