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Title

Hypergolic Propellants with Hydrogen Peroxide: Carbon-Based Nanomaterials as Additives in Ionic Liquid Fuels

Authors

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Abstract

Hydrazine-based propellants are still state of the art for space vehicles like satellites, space probes or upper stages. However, hydrazine as well as its commonly used derivatives such as MMH (monomethyl hydrazine) or UDMH (unsymmetrical dimethylhydrazine) are classified as toxic and carcinogenic. [1] This not only makes handling of these substances hazardous, but because of the special protective equipment required there are also high costs associated with fueling spacecrafts with these propellants. As fuels for hypergolic propellants hydrazine is often combined with dinitrogen tetroxide as oxidizer. This substance is also extremely toxic so that there is even a danger to life if it is inhaled. [1]

For these reasons research is being conducted worldwide into alternatives that can replace these propellants in the future. The present work focuses on hypergolic combinations with hydrogen peroxide as oxidizer which has proven to be advantageous due to its low toxicity, low vapor pressure and high performance. As fuel component ionic liquids with thiocyanate anions are being developed. Ionic liquids are salts with organic cations or anions with melting points below or around 100 °C. They are especially interesting as fuel candidates due to their properties such as negligible vapor pressure and high density. In recent years, the development of these propellant combinations has progressed at the DLR Institute of Space Propulsion in Lampoldshausen.

When ionic liquids are intended to be used as cooling media for combustion chambers in the future, properties such as thermal conductivity and heat capacity of the fluids are of particular interest. As a part of the DLR internal project *NatAs (nanoparticles in propulsion systems)*, carbon-based nanomaterials were investigated as additives to explore how they can positively influence these properties and thus generate so-called heat transfer fluids (HTFs). The previously published IL-based fuel candidate HIM_35 serves as base fluid for these investigations. [2] First of all, a screening of suitable nanomaterials was carried out. Within the framework of various analyses, the physical and chemical properties of the new HTFs such as density, viscosity, temperature stability and oxidation behavior were investigated. The stability of the dispersions was also quantified. Based on this, the analysis of hypergolic ignition behavior followed, as well as the determination of the surface tension and the relevant thermal properties. Overall, an increase in thermal conductivity and heat capacity was achieved and thus an important step in the development of these heat transfer fluids was accomplished.

References

[1] GESTIS Substance Database, entries on “hydrazine”, “monomethylhydrazine”, “1,1-dimethylhydrazine” and “nitrogen tetroxide”, https://gestis.dguv.de/, visited on 01/20/2023.
[2] S. C. Ricker, D. Brüggemann, D. Freudenmann, R. Ricker and S. Schlechtriem, Protic Thiocyanate Ionic Liquids as Fuels for Hypergolic Bipropellants with Hydrogen Peroxide, *Fuel* **2022**, 328, 125290.