FORMATION OF CARBON NANO-STRUCTURES IN BURNING VERY RICH METHANE MIXTURES

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Formation of condensed products in flames of gaseous mixtures is one of the most interesting scientific and practical problems in the combustion science. Studies of this process can be found in papers dealing with gas-phase combustion of organonosilicon and organophosphorous compounds and hydrocarbons. The mechanism of condensed phase formation in gaseous combustion products is extremely complicated and poorly studied. Although the number of publications on soot formation in hydrocarbon flames is enormous, no well-grounded and unique theoretical mechanism of this process is developed as yet. Combustion is one of the efficient technologies for producing nano-particles, therefore experimental study of soot formation in combustion of super-rich methane mixtures can provide information valuable for understanding the mechanism of soot nano-particles formation.

Super-rich methane-oxygen (the oxygen excess coefficient α=0.3) were burned in a constant volume reactor at elevated initial pressures and temperatures. The soot yield after combustion of such mixtures amounted to 12-16 wt% of the initial methane content in the unburned mixture. The specific soot surface is measured with the BET technique. Unexpectedly, the specific surface area turned out to be very sensitive to initial pressure. An increase in the initial mixture pressure from 15 to 40 atm increases the specific surface area from 70 to 700 m^2/g. Calculations yield an average soot particles of 5 nm for the measured specific area of 700 m^2/g under assumption that the particles are identical and spherical. The experimental specific soot surface area versus initial mixture pressure curve shows a leveling-off behavior and suggests that a further pressure increase would increase the specific soot surface area to a certain level that presumably may exceed 1000 m^2/g.

Examining the soot samples on a scanning electron microscope (IEPChPh RAS) did not permit the individual particles to be discerned and their size to be assessed. An X-Ray phase analysis of the soot sample with specific surface area of 700 m^2/g implemented in TIPS RAS showed that the particles size in the sample ranged between 1.2 and 6 nm. According analysis, the elemental carbon content in the soot amounts to 99.5%.

The effect of water vapor, syngas, hydrogen, and carbon monoxide additives on the soot yield is studied experimentally. Water vapor additives to the fuel are found to reduce the soot yield up to its complete vanishing. This suggests a method for controlling the yield of condensed products in the course of mixture combustion.

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