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Short Communication

Production of Metalized UDMH Gel Fuel and Study the Effect of Surfactant on the Homogeneity and Stability of the Aluminium Nano Particles

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Abstract:

Gelled propellants are improved propellants that can be considered as the final extension of liquid propellants. High specific impulse, good density and safety better than that of both solid and liquid propellants are advantages of the gel propellants. They are made by addition a suitable gellant to liquid propellants. In this research, nano Al particles have been used in UDMH gel fuel. The gellation process was done in two steps. First, making metalized nano suspension using ultrasonic-magnetic agitation and second, gellation under mechanical-magnetic agitation. Tween-80 as a surfactant was added to the fuel to distribute nano Al particles in the gel media. Experimental study showed that, adding 3% Tween-80 to the gel mixture caused better distribution of nano particles in gel and improved homogeneity, stability and decreasing synersis of the liquid fuel, UDMH, from network of the gel.

Keywords: *Gel fuel, UDMH, Metalized gel, Nano aluminium*

1. INTRODUCTION

Liquid propellants, due to their advantages such as high specific impulse and trust managements ability have been used in liquid rocket missiles for many years [1]. Gelled propellants are improved propellants that can be considered as the final extension of liquid propellants. They are made by addition a suitable gellant to liquid propellants [2]. They have high specific impulse, good density and safety better than that of both solid and liquid propellants [3]. In gelled propellants, fuel and oxidizer, each one can be gelled [4]. Higher specific impulse rather than liquid propellants is obtained by addition of high energetic materials such as Al, Be, B, Ti and Zr to the composition of gelled propellants. Metallized gel propellants have been studied analytically and experimentally for over forty years, because energetic metal powder additives have been used to enhanced engine specific impulse, increase propellant density and system safety [5, 6].

Hydrazine gels are vigorous fuel for using in rocket propellants [7]. One of the important hydrazine base gel fuels is UDMH (Unsymmetrical Dimethyle Hydrazine) gel fuel. It is used as a fuel in rocket and missiles propellants for many advantages in Indian, Chinese, Russian and most European countries. It acts as a starter and is more stable in high temperatures. It has also many disadvantages such as; toxic, carcinogen, explodable in the presence of oxidizers and is absorbable by the skin [8]. For these reasons, gellation of UDMH is one of the best ways to increase its safety through combusting or storing the fuel.

UDMH has been metallized by Al and Mg particles until now. T. L. Varghese et.al successfully used Al particles (15, 1.5 μm and 0.1-0.2 m^2/gr surface area) in gelled UDMH fuel [9]. However the combustion efficiency of gelled propellants containing micro particle is not attractive this is enhanced using nano particles [10, 11]. scott et.al, used nano Al particles with mean diameter of 100-200 nm and surface area of 12-3 m^2/gr in DMAZ, (Di-methyl amino ethyl azide) and kerosene fuel gel by resonance acoustic mixer. In these fuel gels, a nonionic surfactant polyoxyethylene sorbitantrioleat (PST) was used in some cases. Surfactant was helpful as a wetting agent; it allowed better dispersion of the metal particles, through the mixture of gel fuel [12]. Liu. Xiang et.al also dispersed nano Al (50nm, 7 m^2/gr surface area) powders in kerosene gel fuel by magnetic-ultrasonic agitation to increasing the specific impulse [13,14].

Figure 1: *Making UDMH-nano Aluminium suspension under magnetic-ultrasonic agitation.*

In this research, nano Al particles have been used in UDMH gel fuel. Tween-80 as a surfactant has been added to the fuel, for better distribution of nano Al particles in gel media. For these reasons, percentage of surfactant which is used in gel is a major subject. In this paper the method for finding the best percentage of the surfactant used in UDMH fuel gel has been studied and also the effect of surfactant on the homogeneity, stability and uniformed distribution of Al nano particles in the gel was investigated.

Figure 2: *Gellation process by mechanic-magnetic agitation.*

2. EXPERIMENTAL

Gellation experiments were done at (15-20)^{o}C in a sealed glass reactor. At first, Nitrogen gas was purged in the initial (and final) step of gellation process to avoid air oxidation. Then UDMH (purity minimum 98.5%, moisture content: 0.3%, production of Malek Ashtar University) was charged to the reactor. Tween-80 (two gel samples with 1, 3 wt%, Merk Company) was added to UDMH as a surfactant, after that 5 wt% of nano Al particles (130 nm, Alex passivated by Al_2O_3, ATP/TECHNOLOGIES company, Russian Federal), was added pinch by pinch and the mixture was agitated by ultrasonic processor (UP400S, 60 pulse per second, multitude of 60%, H7/Tip7 sonotrods) and magnetic stirrer for 10 minutes, simultaneously. This process has been shown in figure 1, and stepwise, 7.5 wt% methyl cellulose, (63µm, Merk company) was added to the suspension under mechanical-magnetic agitation for 20 min, this process has been shown in figure 2. At the end UDMH gel was kept for 24 hours for gellation extension. It was shown that the production of metalized UDMH gel fuel has two steps. First, making metalized nano suspension (UDMH-nano Aluminium), by using ultrasonic-magnetic agitation and the second, the gellation process under mechanical-magnetic agitation.

2.1. Homogeneity tests

Homogeneity of nano Aluminium particles in UDMH gels was investigated. Two fuel gel samples (5% nano Aluminium, 1&3 wt% Tween-80) were studied. Piece of each samples, was taken from middle and bottom of the sample container. Each sample was weighted before and after drying (40°C and -400mbar in vacuum oven, 12 hours). Then experimental sendimated percentages of solid were comprised with calculated percentages of solid particles which were used in formulation of gel. Table (1) showed it distinctively.

Table (1), showed that homogeneity of solid nano Al particles in the sample (2), (3 wt% Tween-80) was better than sample (1).

Table 1: *Effect of surfactant on the homogeneity of gel.*

Sample	*(Tween-80)wt%*	*Al(130nm).wt%*	E.P.S.I.M*	C.P.S.I.M**	E.P.S.I.B***	C.P.S.I.B****
a	1	5	13.8	12.5	14.5	12.5
b	3	5	12.7	12.5	12.9	12.5

*: Experimental percentage of solid in the middle part of gel
**: Calculated percentage of solid in the middle part of gel
***: Experimental percentage of solid in the bottom part of gel
****: Calculated percentage of solid in the bottom part of gel

Table 2: *Effect of the surfactant on the stability of solid particles in UDMH gel.*

Sample	*(Tween-80)wt%*	*Al(130nm).wt%*	E.P.S.I.M*	C.P.S.I.M**	E.P.S.I.B***	C.P.S.I.B****
a	1	5	14.0	12.5	16.5	12.5
b	3	5	13.4	12.5	14.1	12.5

*: Experimental percentage of solid in the middle part of gel
**: Calculated percentage of solid in the middle part of gel
***: Experimental percentage of solid in the bottom part of gel
****: Calculated percentage of solid in the bottom part of gel

2.2. Stability tests

Two types of nano gel with different surfactant percentages were centrifuged by 500 g acceleration for 30 min and then samples were taken from middle and bottom of the centrifuged sample container. The test was followed by weighing them both before and after drying (40°C and -400 mbar in vacuum oven, 12 hours). Stability of nano particles in gels have been shown in table (2).

In table (2), it is appeared that by increasing 2% Tween-80 to the nano gel mixture, sendimated nano particles in the middle and bottom of the nano gel in sample (b) was decreased to 14.1% in comparison to sample (a) (16.5% solid percentages).

2.3. Synersis tests

Synersis, separation of liquid phase from network of gel, is one of the major parameters in identifying the homogeneity of the gel. These phenomena, takes place in systems which are not in equilibrium state. It means that the system is not a homogeny system. For identifying the effect of surfactant on the nano gel, two samples with 1% and 3% surfactant contents were weighted before and after centrifuging (in condition similar to centrifuging of stability tests). By this method, the percentages of vaporized UDMH or percentage of liquid fuel which took away from gel was recognized. Table (3) shows the results of synersis tests.

From table (3) It can be seen that in sample 1 vaporization of UDMH from gel was decreased by 3% in comparison to the sample which containing 1% surfactant. It may be resulted that by increasing the percentage of surfactant in gel, syneresis phenomena can be decreased.

Table 3: *Effect of the surfactant on UDMH synersis in gel.*

Sample	*(Tween-80)wt%*	*Al(130nm).wt%*	LOSS WEIGHT
a	1	5	14.0
b	3	5	11.4

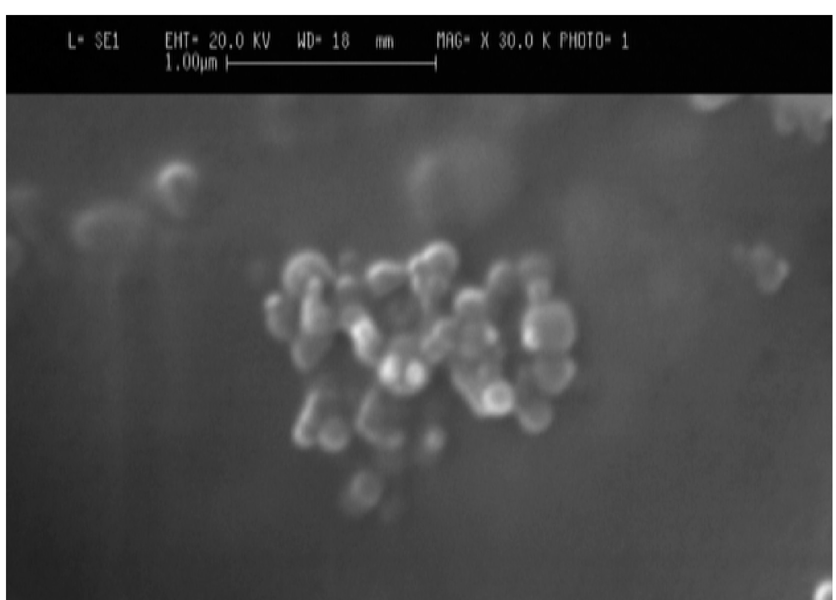

Figure 3: *Agglomerates of nano Aluminium particles (1% Tween-80).*

2.4. SEM

The studies of UDMH metalized gel were also carried out with the help of scanning electron microscope (SEM) in order to get clearer picture of the particles distribution scheme. It was done by LX30 Philiphs company with tungsten fileman. The samples were prepared using gold coating technique. A thick layer of the gel was spread over tiny glass chips which were then dried in the vacuum furnace, (35°C and -200 mbar in vacuum oven, 12 hours). The thickness of conducting metallic coating film could be achieved nearly 20 nm. The samples was then positioned in the sample compartment of SEM. Figure 3 showed that nano aluminium particles (containing 5% aluminium 130 nm and 1% Tween-80) were agglomerated whose sizes were between 500-700 nm but, in figure 4, (containing 5% Aluminium 130 nm and 3% Tween-80), separated nano Aluminium particles in sizes 130nm have been shown. These results were in agreement with the stability and homogeneity tests.

Figure 1, shows that in possessing metalized gel fuel, using ultrasonic processor (to stabilizing distribution of the nano particles in gel) is not efficient. Selecting the best percentage is the major parameter in uniformities and stabilized distribution of nano aluminium particles.

3. CONCLUSIONS

Gelled propellants are extended and improved liquid propellants. To increasing higher specific impulse, addition the energetic nano particles uniformly is one of the best ways to enhance the properties of UDMH gel. In this study, nano aluminium particles have been processed in UDMH gel network in two steps by using ultrasonic-magnetic and mechanical-magnetic agitators. Homogeneity and stability tests and also SEM pictures showed that 3% Tween-80 as a surfactant was an appropriate percentage to distribute nano aluminium particles uniformly and prevent them from agglomerating nano Al particles in the gel media.

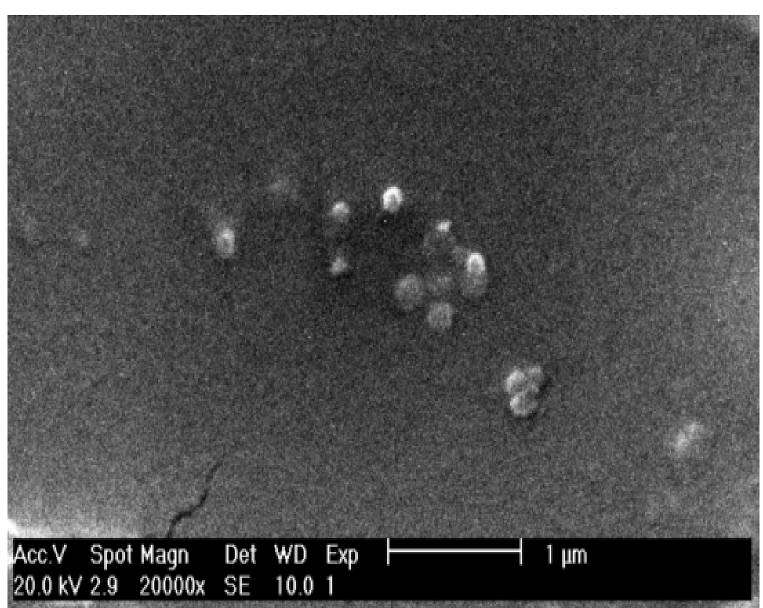

Figure 4: *Separated particles of nano Aluminium particles (3% Tween-80).*

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