THESIS ABSTRACTS

This section presents the abstract of most recent Master or PhD thesis related to aerospace technology and management

Ultrahigh Molecular Weight Polyethylene as a Base Material for Shielding Cosmic Radiation in Aerospace Applications

Marlon Antonio Pereira
Instituto de Estudos Avançados; São José dos Campos/SP – Brazil
marlon@ieav.cta.br

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ADVISORS: Doctors Odair Lelis Gonçalez and Deborah Dibbern Brunelli

KEYWORDS: Shielding, Polyethylene, Ultra-high molecular weight polyethylene, Cosmic radiation, Thermal neutrons.

ABSTRACT: Materials with high content of hydrogen and composed by low atomic mass elements have good properties of shielding against the effects of cosmic rays because they are less effective than the heavy ones, with high nuclear masses in the generation of secondary radiation. Among these materials, besides aluminum, polyethylene has been used as a reference and as basis for composites applied in structures and shielding of ionizing radiation for aerospace applications. In this work, ultra-high molecular weight polyethylene, pure and 10% doped by mass with cadmium chloride, was evaluated with respect to its shielding properties for cosmic radiation existing in a low Earth orbit. Considering the high cost and the difficulties to obtain radiation sources with the composition and energy of the cosmic radiation at space and in the Earth atmosphere, at altitudes of high operational ceiling flights, the methodology used in this evaluation was performing irradiation experiments with conventional radioactive sources under controlled conditions and at simple geometries, and then computational simulation for isotropic fluxes of high energy particles. Narrow beam transmission experiments and measurements of secondary radiation production (electrons, gamma radiation, and thermal neutrons) were performed with a ^{241}Am-Be radioactive neutron source and a set of conventional sources of gamma radiation, in order to certify the shielding microscopic description (materials and cross sections) and effectiveness (transmission coefficients). Based on this description, Monte Carlo simulations were performed on free programs, with performance and reliability widely recognized (Geant4). These were provided by the European Space Agency in the Space Environment Information System (SPENVIS) site, assessing, in particular, the secondary radiation produced by shielding slabs of ultra-high molecular weight polyethylene (pure and with cadmium chloride) subjected to the fluency of a typical trapped cosmic radiation incidence on a low Earth orbit satellite. The energy spectrum and fluency of this radiation were also obtained from a SPENVIS calculation of a low Earth orbit mission in an orbit similar to a sino-Brazilian series satellite of China-Brazil Earth Resources Satellite (CBERS) series. In the energy area of conventional radiation sources, the samples were characterized according to their: gamma total attenuation coefficients from 59 to 1,408 keV; dose deposition curve for ^{60}Co gamma-rays; fast neutron transmission coefficient; generation and self-absorption of thermal neutrons and of internal cascades of secondary electrons; and gamma-rays by nuclear interactions of fast neutrons source with shielding material nuclei. The samples employed in the experiments were cylindrical plates of 6.5 cm in diameter and 0.60 g/ cm^2 thickness, manufactured by hot compression molding. The experimental results were compared with their corresponding values calculated from cross sections of the main interactions of monoenergetic gammas and fast neutrons, with the atoms of the shielding materials and their nuclei. The main effects of the additive (cadmium chloride) in the polyethylene base are the most effective removal of gamma radiation and of secondary electrons with energies below 200 keV, and the reduction of the thermal neutron albedo and of the thermal neutrons transmission by a factor that can reach up to four, depending on the thickness of shielding. However, for dose reduction due to primary cosmic radiation, these results were not significant, since the largest contribution to the dose is due to high energy ionizing particles transmitted and to secondary radiation produced in shielding with energies above 1 MeV.

Analytical Techniques by Via Humid and Instrumental for Characterization of Bonding Agents Used in Solid Propellants

Darci Côrtes Pires
Instituto de Aeronáutica e Espaço; São José dos Campos/SP – Brazil
darcidcp@iae.cta.br

Thesis submitted for PhD degree in Mechanical and Aeronautical Engineering, in 2012.

ADVISORS: Doctors Rita de Cássia Lazzarini Dutra and Koshun Iha

KEYWORDS: Propellants, Characterization, Quantification, FT-IR, Analysis by wet, Thermal analysis.

ABSTRACT: In the open literature, there are few studies on the synthesis and characterization of the bonding agents and their application in industry composite solid propellants. These additives are considered strategic in the formulations, and most of the publications are found as patents. Thus, taking as basis the proper characterization of the bonding agents is the starting point for choosing a particular formulation of propellant in order to test and verify the effect on mechanical and ballistic properties of the composite. Three types were studied, aziridine, amine, and hydantoin by different techniques, ranging from wet and instrumental. The main methodologies developed for their characterization and quantification include new method, which characterized ring opening characteristic of agents aziridine by means of differential scanning calorimetry, wet, and spectroscopy of the mid-infrared. This method is important in the study of changes of chemical structure, aging of these compounds and characterization of novel binding agents with two or three rings open synthesized with starting materials, easily found in the domestic market, such as 12-hydroxystearic acid. The products obtained are reacted with NCO giving a polyurethane resin similarly to the hydroxyl polybutadiene (HTPB). Also, monitoring the reaction by the mid-infrared spectrometer shows that changes occur only in the reaction with formaldehyde, among three types of aldehydes studied, therefore the formation of the product 1,3-bis-(hydroxymethyl) 5,5-dimethylhydantoin in the presence of water. The indication of the NIR analytical bands of the amine bonding agent for quantitative studies in order to determine the equivalent weight of TEPA, with good precision, and agreement with the corresponding data cited in the literature, and the methodology developed being validated by DSC and potentiometry were also included. Data molecular weights are calculated of TEPA from the developed methodology for the determination of equivalent weight. They contribute to a new line of research in the Division of Chemistry of *Instituto de Aeronáutica e Espaço*, and to the characterization and quantification of bonding agents used in propellants.

Synthesis, Characterization and Application of Glycidyl Azide Polymer in the Development of New Propellants to the Brazilian Aerospace Program

Jairo Sciamareli
Instituto de Aeronáutica e Espaço; São José dos Campos/SP – Brazil;
jairojs@iae.cta.br

Thesis submitted for PhD degree in Mechanical and Aeronautical Engineering, in 2012.

ADVISOR: Doctor Koshun Iha

KEYWORDS: Synthesis, Chemistry, Polymer, Characterization, Glycidyl azide polymer, Energetic polymer.

ABSTRACT: In recent years it has been constant the search for new materials that could be used in propellants. It has been sought, among other features, for those more energetic, with greater thermal stability or chemistry, less aggressive to the environment, with lower cost, easier handling, and that allow for better performance of rockets, missiles and explosives. Glycidyl azide polymer (GAP) satisfies this expectation. The presence of azide groups brings to the product positive heat formation, 975 kJ/kg at 293 K, which is important because the energetic performance of propellant is proportional to the enthalpy of reactants formation. This work aimed at allowing Brazil to be at the forefront of research of new propellants, seeking to possess production capacity, characterization and application of glycidyl azide polymer in new formulations. It also allowed us to be into the energetic propellant components research. Synthesis processes were conducted using three different catalysts in three varied proportions. The products obtained were characterized by volumetric (hydroxyl index) and instrumental analyses (FT-IR and thermal analysis). Sample that used $SnCl_4$ as catalyst and relationship monomer/catalyst 20:1 was chosen to repeat its synthesis process for five times, and each of these products has been subjected to the same analyses to ensure that the properties were repetitive. The glycidyl azide polymer obtained was used in a process for the production of polyurethanes with isocyanates, TDI and IPDI, and specimens obtained tested for evaluating mechanical properties. According to the analysis performed, we can say that the process for the production and characterization of glycidyl azide polymer have been fully achieved and has similar features to the product produced abroad.