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Nano-aluminum as energetic material for rocket propellants

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Abstract

A characterization of differently sized aluminum powders, by using BET (specific surface measurements), Scanning Electron Microscopy (SEM), X-Ray Diffraction (XRD), and X-ray Photoelectron Spectroscopy (XPS), was performed in order to evaluate their performance in solid propellant. These aluminum powders were used in manufacturing composite rocket propellants, that are based on Ammonium Perchlorate (AP) as oxidizer and Hydroxyl-Terminated-PolyButadiene (HTPB) as binder. The reference formulation was AP/HTPB/Al with 68/17/15 mass fractions, respectively. The ballistic characterization of studied propellants, made in terms of steady burning rates, showed how better is the performance of nano-aluminized compared to micro-aluminized propellants. Measurements of Al powder ignition time and temperature were also carried out.

Keywords: Materials; Nano-aluminum; Solid propellant; Characterization techniques; Ballistic properties

1. Introduction

Modern solid rocket propellants for aerospace applications commonly contain aluminum powder as a fuel, because of its high energy release in the oxidation process to alumina. The oxidation agent is an inorganic salt as Ammonium Perchlorate (AP), embedded into an organic binder, a polymeric matrix as Hydroxyl-Terminated PolyButadiene (HTPB) [1,2]. First generation of aluminum powders is coated by a very thin layer of alumina [3,4].

Great attention is focused today on ultra-fine (nanometric) Al particles, because of the significant increase of propellant burning rate and of the lower ignition time and temperature. From this observation started the interest in characterizing the chemico-physical properties of pure Al powders. Different preparation techniques allowed us to collect samples over two orders of magnitude in diameter. Scanning Electron Microscopy (SEM) and surface adsorption (BET) were the characterization techniques used to determine sample morphology; X-Ray Diffraction (XRD) was used to evaluate crystalline domains; X-ray Photoelectron Spectroscopy (XPS) gave information on surface chemistry and coatings. A particular attention has been

Table 1
List of considered samples

Name	Production technique	Nominal size (μm)	Year
AL_01a	EEW	0.15	2002
AL_01b	EEW	0.30	2004
AL_01c	EEW	<0.10	2004
AL_02a	EEW	0.17	2003
AL_02b	EEW	0.17	2002
AL_02c	EEW	0.17	1999
AL_03a	MM	0.20	–
AL_03b	MM	0.40	–
AL_03c	MM	0.80	–
AL_03d	MM	2.50	–
AL_04 a	PC	0.20	–
AL_04 b	PC	0.28	–
AL_05	MM	30.00	–
AL_06	MM	50.00	–
AL_07	EEW	0.10	–
AL_08	EEW	<0.10	2004
AL_09 a	PC	0.09	2005
AL_09 b	PC	0.04	2005

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