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Amplification of Antipollution Action of JP8 using a Bioorganic Compound

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***Abstract*—In this paper we try to investigate how a bioorganic compound influences the physicochemical properties of jet fuel (JP8). Using specific volume of JP8(F-34) and specific mass of the hydrophilic polymer, we determine density, kinematic viscosity -20ºC, humidity, total acid number, heat of combustion, distillation residue, distillation temperature 10% recovered and flash point in order to study the effect of the bioorganic compound. The results show that humidity, total acid number could decrease considerably and heat of combustion, flash point could increase significantly, so that jet fuel's quality is improving.**

***Index Terms*—Bioorganic Compound, Distillation Proces, JP8, Physicochemical Properties, Total Acid Number (TAN).**

I. Introduction

JP-8 is a kerosene-based fuel that is blended with specific additives to make it suitable for use in military applications. Although, initially, it was used as an aviation fuel, its applications have been expanded to include ground vehicles as well as all types of diesel engine-powered systems and furnaces [4]. This is because both the U.S. and the NATO military forces have decided to simplify their fuel transport and distribution operations through the use of a single fuel **[**1**]**. JP-8 is approximately 99.8% kerosene by weight [1,2] and is a complex mixture of higher-order hydrocarbons, including alkanes, cyclo-alkanes, and aromatic molecules. JP-8 contains three mandatory additives: a fuel system icing inhibitor, a corrosion inhibitor, and a static dissipater additive [3].

In this paper, specific laboratory exercises for the analysis of jet fuel properties are presented, which concern the determination of density, kinematic viscocity (-20ºC), humidity, total acid number, heat of combustion, distillation temperature 90% recovered.

However, two of the most important factors during the combustion of JP8 are humidity and total acid number (TAN). Humidity because it causes corrosion, can cause ice blockage in the power grid that can be formed in low temperatures and last it can be divided during the warming-up and cause flame extinguishing from the produced steam (water vapour) and total acid number, because is an indication of the degree of oxidation and it is a facile method for monitoring fuel quality.

Our effort focuses on, how the conformation of the hydrophilic polymer via charged groups and dynamic absorption of water molecules (because we expect the polymer to retain these molecules) [5], acts on the physicochemical properties of JP8 which have significant role in qualitative control of jet fuels and their behavior during combustion. For this aim we introduce in a sample of JP8 the hydrophilic polymer Thermal Polyaspartate Anion TPA for forty five (45) minutes [5]. It is stressed that the volume of JP8 and the mass of the polymer maintain stable.

II. Production, Characteristics And Specifications of Jp8

A. Production and Characteristics of JP8.

Light jet fuels such as jet fuel no.1 (kerosene) are refined from straight distillation of crude oil or distillation of crude oil in the presence of a catalyst. Fuels such as JP-8 are then chemically enhanced with antioxidants, dispersants, or corrosion inhibitors to meet the requirements for a specific application. It consists of a mixture of petroleum hydrocarbons, chiefly of the methane series, which typically have from 10 to 16 carbon atoms per molecule. The typical components of the end product of jet fuel include paraffins (n-, iso-, monocycle-, bicycle- and tricycle-), olefins, aromatics and nitrogen and sulfur impurities [14].

B. Specifications of JP8.

Jet fuels are produced from refined crude petroleum to meet specifications for particular uses.

In the Table I below specifications of US Air Force for JP8-F34 (MIL-DTL-83133E 1 April 1999) are presented.

III. Experimental Process

A. Determination of physicochemical properties of JP8.

At first the values of physicochemical properties of JP8 (F34) (using an amount of 1000 mL) are determined with the

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ASTM methods and the appropriate equipment.

Although there are many standard methods used for analyzing the various properties, emphasis is placed on methods determined in our laboratory. The results are presented in the Table II below.

TABLE I SPECIFICATIONS OF PHYSICOCHEMICAL PROPERTIES AND THEIR METHODS OF DETERMINATION OF JP8 (US AIR FORCE MIL-DTL-83133E 1 APRIL 1999) [15].

Physicochemical Property	JP8 (F34)	Methods of Determination ASTM
Density 15°C, g/mL	0.775-0.840	D 1298 [8]
Kinematic Viscosity, (-20°C) mm^2/s (cSt)	<8.00	D 445 [9]
Humidity mg/kg	-	D 1744 [6]
Total Acid Number (mg/g KOH)	<0.015	D 664 [11]
Heat of Combustion, MJ/Kg	>42.8	D 4809 [10]
Flash Point (°C)	>38	D 93 [13]
Distillation Residue (vol %)	<1.5	D 86 [12]
Distillation Temperature 10% Recovery (°C)	<205	D 86 [12]

TABLE II: VALUES OF PHYSICOCHEMICAL PROPERTIES OF JP8 AND ITS METHODS OF DETERMINATION.

Physicochemical Property	JP8 (F34)	Methods of Determination ASTM
Density 15°C, g/mL	0.797	D 1298 [8]
Kinematic Viscosity, (-20°C) mm^2/s (cSt)	2.79	D 445 [9]
Humidity mg/kg	57.1	D 1744 [6]
Total Acid Number (mg/g KOH)	0.014	D 664 [11]
Heat of Combustion, MJ/Kg	43.52	D 4809 [10]
Flash Point (°C)	46	D 93 [13]
Distillation Residue (vol %)	0.005	D 86 [12]
Distillation Temperature 10% Recovery (°C)	180	D 86 [12]

The results of the distillation experiment it is shown in the Table III and the Fig. 1 below.

TABLE III: DISTILLATION OF JP8 (F34) [12].

Distillation of JP8 (F34) (Volume 50 mL)		
Distillation Volume % Recovered	Volume (mL)	Temperature (°C)
Initial Boiling Point	0	155
10	5	180
20	10	190
30	15	198
40	20	202
50	25	207
60	30	210
70	35	215
80	40	221
90	45	230
95	47.5	238

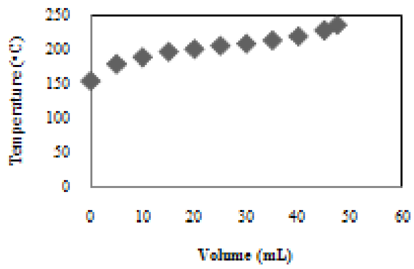

Fig. 1. Curve of Distillation of JP8 (F34) [12].

B. Determination of physicochemical properties of JP8 with TPA.

Since polymer TPA (Fig. 2) has been prepared in a quality of 5 g we introduced this amount in a sample of the same jet fuel (as above) of a volume 1000 mL (1L) (5 g of polymer is defined from the limits of chemical additives in liquid fuels which is 1-4 Kg/tn). This sample stays in an environment temperature for 45 minutes and we observe that the polymer remains indissoluble [5].

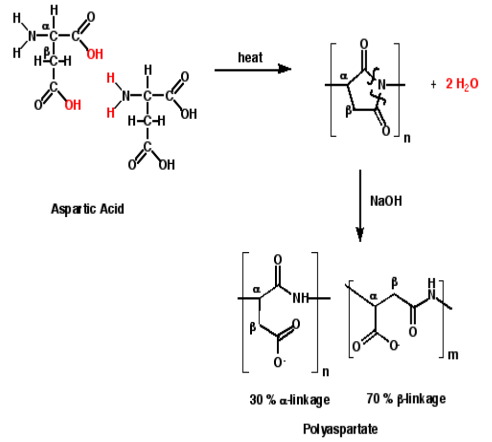

Fig. 2. Synthesis of Hydrophilic Polymer, Thermal Polyaspartate Anion (TPA). [5].

Next, we filtrate the mixture via the method ASTM D-2276 [7] by using the filtration device Millipore. We determine the same physicochemical properties (using the ASTM methods) and the results are presented in below Table IV.

TABLE IV: VALUES OF PHYSICOCHEMICAL PROPERTIES AND THEIR METHODS OF DETERMINATION OF JP8.

Physicochemical Property	JP8 (F34)	Methods of Determination ASTM
Density 15°C, g/mL	0.795	D 1298 [8]
Kinematic Viscosity, (-20°C) mm^2/s (cSt)	2.74	D 445 [9]
Humidity mg/kg	42.4	D 1744 [6]
Total Acid Number (mg/g KOH)	0.004	D 664 [11]
Heat of Combustion, MJ/Kg	44.56	D 4809 [10]
Flash Point (°C)	49	D 93 [13]
Distillation Residue (vol %)	0.005	D 86 [12]
Distillation Temperature 10% Recovery (°C)	182	D 86 [12]

The results of the distillation experiment it is shown in the Table V and the Fig. 3 below.

TABLE V: DISTILLATION OF JP8 (F34) WITH TPA [12].

Distillation of JP8 (F34) with TPA (Volume 50 mL of JP8)		
Distillation Volume % Recovered	Volume (mL)	Temperature (^oC)
Initial Boiling Point	0	158
10	5	182
20	10	193
30	15	198
40	20	203
50	25	207
60	30	211
70	35	215
80	40	221
90	45	229
95	47.5	239

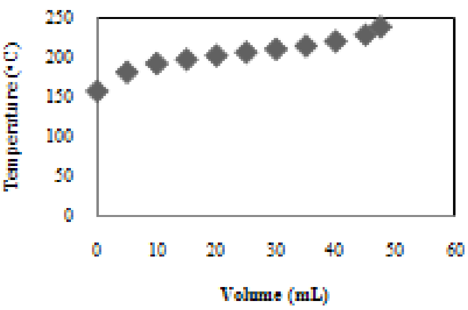

Fig. 3. Curve of Distillation of JP8 (F34) with TPA[12].

IV. CONCLUSIONS

According to the values of the physicochemical properties we realize that the sample of JP8 (F34), as well as the sample of JP8 with TPA met the US Air Force specifications (Tables I, II and IV) (MIL-DTL-83133E 1 April 1999).

Firstly, comparing values of physicochemical properties of density, kinematic viscosity (-20oC), distillation residue and distillation temperature of 10% recovery (Tables II-IV) we realize that they are not influenced by the use of the polymer.

Secondly, the values of Tables II -IV have shown, that JP8 with TPA, have less water and lower total acid number (TAN) than the other sample with simple JP8 (about 26% and 71% equivalently). The result of elimination of humidity and the low TAN, may not only effect in several functions (reduce icing effect- no use of anti-icing additives), but also could avert corrosion during storage.

Thirdly, the increased values of the heat of combustion and the flash point (Tables II and IV) could upgrade the thermal efficiency of producing power, improve ignition quality and reduce knock and smoke.

Furthermore, TPA could be used during the transportation of JP8 into the airports or in the storage tanks in order to eliminate humidity in short time before fuels use.

In conclusion, the values of the physicochemical properties from JP8 with TPA, amplifies its antipollution action, because no anti icing additives or chemicals for reducing acidity are needed so that the exhaust gases are less polluting to the environment.

REFERENCES

[1] *JP-8, the Single Fuel Forward, an Information Compendium. U.S. Army Tank Automotive and Armaments Command*, Warren, MI,May 2001.

[2] *Aviation Fuels Technical Review (FTR-3)*, Chevron Products Company, 2000.

[3] *Annual Energy Outlook 2002 with Projections to 2020.* U.S. Department of Energy and National Energy Information Center, DOE/EIA 0383, December 2001.

[4] Constantinos D. Rakopoulos, Dimitrios T. Hountalas, Dimitrios C. Rakopoulos and Yiannis A. Levendis "Comparative Environmental Evaluation of JP-8 and Diesel Fuels Burned in Direct Injection (DI) or Indirect Injection (IDI) Diesel Engines and in a Laboratory Furnace" *Energy & Fuels*, Vol. 18, No. 5 pp1302 -1308, 2004.

[5] C.G. Tsanaktsidis, S.G. Christidis and G.T. Tzilantonis, "Study about Effect of Processed Biodiesel in Physicochemical Properties of Mixtures with Diesel Fuel in order to Increase their Antifouling Action", *International Journal of Environmental Science and Development*, Vol. 1, No. 2, pp 206, 2010.

[6] *Determination of Water in Petroleum Products by Karl Fischer Reagent* ASTM D1744-92 Standard Test Method, Withdrawn 2000.

[7] *Particulate Contaminant in Aviaton Fuel by Line Sampling*, ASTM D2276 - 06 Standard Test Method, 2006.

[8] *Density Relative Density (Specific Gravity), or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method*, ASTM D1298 – 99 Standard Test Method, 2005.

[9] *Kinematic Viscosity of Transparent and Opaque Liquids (and Calculation of Dynamic Viscosity)*, ASTM D445-06 Standard Test Method, 2006.

[10] *Heat of Combustion of Liquid Hydrocarbon Fuels by Bomb Calorimeter (Precision Method)*, ASTM D4809 - 09a Standard Test Method, 2009.

[11] *Acid Number of Petroleum Products by Potentiometric Titration*, ASTM D664-09α Standard Test Method, 2009

[12] *Distillation of Petroleum Products at Atmospheric Pressure*. ASTM D86 - 10a Standard Test Method, 2010.

[13] *Flash Point by Pensky-Martens Closed Cup Tester*, ASTM D93 - 10a Standard Test Methods, 2010.

[14] http:// *www.atsdr.cdc.gov/.../tp76-c4.pdf*

[15] http://propellants.ksc.nasa.gov/commodities/specs MIL_DTL_83133E.pdf

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