Nitramine-Rich Amorphous Energetics

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Abstract: Controlling the initiation sensitivity of explosive materials to stimuli such as impact and shock has been a leading research topic in the energetics community. Traditionally, this has been achieved by changing the crystal characteristics including the size, quality, habit, and polymorph. In this seminar, we will report on the recent research performed at US Army, ARDEC aimed at the production and evaluation of nitramine-based energetics in the amorphous state. The constituent nitramines including CL-20 and HMX are poor glass formers, however, it was discovered that when prepared as molecular solid dispersions, stable glasses were readily produced. The glassy materials were prepared by rapid co-precipitation of the composite ingredients using spray drying. Characterization of these novel materials revealed multiple properties unique to the glassy state. Differential scanning calorimetry (DSC) analysis showed that in the glassy state, the materials have a higher configurational enthalpy, making them more energetic. Thermomechanical analysis (TMA) results indicate that the glassy materials undergo a glass transition (T_g) at ~ 50 ^oC, during which a transformation from a rigid to a liquid-like state occurs. Above the T_g, crystallization of the amorphous phase was observed. When compacted to full density, which can be readily done at temperatures above the T_g, highly structurally homogeneous pellets are formed, lacking defects such as pores, grain boundaries, and dislocations which are always found with polycrystalline materials. Elimination of such defects is expected to greatly improve the safety characteristics and therefore minimize the likelihood of inadvertent initiation. It was also observed that at full density, the glassy energetic materials become optically transparent. While the feasibility of preparing such materials has been demonstrated, significant work remains in optimizing their physicochemical properties, in particular controlling the key characteristics such as the T_g, and crystallization kinetics above and below T_g.

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