Title: Removing Hydrochloric Acid Exhaust Products from High Performance Solid Rocket Propellant Using Aluminum-Lithium Alloy

Author: Brandon C. Terry Travis R. Sippel Mark A. Pfeil I.Emre Gunduz Steven F. Son

PII: S0304-3894(16)30505-2
DOI: http://dx.doi.org/doi:10.1016/j.jhazmat.2016.05.067
Reference: HAZMAT 17756

To appear in: *Journal of Hazardous Materials*

Received date: 3-12-2015
Revised date: 13-5-2016
Accepted date: 22-5-2016

Please cite this article as: Brandon C.Terry, Travis R.Sippel, Mark A.Pfeil, I.Emre Gunduz, Steven F.Son, Removing Hydrochloric Acid Exhaust Products from High Performance Solid Rocket Propellant Using Aluminum-Lithium Alloy, Journal of Hazardous Materials http://dx.doi.org/10.1016/j.jhazmat.2016.05.067

Removing Hydrochloric Acid Exhaust Products from High Performance Solid Rocket Propellant Using Aluminum-Lithium Alloy

Brandon C. Terry*[a], Travis R. Sippel [b], Mark A. Pfeil [a],
I. Emre Gunduz [c], Steven F. Son [c]

[a] School of Aeronautics and Astronautics, Purdue University, Zucrow Laboratories, 500 Allison Rd, West Lafayette, IN 47907, United States, *E-mail: terry13@purdue.edu, Fax: (765) 494-0530

[b] Department of Mechanical Engineering, Iowa State University, 2025 Black Engineering, Ames, IA 50011, United States

[c] School of Mechanical Engineering, Purdue University, Zucrow Laboratories, 500 Allison Rd, West Lafayette, IN 47907, United States

Highlights

- Al-Li alloy propellant has increased ideal specific impulse over neat aluminum
- Al-Li alloy propellant has a near complete reduction in HCl acid formation
- Reduction in HCl was verified with wet bomb experiments and DSC/TGA-MS/FTIR

Abstract

Hydrochloric acid (HCl) pollution from perchlorate based propellants is well known for both launch site contamination, as well as the possible ozone layer depletion effects. Past efforts in developing environmentally cleaner solid propellants by scavenging the chlorine ion have focused on replacing a portion of the chorine-containing oxidant (i.e., ammonium perchlorate) with an alkali metal nitrate. The alkali metal (e.g., Li or Na) in the nitrate reacts with the chlorine ion to form an alkali metal chloride (i.e., a salt instead of HCl). While this technique can potentially reduce HCl formation, it also results in reduced ideal specific impulse (I_{SP}). Here, we show using thermochemical calculations that using aluminum-lithium (Al-Li) alloy can reduce HCl formation by more than 95% (with lithium contents $\geq$ 15 mass %) and increase the ideal I_{SP} by ~7 seconds compared to neat aluminum (using 80/20 mass % Al-Li alloy). Two solid propellants were formulated using 80/20 Al-Li alloy or neat aluminum as fuel additives. The halide scavenging effect of Al-Li propellants was verified using wet bomb combustion experiments (75.5 ± 4.8% reduction in pH, $\propto$ [HCl], when compared to neat aluminum). Additionally, no measurable HCl evolution was detected using differential scanning