IONIZATION BEHIND SHOCK WAVES STUDIED USING ELECTRIC PROBES WITH DIELECTRIC SURFACE

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Abstract: Chemical ionization is the process of formation of charged particles as a result of energy release in chemical reactions between neutral components during the formation of chemical bonds in a newly forming compound with a relatively low ionization potential. Chemical ionization is most often observed in the processes of combustion of hydrocarbons and their oxidation behind the shock waves. Electric probes are widely used for experimental measurement of ionization processes. In this paper, experiments were performed to record electric currents on cylindrical probes with an electrically insulated and noninsulated surface that were under a negative (-9 V) or positive (+9 V) potential. In these experiments, the displacement currents and total currents on the cylindrical probes were recorded. Simultaneously, signals of chemiluminesce from electronically excited OH^* radicals ($\lambda = 308$ nm) were recorded. The main goal of this work was to experimentally measure (i) the displacement currents on cylindrical probes that were under positive or negative potentials, (ii) the total current and displacement current on a cylindrical probe under a negative potential (-9 V) during pyrolysis and oxidation of acetylene, and (iii) confirm the time correlation between the displacement currents and signals of chemiluminescent emission from electronically excited OH^* radicals.

Keywords: chemical ionization; pyrolysis and oxidation of hydrocarbons; electric probes; displacement currents; chemiluminescent emission; electronically excited hydroxyl radicals; ignition delay time

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Figure Captions

Figure 1 Experimentally measured profiles of pressure (*1*), intensity of chemiluminescence radiation of OH^* radicals (*2*), total current (*3*), and displacement current (*4*) for the case of acetylene ($0.5\%C_2H_2 + 99.5\%$ Ar) pyrolysis for three different temperatures behind the reflected shock wave front: (*a*) $T_{50} = 1601$ K; $P_{50} = 1{,}0$ bar; (*b*) $T_{50} = 2147$ K; $P_{50} = 1{,}40$ bar; and (*c*) $T_{50} = 2587$ K; $P_{50} = 1{,}63$ bar. Electric probes, both with insulated (*3*) and conducting (*4*) surfaces, were supplied with a constant electric potential of -9 V

Figure 2 Experimentally measured profiles of pressure (*1*), intensity of chemiluminescence radiation of OH^* radicals (*2*), total current (*3*), and displacement current (*4*) for the case of acetylene ($0.5\%C_2H_2 + 2.5\%\,O_2 + 97.0\%$ Ar) oxidation for three different temperatures behind the reflected shock wave front: (*a*) $T_{50} = 1688$ K; $P_{50} = 1{,}25$ bar; (*b*) $T_{50} = 2080$ K; $P_{50} = 1{,}45$ bar; and (*c*) $T_{50} = 2575$ K; $P_{50} = 2{,}13$ bar. Electric probes, both with insulated (*3*) and conducting (*4*) surfaces, were supplied with a constant electric potential of -9 V

Figure 3 Experimentally measured profiles of displacement currents to probes with an electrically insulated surface at positive $+9$ V (*1*) and negative potential -9 V (*2*); *3* — signals of chemiluminescence radiation of electronically excited OH* radicals; and *4* — signals from sensors pressure for a mixture of $0.5\%\,C_2H_2 - 2.5\%\,O_2$–97.0% Ar behind reflected shock waves: (*a*) $M_5 = 8{,}8 \cdot 10^{-6}$ mol/cm^3; $T_5 = 2033$ K; $p_5 = 1{,}47$ bar; (*b*) $M_5 = 9{,}1 \cdot 10^{-6}$ mol/cm^3; $T_5 = 1731$ K; $p_5 = 1{,}29$ bar; (*c*) $M_5 = 8{,}9 \cdot 10^{-6}$ mol/cm^3 $T_5 = 1658$ K; $P_5 = 1{,}21$ bar; and (*d*) $M_5 = 8{,}6 \cdot 10^{-6}$ mol/cm^3; $T_5 = 1459$ K; $P_5 = 1{,}03$ bar

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