Activating Alumina Surface Reactions Toward Enhanced Aluminum Particle Combustion

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Abstract

Micron scale aluminum (Al) particles are notoriously plagued with incomplete combustion and sluggish ignition. One way to increase overall Al reactivity is through surface reactions with the aluminum oxide shell. This presentation will focus on fundamental reaction kinetics between the Al particle surface and different oxidizing agents as well as functionalizing Al particles to promote the mechanisms that optimize combustion. One functionalization approach is through the polarity of processing liquids used as carrier fluids to intermix fuel and oxidizer particles. Controlling the hydration layer on Al effects surface reactions. Another functionalization approach is through self-assembled-monolayers of carboxylic acids that also induce exothermic surface reactions with the alumina passivation shell. Equilibrium experiments will show pre-ignition reaction kinetics attributed to surface chemistry and the corresponding effect on overall Al combustion. Non-equilibrium experiments will show a direct link between molecular level surface chemistry and overall global reactivity. Density functional theory calculations complement experimental results to aid in resolving the mechanism controlling Al particle combustion. New diagnostic approaches will also be introduced that reveal the polymorphic nature of micron Al core particles and the implications of this microstructure on reaction mechanisms. Processing parameters such as annealing and quenching will also be discussed to explain how altering microstructure and interface behaviors can influence impact ignition scenarios. Imaging diagnostics will show with clarity the multiphase nature of the combustion process often masked by the high luminescence of the reactions. Harnessing more of the abundant chemical energy stored in an Al particle (i.e., theoretically estimated specific energy is 31 MJ/kg) will have tremendous benefits for the use of Al as an energy generating material in many applications.

Biography:

Dr. Michelle Pantoya received her PhD from the University of California, Davis in 1999 and joined the faculty in the Mechanical Engineering Department at Texas Tech University in 2000. As the J. W. Wright Regents Endowed Chair Professor, her research focuses on studying aluminum particle combustion in ways that can enhance our national safety and security. She has received many research awards including the US Presidential Early Career Award (PECASE) and the DoD Young Investigator Program Award and has over 150 publications on this topic. Dr. Pantoya is also the co-author of several children's books introducing engineering to young kids (i.e., *Engineering Elephants* & *Designing Dandelions*).