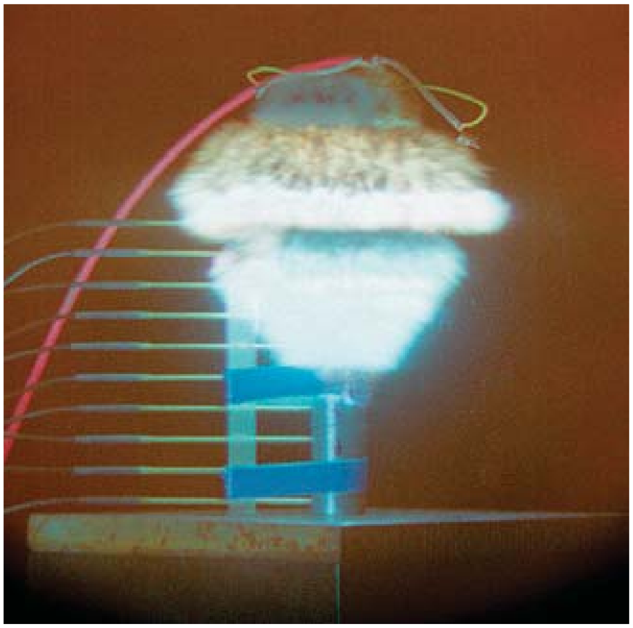
Processing of Explosive Formulations with Nano-Aluminum Powder

Accomplishment: A processing methodology was developed to incorporate a high volume fraction of nano-aluminum powder into moldable munitions formulations.



Impact: Munitions enhanced with nano-aluminum powder are being developed to give performance and lethality enhancements in miniaturized munitions needed for the reduced volume of advanced aircraft munitions bays and for weaponization of unmanned air vehicles (UAVs). Munitions using nano-aluminum powder may give improved lethality by improving the airblast and the shrapnel accelerating capability over conventional formulations.

Motivation and Approach: Aluminum powders that are tens of microns in diameter are used to increase the energy density in conventional munitions and solid rocket fuels. Oxygen reacts with the powder surface, giving off significant heat but forming a barrier to further oxidation, so that only partial reaction is achieved. Nanoparticles have much higher surface area than conventional powders. The reaction rate of nano-powders can be controlled by adjusting the nanoparticle diameter, giving tailorability for optimized airblast and for fragment formation and acceleration. Higher power density is provided by more complete reaction and higher reaction rate of nano-aluminum powders. The high surface area is wetted by binders used to make conventional munitions formulations processible, increasing the viscosity and making blending and casting difficult. Only a few percent by volume of nano-aluminum powder could previously be added to munitions formulations, forming a major barrier to the development, production and characterization of advanced munitions with significant additions of nano-aluminum powders.

A new processing methodology has been developed to overcome this barrier. A conventional castable munitions formulation, which typically has a viscosity similar to honey, is thinned with a solvent so that the nano-aluminum powder can be added. The solvent also desensitizes the formulation so that it is safer to handle during processing. The solvent vaporizes during blending, leaving a granular formulation with the consistency of brown sugar that can be easily molded to fill munitions containers. Only 6% by volume of binder is needed, and up to 50% by volume of nano-aluminum powder can now be added, compared to only a few percent using previous techniques. An order of magnitude improvement in density control is achieved, giving better reproducibility of blast characteristics. Extension of this processing methodology to add nano-aluminum powders to conventional munitions formulations is being pursued at industrial partners, including ATK and Savannah River National Laboratory. Performance testing is underway.

Team: This research was accomplished at the Munitions Directorate by Chad Rumchik.