Greener stabilizers for NC propellants

MADALINA MOLDOVEANU[1], DUMITRITA JAR[1]

Abstract:

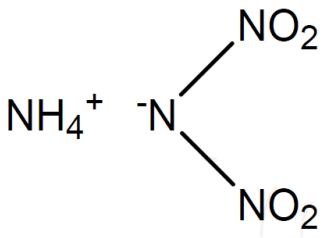
Green oxidizer

Ammonium perchlorate (AP) is considered the best oxidizer for use solid rocket propellants. The most widely used solid rocket propellant for space applications consists of AP (70%), aluminium as fuel (16%) and elastomeric binder (14%). Propellants using AP as oxidizer produce chlorine rich combustion products, and large quantities of HCl and Al oxides posing environmental hazards such as ozone depletion and acid rain. The compounds of aluminium are toxic and are harmful to human beings, animals and plants. The AP residues are rapidly transported through soil to the aquifer thus contaminating the water supplies. The issue of AP water contamination is very serious in US where numerous ranges, extensively used for training, were found being heavily contaminated with this compound. In 2009, a workshop organised by the US Department of Defence identified AP as one of the key environmental, safety and occupational health issues. At high concentrations, perchlorate can affect thyroid gland functions, where it is mistakenly taken up in place of iodide.

Research activities have been undertaken worldwide for the synthesis of a more performant and greener oxidizer for future solid rocket propellants. Ammonium dinitramide (ADN), hydrazinium nitroformate (HNF) and its derivatives are the most promising candidates.

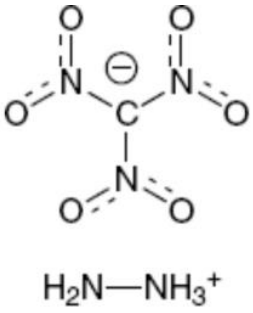
Ammonium dinitramide (ADN) is one of few such compounds currently known but unfortunately it has big compatibility issues with the components of the polymer binder systems (iso-cyanates), unexplained solid-state behaviour, highly hygroscopic, and has low melting point (93°C). These issues prevented so far the development of ADN based propellants.

[1] Military Technical Academy



ADN

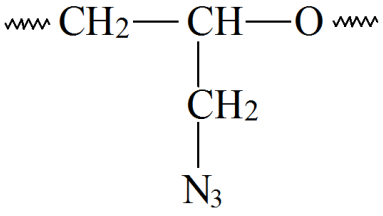
HNF (hydrazinium nitroformate) at the first look shows better than ADN being easy synthesized, denser, less hygroscopic, and having a higher melting point. On the other hand, HNF is non-hygroscopic in nature and has a melting point above 100 ◦C. But the major disadvantages of HNF are its sensitivity towards friction, chemical stability issues and incompatibility with common binder systems.



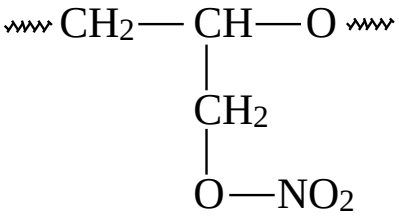
HNF

Energetic polymers

Energetic Polymers (EP) are already in use for the manufacture of next generation green rocket propellants. The use of EP instead of inert conventional HTPB binders allow using less performing but greener oxidizers like RDX, HMX, CL-20. Thus the pollutant AP is partially or totally removed.



Glycidyl azide polymer (GAP)



Polyglycidyl nitrate (PGN)

One of the main concerns of the industry nowadays is related to the replacement of phthalates and stabilizers, which are requested in large quantities and are no longer available in Europe due to REACH. Sebacates, adipates and terephtalates are investigated as replacements as they are not yet on the SVHC list.

References

[1] M.B. Talawar, R. Sivabalan, T. Mukundan, H. Muthurajan, A.K. Sikder, B.R. Gandhe, A. Subhananda Rao, Environmentally compatible next generation green energetic materials (GEMs), Journal of Hazardous Materials 161 (2009) 589–607

[2] T. Brinck, *Green Energetic Materials*, Wiley, UK, 2014.