IGNITION DYNAMICS OF HIGH EXPLOSIVES

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Mechanical insults of granular high explosives (HE) can result in localized areas of elevated temperature, or "hot spots". The evolution of these hot spots is a central issue of HE science. Because of the complexity involved, it is worthwhile to study mechanical and reaction processes in isolation. Mechanical processes are isolated and studied using inert materials or weak insults where reaction may be minimal. Likewise, purely thermal processes can be considered to isolate HE reaction response. For example, radiant ignition has been used to characterize the reaction response of propellants. In this work we study the radiant ignition of various HEs of interest, including HMX (C\textsubscript{5}H\textsubscript{3}N\textsubscript{8}O\textsubscript{3}), PBX 9501 (95% HMX, 2.5% Estane, 2.5% BDNPA/BDNPF), RDX (C\textsubscript{3}H\textsubscript{6}N\textsubscript{6}O\textsubscript{6}), TATB (C\textsubscript{6}H\textsubscript{6}N\textsubscript{6}O\textsubscript{6}), and PBX 9502 (95% TATB, 5% Kel-F) and aged PBX 9502. Initial work has included unconfined samples at ambient pressure in air. Diagnostics have included photodiodes to record first light emission, high speed photography, microthermocouple and IR emission measurement to obtain surface temperature, IR emission of gases above the pellet, and a novel nonlinear optical technique (second harmonic generation, see Fig. 1) to characterize the dynamic \(\beta-\delta\) solid phase transformation and the formation of a liquid layer. We find that ignition delays at various power levels is very similar for HMX and RDX; except that the minimum radiant flux needed for RDX ignition is higher. The addition of only 5% binder (PBX 9501) causes significantly longer ignition delays at lower heat fluxes compared with HMX alone. TATB and TATB-based explosives exhibit much longer ignition delays than HMX. In contrast to HMX, however, no measurable difference is observed in TATB by the addition of a binder (PBX 9502, aged or pristine). High speed photography of the ignition dynamics and gas IR emission measured above the pellet surfaces at discrete locations indicate vigorous ignition occurs first downstream in the gas that then propagates back to the pellet surface ("snap-back"). Voids or cracks in a damaged HE can potentially be on the same scale as the gas phase flame of a burning explosive. Consequently, the ignition process may be affected. The standard ignition experiment has been modified to begin to study this issue. Specifically, a salt window has been placed at various distances above the pellet surface (see Figs. 2 and 3). From these experiments we have found that there is a critical gap below which full ignition will not occur. For HMX at 29 W/cm\(^2\) or 38 W/cm\(^2\) the critical gap was found to be 6±0.4 mm. These results clearly show that a simple ignition criterion such as a critical surface temperature is inadequate under some conditions.
Fig. 1  Second harmonic experimental schematic (top left), thermocouple and image intensity measurements (top right), and δ-phase formation (bottom center).

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Fig. 2  Schematic of gap laser ignition experiment.

Fig. 3  Image of burning HE with a gap following laser ignition.