Comparative Study of Rheological Properties of Ethanol and UDMH based Gel Propellants

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Abstract

In modern propulsion systems, the main focus is on development of high performance propellant systems with improved storage, handling, safety and preferably eco-friendly characteristics. With advancement from solids to storable liquids and then to cryogenic propellants, the performance increases but the toxicity, safety, storage and handling aspects impose high restrictions. As a result, the gelled propulsion systems especially using eco-friendly gel propellants have become a potential choice to improve safety, handling and performance for rocket applications and provide a promising alternative for next generation propulsion systems. The great advantage of gelled propellant lies in the fact that they combine the properties of liquid and solid propellants. In terms of application, gelled propellant can be used as mono or bipropellant, wherein the latter case both fuel and oxidizer are gelled and stored separately. The safety factor is enhanced by separating the fuel and oxidizer in the bipropellant engine system. In addition due to the semi-solid like behavior of gels during storage, they can be handled, stored and transported in a safer way. Moreover, their thixotropic i.e. shear-thinning character helps in ease of flow much like the liquid propellants during rocket engine operation. These systems also provide ability to control the thrust by controlling the mass flow of propellant into the combustion chamber and also reduce the risk of leakage. However, most of the gel propellants used today are toxic, carcinogenic and are not environment friendly. Therefore in the present study, efforts have been made to formulate, prepare and characterize the eco-friendly Ethanol based gel system along with unsymmetrical dimethyl hydrazine (UDMH) gel for purpose of comparison of their rheological properties.

Formulation of any gel propellant mainly deals with right choice of gellant and its critical concentration to obtain desired properties. However, other physical parameters such as temperature, mixing approach and time and particle size of gellant also play an important role in formulation. Methyl cellulose (MC) has been used as gelling agent in the present study. MC is a natural water-soluble polymer and has substitution of certain number of the hydroxyl groups with methoxyl groups in its chemical structure. These hydrophobic repeat units act as physical “cross-linking loci” and hence form a three-dimensional network to form gel. The rheological properties of the prepared gels of virgin Ethanol and UDMH propellant gels were studied using a rotational viscometer in lower shear rate range at different temperatures. The ethanol gels were found to exhibit thixotropic nature (Fig.1). The obtained results are compared with that of UDMH-MC gelled fuel in order to assess the variation of viscosity and nature of rheograms.

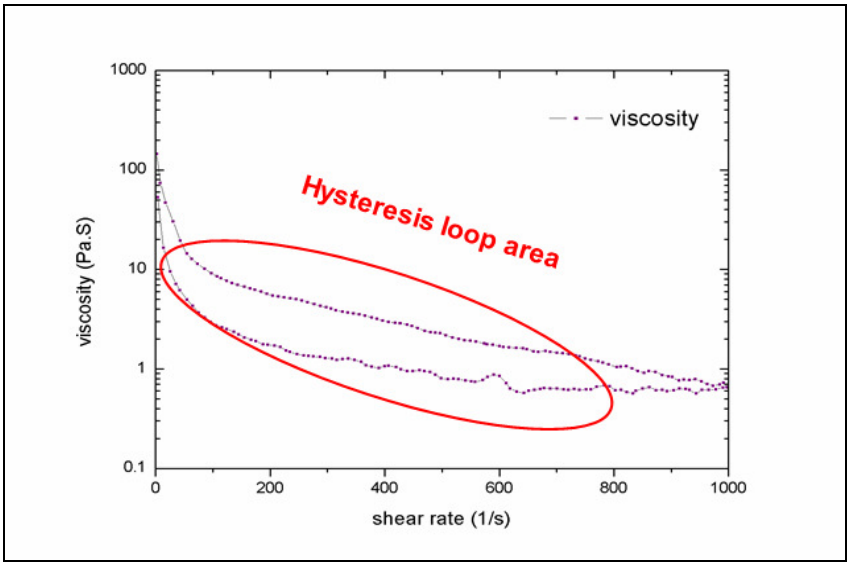

Fig 1 : A typical rheogram of Ethanol-MC gelled propellant.