Chapter 1

Innovative Solid Rocket Propellant Formulations for Space Propulsion

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ABSTRACT

Solid rocket propulsion enjoys unique properties favoring its use in space exploration and military missions still for decades to come. Yet, it also suffers a limited performance especially in terms of gravimetric specific impulse. Although new high-energy materials have been identified, most of them are far from being practically usable in the short range. Presently, no integrated vehicle designs make use of these new ingredients. A broad overview is discussed in this paper and attention is paid to Ammonium Dinitramide, ADN to overcome the current limitations of Ammonium Perchlorate, AP. The latter imply not only a limited gravimetric specific impulse but also a negative impact on the environment and personal health. ADN-based dual-oxidizer formulations, with Al-based dual-metal fuels and inert or energetic binders, are promising solutions for a variety of solid rocket propulsion missions aiming respectively at minimizing environmental impact (ADN + AN) or maximizing performance (ADN + AP).

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NOMENCLATURE

Roman Symbols

ADN: Ammonium DiNitramide
AN: Ammonium Nitrate
AP: Ammonium Perchlorate
ARC: Atlantic Research Corporation
BAMO: 3,30-Bis(AzidoMethyl) Oxetane
BC: Before Christ
BFF: 3,4-bis(3-fluorodinitro-methyl furazan-4-oxy)furazan
BHEGA: N, N-bis(2-hydroxyethyl)glycol amide, bonding agent also known as HX-880; BHEGA may act also as a cross-linker
BPS: Bis-Propargyl Succinate
Bu-NENA: n-Butyl-NitratoEthylNitrAmine
c/a: circa
CalTech: CALifornia institute of TECHNOlogy
CCP: Condensed Combustion Products
CL-20: 2,4,6,8,10,12-hexanitro-2,4,6,8,10,12-hexaazaaisowurtzitane, also known as HNIW
CMDB: Composite Modified Double-Base
CTPB: Carboxyl-Terminated PolyButadiene
DB: Double-Base
EMCDB: Elastomer Modified Cast Double-Base
ESA: European Space Agency
ESD: ElectroStatic Discharge
FOI: Swedish Defence Research Agency
GALCIT: Guggenheim Aeronautical Laboratory at California Institute of Technology
GAP: Glycidyl Azide Polymer
GUDN: GuanylUrea-DiaNitramide, also called FOX-12
HADNMNT: HydroxylAmmonium 2-DiNitroMethyl-5-NitroTetrazolate
HATO: diHydroxylAmmonium 5,5’-bisTetrazole-1,1’-diOlate (also known as TKX-50)
HBIW: HexaBenzylhexaaazaIsoWurtzitane
HEM: High-Energy Materials
HMX: cyclotetramethyleneenetetranitramine, High Melting Explosive (also known as Octogen, Her Majesty’s Explosive)
HNF: Hydrazinium nitroformate
HNIW: 2,4,6,8,10,12-HexaNitro-2,4, 6,8,10,12-HexaaazaIsoWurtzitane, commonly known as CL-20
HTPB: Hydroxyl-Terminated PolyButadiene
HTPE: Hydroxyl-Terminated PolyEther
ICBM: InterContinental Ballistic Missile
ICP: Institute of Chemical Physics
ICT: Fraunhofer Institute for Chemical Technology
IM: Insensitive Munitions
Is: Gravimetric Specific Impulse
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