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PROCEEDINGS of III Conference of Students and Young Scientists "CHEMICAL PHYSICS AND NANOMATERIALS" dedicated to the memory of Mansurov Batyr

СБОРНИК ТРУДОВ III конференции студентов и молодых ученых «ХИМИЧЕСКАЯ ФИЗИКА И НАНОМАТЕРИАЛЫ», посвященной памяти Мансурова Батыра Зулхаирович

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THE TEMPERATURE SENSITIVITY OR THERMAL BEHAVIOR OF STOICHIOMETRIC COMPOSITIONS AND THE LINEAR VELOCITY OF COMBUSTION

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Thermal behavior of NH_4ClO_4/Mg binary pyrotechnic mixtures heated in air was investigated by thermal analysis. Effects of oxygen balance and heating rates (5, 15 and 20 $^0C\ min^{-1}$) on the TG–DSC curves of mixtures were examined. Results showed that NH_4ClO_4/Mg had two separate exothermic processes, which corresponded to ignition and afterburning reactions, respectively. Exothermic peaks were influenced by both heating rates and the NH_4ClO_4/Mg ratios. When heating rates were increased, exothermic peaks of these two processes all shifted to higher temperatures. Compared with the stoichiometric composition NH_4ClO_4/Mg (58.8/41.2), the fuel-rich mixture NH_4ClO_4/Mg (50/50) had a lower peak ignition temperature, but the exothermic peak of afterburning reactions changed little. The ignition process was suggested to comprise five step overlapping reactions. The initial mass increase of samples heated in air revealed that the first step reaction was the oxidation of Mg by air. Reactions of four other steps were inferred based on published data on similar pyrotechnic systems. That is, the incomplete solid–solid reaction between NH_4ClO_4 and Mg, the two-step decomposition of NH_4ClO_4, and the reaction of decomposition induced O_2 with Mg. Apparent activation energies of the overall ignition process, afterburning process and individual reactions belonging to ignition process indicated that the whole combustion rate of NH_4ClO_4/Mg (58.8/41.2) in air was controlled by the afterburning process, and the solid–solid reaction of NH_4ClO_4 with Mg was the controlling step in the ignition process. Fuel-rich NH_4ClO_4/Mg compositions were expected to obtain a better performance in practical applications in case of combusting in air.

Reaction kinetics of the two exothermic processes for the stoichiometric mixture was calculated using Kissinger method. Apparent activation energies for ignition and afterburning process were 153.6 and 289.5 kJ mol^{-1}, respectively. A five-step reaction pathway was proposed for the ignition process in air, and activation energies for each step were also calculated. These results should provide reference for formula design and safety storage of NH_4ClO_4/Mg-containing pyrotechnics.

СОДЕРЖАНИЕ