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Two-route formation of soot nuclei: experimental and modeling evidence

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EXPERIMENTAL DETAILS

Shock Tube

A stainless steel shock tube was used in our experiments (inner diameter of 75 mm, low-pressure section length of 3.2 m, high-pressure section length of 1.5 m) The low-pressure section was evacuated with two 2NVR5D fore pumps to a residual pressure of 10^{-2} Torr and with an NVDS100 oil diffusion pump to 10^{-3} Torr. For attaining a higher vacuum, the system was equipped with two liquid nitrogen traps. The residual pressure was monitored with a VIT2 ionization–thermocouple vacuum gage. The high-pressure section was evacuated with a 2NVR fore pump through a liquid nitrogen trap to a residual pressure of 0.1 Torr. Air leakage into the low-pressure section did not exceed 10^{-4} Torr/min. Before each experiment, the low-pressure section was purged two times with argon to be used in mixture preparation with intermediate pumping to 10^{-1} Torr. The parameters of the gas behind the incident and reflected shock waves were calculated from the initial pressure, mixture composition, and incident shock wave velocity within the theory of ideal flow in a shock tube. The velocity of the incident shock wave was measured on two bases using three pressure sensors placed in series (D1, D2, and D3). The distances between D1 and D2 was 528 mm; the distance between D2 and D3, 281 mm. The most remote sensor, D3, was positioned 40 mm from the set of optical windows in the body of the shock tube. The pressure sensors, with a sensing element 1 mm in diameter, were made from piezoceramics (lead zirconate titanate) and were coated with a protective wax layer 0.3–0.5 mm in thickness. They were mounted flush with the inner wall of the shock tube. The signals generated by the sensing elements of the pressure sensors during the passage of the shock wave were inputted into emitter followers and were then directed to G515 generating amplifiers and Ch3-33 frequency meters operating in the time measurement mode. The shock wave was generated by a spontaneous burst of one or several piled aluminum diaphragms 0.05–0.2 mm in thickness, depending on what conditions were to be established behind the incident or reflected shock wave. The diaphragms were placed in a special purpose holder between the high and low pressure sections, where they were secured with two vacuum rubber rings (one on either side) 80 mm in diameter, 5 mm in width, and 4 mm in thickness. The driver gas was helium. The diaphragms of the above specified thickness ruptured at a nearly the same driver gas pressure. For this reason, when it was necessary to vary the temperature behind the incident or reflected shock wave at an approximately constant density of the shock compressed gas, the driver gas was a helium–air mixture with a prescribed air content of up to 50%: the lower the temperature to be established behind the shock wave, the higher the percentage of air to be introduced in to the driver gas mixture.

Two-Beam Absorption–Emission Technique

This technique was used to simultaneously measure the time profiles of the soot yield and effective soot temperature behind the reflected shock wave. The relative soot yield as the ratio of the carbon atom concentration due to the soot to the total carbon atom concentration in the system—so called soot yield—is usually determined in practice.