

MECHANICALLY ACTIVATED ENERGETIC COMPOSITES BASED ON BORON

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Abstract: The mechanical activation in a planetary ball mill of boron with additives of graphite, aluminum, titanium, and fluoropolymer as well as boron mixtures with ammonium perchlorate (AP) was studied. Simultaneous thermal analysis (differential scanning calorimetry (DSC) and thermogravimetry (TG)) of the effect of mechanical activation on powder oxidation was conducted. Data were obtained on the reaction onset temperatures of boron with additives upon heating in oxygen and the ignition temperature of a hot surface in air depending on the activation dose. Fast-burning compositions based on activated boron with additives and AP capable of transitioning to detonation at distances of less than 50 mm were obtained.

Keywords: mechanical activation; boron; graphite; aluminum; titanium; ammonium perchlorate; ignition temperature; combustion; detonation

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Figure Captions

Figure 1 Electron micrographs of the starting powders: (a) boron — B-99B; (b) graphite P; (c) Al — PP-2L; and (d) AP

Figure 2 Electron micrographs of activated powders: (a) B/graphite 49BG1 $t_a = 1$ min; (b) B/graphite 47BG4 $t_a = 4$ min; (c) B/graphite/Ti/fluralite 41BGTF $t_a = 15$ min; and (d) 45 (41BGTF/AP 30/70) $t_a = 15 + 5$ min

Figure 3 The DSC oxidation curves in oxygen: 1 — B-99B; and 2–4 — B/graphite ($2 - t_a = 1$ min; $3 - 2$; and $4 - t_a = 9$ min)

Figure 4 Change in mass (TG) during oxidation in oxygen: 1 — B-99B, 2–5 — B/graphite ($2 - t_a = 1$ min; $3 - 2$; $4 - 4$; and $5 - t_a = 9$ min)

Figure 5 The DSC and TG curves of heating of sample 58 (52BG/AP) in a helium atmosphere

Figure 6 Schematic diagram of the setup for determining the ignition temperature (a) and frames of two oxidation modes: combustion (b) and flameless smoldering (c)

Figure 7 Ignition delay: a) boron and boron/graphite at 600 °C depending on t_a ; and (b) compounds with AP at 280 °C

Figure 8 Setting up experiments on the transition from combustion to detonation (a) and photographs of tubes after experiments without transition (b) and with transition to explosion (c)

Figure 9 Detonation velocity of activated mixtures with AP

Table Captions

Table 1 Composition of mixtures and activation time

Table 2 The DSC and TG data for the oxidation of boron and activated boron/graphite + Me mixtures; T_{+5} is the onset temperature of boron oxidation (+5% (wt.) according to TG); T_{1DSC} is the temperature of maximum heat release during graphite oxidation; T_{2DSC} is the temperature of maximum heat release during boron oxidation; J is the total heat release (J_0 is the heat release of pure boron); and ΔM is the mass gain

Table 3 The DSC and TG data for reactions in mixtures of activated compounds with AP; T_{-5} is the temperature of mass loss at -5% by TG; T_{1DSC} and T_{2DSC} are the temperatures of the first and second maximum of heat release; and ΔM is the mass loss

Table 4 Detonation velocity of porous charges in a steel tube: ρ_0 is the charge density; and ε is the porosity

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