TEXAS TECH UNIVERSITY
Department of Mechanical Engineering

Predicting Explosive Performance from Non-Detonative Experiments

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Abstract: Understanding the chemistry that occurs in the reaction front of an explosive detonation is extremely difficult due to the short time-scale and violent release of energy in the form of heat, sound, light and blast. In addition, full-scale detonation testing requires many grams of energetic material and is quite expensive. The ability to study the chemical reactions and properties of explosives in laboratory-scale experiments would greatly benefit the development of improved explosive formulations. A focused, nanosecond-pulsed laser with sufficient energy to exceed the breakdown threshold of a material generates a laser-induced plasma with high peak temperatures (>10,000 K), pressures (tens of GPa), and shock velocities (multiple km/s). Depending on the laser parameters and material properties, nanograms to micrograms of material is ablated, atomized, ionized and excited in the laser-induced plasma. The feasibility of exploiting laser-induced plasma chemistry to study the chemical reactions of energetic materials has been demonstrated. In addition, the shock wave generated in the air by the laser-induced plasma can be used to predict the explosive properties of the ablated material, i.e., energetic materials generate faster laser-induced shock velocities than non-energetic materials. Based on the observed linear correlation between the laser-induced shock velocity and the measured performance from full-scale detonation testing for a large suit of pure and composite energetic materials, this method is a potential screening tool for the development of new energetic materials and formulations prior to detonation testing. Recent results on the extension of this method to metal-containing energetic materials, porous silicon explosives, and novel energetic materials will be presented. Other methods being developed for laboratory-scale characterization of energetic materials will also be discussed.

Bio: Dr. Gottfried obtained a Ph.D. in Physical Chemistry from the University of Chicago in August 2005, receiving numerous fellowships and awards for excellence in academics and research, including a National Science Foundation Graduate Fellowship and the William Rainey Harper Dissertation Fellowship. She joined ARL in September 2005 as a postdoctoral fellow and was hired in May 2008. In 2009 Dr. Gottfried was the Gold medal winner for Rookie Employee of the Year – Technical Scientific and Program Support (Excellence in Federal Career Award, Baltimore Federal Executive Board). She was a co-recipient of a 2009 Research and Development Award for "Stand-off Detection of Explosives." Dr. Gottfried has written two book chapters and has 34 peer-reviewed papers, including four invited reviews and three featured cover articles. She has also published more than 50 ARL technical reports. She has been an invited speaker at 8 international conferences, presented her work in more than 60 scientific conference presentations, and taught a short course on chemometric analysis at an international conference. Dr. Gottfried's work is focused on laser spectroscopy of energetic materials for laboratory-scale characterization, model validation, and fundamental understanding of reaction mechanisms during explosive initiation.

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Coordinator: Dr. Michelle Pantoya (michelle.pantoya@ttu.edu)