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Benchtop Energetics Progress[1]

MARIO FAJARDO, US Air Force Research Lab

We have constructed an apparatus for investigating the reactive chemical dynamics of mg-scale energetic materials samples. We seek to advance the understanding of the reaction kinetics of energetic materials, and of the chemical influences on energetic materials sensitivity. We employ direct laser irradiation, and indirect laser-driven shock, techniques to initiate thin-film explosive samples contained in a high-vacuum chamber. Expansion of the reacting flow into vacuum quenches the chemistry and preserves reaction intermediates for interrogation *via* time-of-flight mass spectrometry (TOFMS). By rastering the sample coupon through the fixed laser beam focus, we generate hundreds of repetitive energetic events in a few minutes. A detonation wave passing through an organic explosive, such as pentaerythritol tetranitrate (PETN, $C_5H_4N_4O_{12}$), is remarkably efficient in converting the solid explosive into final thermodynamically-stable gaseous products (*e.g.* N_2, CO_2, H_2O...). Termination of a detonation at an explosive-to-vacuum interface produces an expanding pulse of hyperthermal molecular species, with leading-edge velocities $\sim$ 10 km/s. In contrast, deflagration (subsonic combustion) of PETN in vacuum produces mostly reaction intermediates, such as NO and NO_2, with much slower molecular velocities; consistent with expansion-quenched thermal decomposition of PETN. We propose to exploit these differences in product chemical identities and molecular species velocities to provide a chemically-based diagnostic for distinguishing between detonation and deflagration events. In this talk we also report recent progress towards the quantitative detection of hyperthermal neutral species produced by direct laser ablation of aluminum metal and of organic energetic materials, as a step towards demonstrating the ability to discriminate slow reaction intermediates from fast thermodynamically-stable final products.

[1]Work done in collaboration with Emily Fossum, Christopher Molek, and William Lewis, US Air Force Research Laboratory.