

Physics and Chemistry of Combustion at Flame Spread over Solid Fuels

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A review of the recent experimental studies and numerical simulations made by the authors and their colleagues is presented, relating to the physics and chemistry of combustion at flame spread over solid fuels. As solid fuels, polymers polymethyl metacrylate (PMMA), polyethylene (PE), and polystyrene (PS) were used, with phosphorus-containing flame retardants (FR) and without them, as well as forest fuels. The thermal structure of the diffusion flames of solid fuels was investigated with the microthermocouple technique, while the chemical structure was studied by using probing mass spectrometry. Temperature and species concentration fields have been determined for flame spread in horizontal and vertical directions along polymer slabs, as well as heat fluxes from the flame to the solid fuel, the flame spread velocities and the impact of flame retardants on these parameters. The structure of counterflow flames of polymers has been investigated. OH radicals and H atoms were first identified in the polymer flame, and their concentrations were measured by molecular-beam mass spectrometry with soft ionization by electron impact. The influence of the additives of phosphorus-containing flame retardants on the concentration profiles of H and OH in polymer flame has been studied. The data obtained have been used for developing a model of flame spread over PMMA in supposition of a one-step global reaction in flame. Comparison of the experimental results and of numerical simulation relating to the flame spread velocity has shown them to be in satisfactory agreement. Certain divergence between the experimental data and modeling relating to the profiles of O₂ and the fuel decomposition product, methyl metacrylate (MMA) can be attributed to the deficiencies of using the simple one-step mechanism of MMA oxidation in the model. The mechanism of the action of phosphorus-containing FR in reduction of polymers' flammability is discussed.

Acknowledgements

The study has been performed with partial support of the Russian Science Foundation (grant # 16-49-02017).

The authors express their gratitude to their colleagues who took part in the works: A.A. Paletsky, A.I.Karpov, M.B. Gonchikzhapov, I.E. Gerasimov, A.G. Tereshchenko, S.A. Trubachev, A.A. Shaklein, and R.K. Glaznev.