COATING NANO-SIZED ALUMINUM TO IMPROVE SOLID ROCKET PROPELLANT PERFORMANCE

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Solid rocket propellants are generally used in space and defense applications. The most common formulation involves ammonium perchlorate as oxidizer, HTPB as binder and micrometric Aluminum as fuel. In the last years progress in technologies made available a new class of metallic powders characterized by nanometric size. Nanoparticles show different chemical and physical properties with respect to larger scale materials, making them appealing in a wide number of industrial fields. Because of the enhanced reactivity interest arises also for propulsive applications: the substitution of micrometric Aluminum with nanometric one in solid propellant grants an increase in burning rate and a decrease in agglomerates formation in the near-surface are[1]. Together with desirable properties, nanometric particles are characterized also by different surface interactions with respect to bulk materials, resulting in difficulties in handling because of the tendency to form clusters that hinders the complete exploitation of nano-sized materials potential.

In order to improve dispersion degree of nanosized powders, coating with different materials are evaluated in this work: Hydroxyl-Terminated PolyButadiene (HTPB), Viton, SUREL or 8-hydroxyquinoline. In this work first a characterization of powders is carried out: TEM analyses are performed to show the quality of the coating, while DSC/TG analyses are considered to evaluate the oxidation of powders in air. A ballistic characterization has been performed on propellant containing Alex with various coatings and 2 different kind of inert binders (HTPB and SKDM80). Tests are conducted in a closed vessel at pressure ranging from 1 to 60 bar. Nitrogen as pressurizing gas is used. Videos of the combustion process are performed by high-speed and high-resolution camera during combustion. An analyses with a proprietary software is carried out to find burning rate. Values obtained are fitted according to the standard Vieille law. An increase in burning rate is shown by formulations containing coated powders with respect to propellants containing standard uncoated Alex. Analyses also in sub-atmospheric conditions are carried out in order to find Pressure Deflagration Limit (PDL). Tests are conducted in a closed vessel in which pressure, regulated by a vacuum pump is constantly checked. Data from the pressure transducer are collected by a scope as well as signals from two photodiodes faced on the optical access of the chamber. A comparison among signals allows to identify when permanent extinction of the propellant is reached.

For some of the propellants condensed combustion products (CCP) are collected and analyzed using a X-Ray Diffractometer (XRD) in order to find the composition. Viton coated powders lead to an increase up to 7% in the amount of CCP with respects to uncoated Alex, while 8-hydroxyquinoline coated Alex allows a reduction of 19%.

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[1] L.T. De Luca, L. Galfetti, F. Maggi, G. Colombo, A. Bandera, S. Cerri, and P. Donegà, "Burning of Metallized Composite Solid Rocket Propellants: Toward Nanometric Fuel Size", ESA Space Propulsion 2008: 2nd International Symposium on Propulsion for Space Transportation, Heraklion, Crete, Greece, 5-8 May 2008, pp.1-10.