Synthesis and Characterization of Polyimide Residuum, Friable Balloons, Microspheres and Foams

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Abstract

In order to meet requirements of future NASA systems for advanced polymeric cellular materials, research was undertaken to develop the next generation of polyimide foams which could be utilized as a reusable structural insulation on future Reusable Launch Vehicle (RLV) Programs. This research activity focused on developing polyimide foam and foam structures which were made using monomeric solutions or salt solutions formed from the reaction of a dianhydride and diamine dissolved in a mixture of foaming agents and alkyl alcohols. This process produced a precursor solid residuum which could then be manufactured into foams, friable balloons and microspheres. Polyimide foams and microspheres were produced from over twenty-five different solid residuum precursors to densities ranging from 0.008 g/cc to 0.32 g/cc. Polyimide foams made from the solid residuum and friable balloons were subjected to thermal, mechanical, flammability, and combined environments testing.

High temperature polyimide microspheres were developed from polyimide solid residuum by a simple inflation process using a circulating air oven. A geometric model was developed to help understand the precursor solid residuum inflation mechanism by using simple geometric rules for an incompressible polymeric material. Microsphere mesostructure and inflation kinematics were analyzed visually and basic mechanical and thermal testing was performed to understand the microsphere formation and final physical properties.

This new foam technology allows for the processing of polyimide neat or syntactic foams, foam-filled honeycomb or other shapes, and microspheres, all of which could meet future NASA program requirements for advanced polymeric cellular materials. These products can be used in a variety of ways: flame retardant materials for fire protection, thermal and acoustic insulation, gaskets and seals, vibration damping pads, spacers in adhesives and sealants, extenders, and flow/leveling aids. Finally, data generated from this research revealed vital information involving foam technology and the importance of chemical and cell structure. The degradation studies performed also gave insight into the parameters most important to the performance of these materials for insulation and fire resistant structural components on future vehicles.