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Evaporation and Flammability Studies of Jet A-1 Fuel Blended with n-hexane and Domestic Grade Kerosene

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Abstract:

In the present study, Jet A-1 blended fuels were prepared using n-hexane and domestic-grade kerosene in different ratios. Afterwards, characterization studies were conducted which includes, a) density, b) dynamic/kinematic viscosity, c) calorific value, d) flammability, and e) evaporation constant. For evaporation studies, an in-house developed hanging droplet method was used. Evaporation constant (λ) was determined for each sample by varying the heat flux and by noting down the evaporation time. From the experiments, positive result was obtained for the blends of n-hexane and domestic grade kerosene with Jet A-1. From the obtained results, it was observed that blends of 90 % Jet A-1, 5 % n-hexane & 5 % DGK, and blends of 80 % Jet A-1 & 20 % n-hexane show the better results.

Keywords:

Jet A-1, Jet A-1 fuel blends, droplet evaporation, evaporation constant, fuel efficiency, fuel performance

Nomenclature:

D	Droplet diameter [m]
D_0	Initial droplet diameter [m]
t_e	Total evaporation time [s]
$\dot{m}_f$	Evaporation rate [kg/s]
ρ_f	Fuel density [kg/m^3]
k_g	Thermal conductivity of gas [W/(m·K)]
c_p	Specific heat at constant pressure [J/(kg·K)]
B	Spalding mass transfer number [–]
λ	Evaporation constant [m^2/s]

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1 Introduction

Military aircrafts heavily rely on aviation grade kerosene for their operation. Aviation fuel is a type of hydrocarbon fuel which offers high specific energy (energy per unit mass of fuel burnt) and high energy density (power per unit volume). As compared to the aviation fuel, any rechargeable modern battery has yet to produce enough energy to be directly used for aviation purpose [1]. Due to high energy content per unit volume of liquid jet fuels, it is the primary choice as a fuel for defense applications [2, 3].

Initially, unpurified kerosene was used as fuel for aviation purposes. As of now, several grades of jet fuel have been developed and are being used consistently. To increase the efficiency of the jet engines and to lower the space occupied by the fuel, the need to produce fuels that have higher specific energy is prominent. In general, kerosene, jet fuel and aviation turbine fuels are used to power jets. However, jet fuel is majorly used for commercial flights and for military Jet aircrafts.

Jet fuels are colorless energetic liquids and are classified on the basis of octane ratings into Jet A, Jet A-1, and Jet B. Jet A or JP-8 are used in the civilian jets only. Jet B or JP-4 are mostly used in military jets. JP-4 is used for defense purposes because it can operate well in harsh climatic conditions. Jet-B fuels have a lower freezing point and flash point than JP-8 or any other grade [4]. Jet fuels are extracted from crude petroleum oil through a process called atmospheric and vacuum fractional distillation. The schematic diagram of the process can be seen in Fig. 1.

Jet fuels derived from such methods contains a wide distribution of paraffins, Generally, Jet fuel has 20 % normal paraffins, 40 % iso-paraffins, 20 % naphthene, and 20 % aromatics [5].

Recently, various additives are being mixed with the Jet fuel to increase the thrust production and to decrease the emission of harmful gases [6]. Due to its sustainability, the recent introduction of hydrogen and vegetable oil into the conventional fossil fuel has gained popularity without requiring significant changes to existing engine's architecture [7, 8]. Because of its low combustion rate and increased NOx emissions, direct usage of vegetable oil shortens engine life [9]. The transesterification technique is used to combine the vegetable oil in order to separate the glycerin. Fuel atomization is also increased when glycerin is removed from vegetable oil, which is very crucial for the injection of the fuel in combustion chamber. By the elimination of the glycerin content in the neat oil, the viscosity of the vegetable oil is also decreased [10]. Many studies have conducted experiments on the mixture of vegetable oil and the fossil fuel. Kegl and Hribernik mixed rapeseed with neat mineral diesel D2 showing that the addition of rapeseed actually decreases the formations of CO, HC and soot emission [11] while Qi et al. [12] produced contrary results.

Ethanol is also very popular as an additive though there is some inconsistency with its blend with jet fuel. Low solubility, low cetane, and lower flashpoint of ethanol present some obstacles to its addition into aviation fuel [13]. The solubility of ethanol on Jet-A fuel declines as the percentage of ethanol increases in the Jet fuel [14]. The pioneers were compelled to use no more than 20 % ethanol in the jet fuel in order to prevent that. Several studies shown that 15 % v/v ethanol could be employed straight into a diesel engine without requiring significant engine modifications [15]. Lapuerta et al. demonstrated that 20 % v/v ethanol is feasible [16]. Xiu-tian-feng et al. showed the improved ignition and combustion efficiency of high energy density fuel JP-10 with introducing Pt (Platinum) and Pd (Palladium) nanoparticles [17]. From these studies, it is clear that the mixing of additives in conventional fuel is very crucial to increase the efficiency of the fuel. In the present work, Jet A-1 fuel was modified with the addition of n-hexane and Domestic Grade kerosene in different ratios. N-hexane has lower viscosity and lower boiling point than the Jet A-1 fuel. Mixing it with Jet fuel will overall reduces the viscosity and increase the volatility improving the atomization and promoting the rate of evaporation of the fuel droplets. Afterwards, experiments were performed to evaluate physical and chemical properties of prepared fuels. Finally, evaporation studies were performed by suspended droplet method to evaluate evaporation rate and evaporation constant $\lambda$for different ambient temperatures. Fig. 2 shows the setup for performing the evaporation studies on the hanging droplet. All these studies were performed to check the best prepared fuel sample having high energy density and high specific energy. From the preliminary studies, it was observed that 90 % Jet A-1, 5 % n-hexane & 5 % kerosene (domestic grade) and 80 % Jet A-1 & 20 % n-hexane fuel sample have the potential to use in military aircrafts for superior performance.

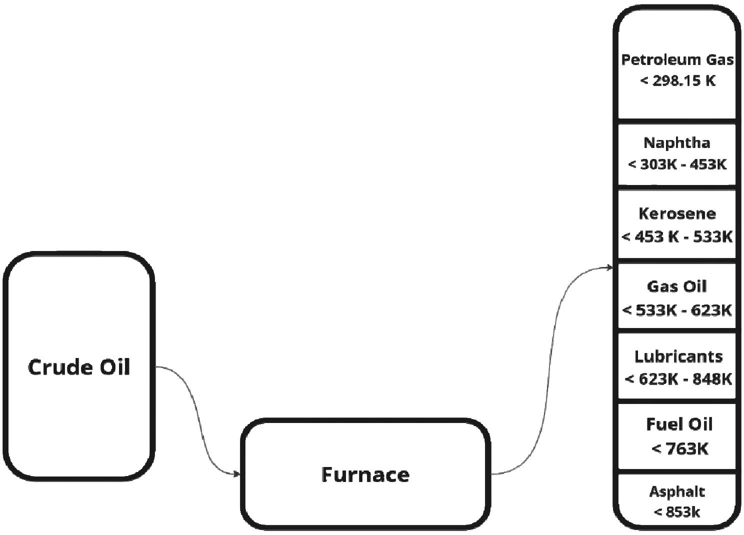

Fig. 1 Fractional distillation of crude oil

2 Methods and Materials

2.1 Materials and Preparation of Fuel Samples

Several blends of jet-fuel with n-hexane and kerosene (domestic grade) were prepared in different proportions. N-hexane is colorless liquid with a gasoline-like odor. Jet A-1 is provided by the Department of Aerospace Engineering, IIT Kharagpur. Commercially available kerosene (domestic grade) was used, and n-hexane was produced from Merck. A total of 9 samples were considered for the study, out of which 3 were pure samples of Jet A-1, n-hexane, and *DGK* (domestic-grade kerosene) in different proportions. The samples were prepared using volume/volume method, and each sample was mixed homogeneously using prove sonicator. The details of fuels used in the present study is given in Tab. 1.

Tab. 1 Sample fuels with various proportions of Jet A-1, n-hexane and DGK (domestic-grade kerosene)

S. no.	**Concentration [%]**		
	Jet A-1	**n-hexane**	***DGK***
1	—	100	—
2	100	—	—
3	—	—	100
4	80	20	—
5	80	—	20
6	80	10	10
7	90	10	—
8	90	—	10
9	90	5	5

* *DGK* = Domestic Grade Kerosene

2.2 Viscosity of the Fuel Samples

Rotational viscometer [*Make: Anton Paar, Model: Visco QC 300*] was used to measure the viscosity of the fuel samples. The readings for dynamic viscosity were measured in [mPa·s]. The spindle code of the spindle used for viscosity measurement was DG36. The Rotational Viscometer measures the viscosity by moving a spindle in the fluid sample and measuring the torque generated by the rotating spindle.

2.3 Calorific Values of the Fuel Samples

The heat of combustion [cal/g] was measured using Digital Bomb Calorimeter [*Make: Labtronics*]. The apparatus was well calibrated by Benzoic Acid which is a thermochemical standard for the calibration of any bomb calorimeter. The bomb calorimeter was used to determine the energy content of a particular fuel sample. Inside the Bomb Calorimeter, sample was combusted in the presence of oxygen maintained at a pressure of 1.38 MPa (200 psi).

2.4 Density

Density meter [*Make: Labman*] was used to measure the density [kg/m^3] of all the samples.

2.5 Rate of Evaporation of Hanging Droplet

The first-ever theoretical approach towards the problems of the Droplet Evaporation was given by Godsave [18] and Spalding [19]. The rate of evaporation was derived for a single droplet.

$$\dot{m}_\mathrm{f} = \frac{\pi}{4} \rho_\mathrm{f} \lambda D \tag{1}$$

where

$$\lambda = \frac{\mathrm{d}D^2}{\mathrm{d}t} \tag{2}$$

From Eq. (1), we can derive the average rate of evaporation during the drop lifetime.

$$\dot{m}_\mathrm{f} = \frac{\pi}{6} \rho_\mathrm{f} \lambda D_0 \tag{3}$$

Now, if we assume λ as constant, then integrating Eq. (2) can get us the value of Drop Lifetime.

$$\int_0^{t_\mathrm{e}} \lambda \mathrm{d}t = \int_{D_0}^{0} \mathrm{d}D^2 \tag{4}$$

$$t_\mathrm{e} = \frac{D_0^2}{\lambda} \tag{5}$$

The evaporation rate of droplet can also be expressed in the terms of mass transfer number B [19, 20].

$$\dot{m}_\mathrm{f} = 2\pi D \left(\frac{k}{c_\mathrm{p}} \right)_g \ln\left(1+B\right) \tag{6}$$

From the above equations, now the droplet lifetime can be obtained.

$$t_\mathrm{e} = \frac{\rho_\mathrm{f} D_0^2}{8\left(k/c_p\right)_g \ln\left(1+B\right)} \tag{7}$$

The transfer number B can also be obtained from the Evaporation Constant (λ).

$$\lambda = \frac{8\left(k/c_p\right)_g \ln\left(1+B\right)}{\rho_\mathrm{f}} \tag{8}$$

If we calculate the $\dot{m}_f$ and t_e from the mass transfer number B then the results are very dependent on the values of k and c_p [21].

2.6 Flammability Limit of the Fuel Samples

Flammability limit of each sample was theoretically evaluated using lower specific energy and molecular mass values. Flammability limits tells us the minimum (lean) and maximum (rich) concentration of the fuel which is needed to initiate the combustion in the mixture of air and fuel. Knowing these values is crucial for the safe handling and transportation of aviation fuels. The lean limit for the fuels at 1 atm can be obtained by:

$$L = \frac{4349}{LSE \cdot MM} \tag{9}$$

where L is the lean limit [percent by volume], MM is the molecular mass of the fuel sample and LSE is the lower specific energy in [MJ/kg].

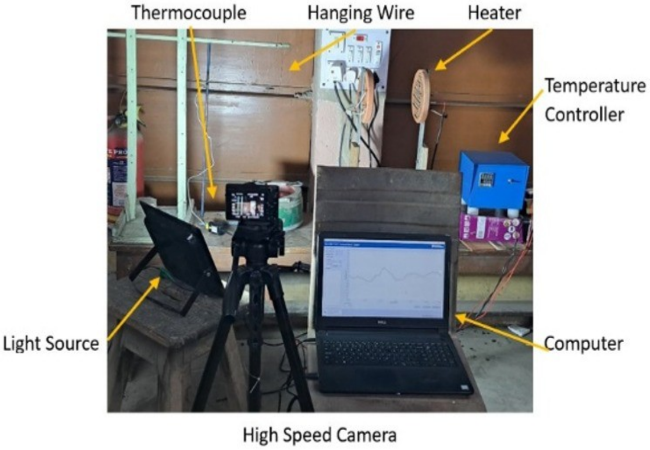

Fig. 2 Experimental setup

3 Results and Discussion

3.1 Density Measurements

Some basic properties of Jet A-1, n-hexane, and *DGK* (domestic grade kerosene) that were measured experimentally are listen in Tab. 2.

Physical properties like density and viscosity play a vital role on the atomization and the spray characteristics. Also, the overall extent of the atomization depends on the secondary breakup which follows after the initial breakup of the bulk liquid into small droplets, while the secondary breakup depends upon the Weber number. The increment in the fuel density lowers the fuel injection velocity which results in a high value of Weber Number. Thus, the increased density of the fuel decreases the extent of atomization [22].

Tab. 2 Density, viscosities and calorific values of fuel samples

S. no.	Density [kg/m^3]	Dynamic Viscosity [mPa·s]	Kinematic Viscosity [mm^2/s]	Calorific Value [kJ/kg]
1	784	1.165	1.5	43 572.03
2	794	1.357	1.7	44 208.42
3	653	0.738*	1.1	42 128.08
4	753	0.900	1.2	40 479.28
5	786	1.255	1.6	41 366.55
6	788	1.164	1.5	40 867.10
7	793	1.252	1.6	41 442.08
8	785	1.027	1.3	41 260.70
9	778	1.030	1.3	40 915.67

* Due to the lowest viscosity of n-hexane, the frequency of the moving spindle was set to 200 rev/min. In every other reading except the n-hexane, the spindle is moving at 100 rev/min.

3.2 Relative Density, API Gravity and Molecular Mass

Relative density (formerly known as specific gravity) is the density of a fuel measured in relation to the density of water at a specified temperature for liquid fuels, or in relation to air for gaseous fuels. At the time of the experiments, the room temperature was 28.4 °C. The density of water at 28 °C (atmospheric pressure) is 996 kg/m^3 [23]. The relative density or the specific gravity can be calculated as:

$$SG_{\text{true}} = \frac{\rho_{\text{sample}}}{\rho_{\text{water}}} = \frac{m_{\text{sample}}/V}{m_{\text{water}}/V} = \frac{m_{\text{sample}}}{m_{\text{water}}} \tag{10}$$

In the United States, fuel density is often expressed in terms of API gravity (American Petroleum Institute gravity). It can be calculated as:

$$API_{\text{Gravity}} = \frac{141.5}{d_{\text{r}}} - 131.5 \tag{11}$$

Here d_{r} refers to relative density. Relative density and API gravity are both dimensionless quantities.

In his book gas turbine combustion: Alternative fuels and emissions, Lefebvre described a formula of finding the molecular mass of the fuel from its API gravity [24] as follows:

$$MM = \frac{11280}{API_{\text{Gravity}}^{1.1}} \tag{12}$$

Density was measured using a 10 ml specific gravity bottle. The values for the density kg/m^3, relative density, API gravity and molecular mass are given in Tab. 3.

Tab. 3 Density [kg/m^3] of fuel samples

S. no.	**Density [kg/m^3]**	**Specific Gravity**	**API Gravity**	**Molecular Mass**
1	784	787	48.296	158.492
2	794	797	46.041	167.052
3	653	656	84.201	85.993
4	753	756	55.669	135.562
5	786	789	47.841	160.149
6	788	791	47.387	161.839
7	793	796	46.264	166.166
8	785	788	48.069	159.315
9	778	781	49.678	153.649

Standard Jet A-1 fuel has a density of 784 kg/m^3 which is slightly lower than the *DGK* (794 kg/m^3). Among the fuel samples, pure n-hexane has the lowest density, indicating that blending of n-hexane with Jet A-1 fuel will reduce the overall density of the mixture. In contrast, blending *DGK* with Jet A-1 – regardless of the mixing ratio – will increase the overall density of the fuel sample. Among the blends, sample no. 4 i.e. 80 % Jet A-1 fuel and 20 % n-hexane shows the lowest density of 753 kg/m^3. Sample no. 9 i.e. 90 % Jet A-1 fuel, 5 % *DGK*, and 5 % n-hexane has a density lower than that of the neat Jet A-1 fuel. Though the density is not the sole criteria for the quality of the atomization yet we can say that sample 4 (80 % Jet A-1 and 20 % n-hexane) and sample 9 (90 % Jet A-1, 5 % *DGK*, and 5 % n-hexane) may increase the extent of atomization in the engine that could result into the increased efficiency of the aviation fuel.

3.3 Lower Specific Energy and Flammability Limit

In his book, Ragozin proposed several methods for calculating the lower specific energy of fuels, as it is particularly relevant in studies of alternative aviation fuels. He suggested a formula given by Mendeleyev [25].

$$LSE = 0.399C + 1.03H - 0.109(O - S) - 0.025W \tag{13}$$

where *LSE* (Lower Specific Energy) of the fuel is in megajoule per kilogram. *C*, *H*, *O*, *S* and *W* are the mass percentage of carbon, hydrogen, oxygen, sulfur and water respectively. If the chemical composition of the fuel is not known, then also, the Lower Specific Energy of the fuel can be calculated by the values of relative density with less precision.

$$LSE = 51.5 - \frac{5.95}{1.53 - d_{\mathrm{r}}} \tag{14}$$

where *LSE* is in megajoule per kilogram and d_{r} is relative density. Tab. 4 contains the values of lower specific energy driven from the relative density of the fuel samples, as stated in.

The lower specific energy of the hydrocarbon fuels can be related to their specific gravity. The relation between them can be seen from Fig. 3.

Tab. 4 Calorific values of fuel samples

S. no.	***J* [%]**	***DGK* [%]**	**nh [%]**	**Relative Density**	***LSE* [kJ/kg]**
1	100	–	–	787	43 492
2	–	100	–	797	43 383
3	–	–	100	656	44 692
4	80	–	20	756	43 813
5	80	20	–	789	43 471
6	90	–	10	791	43 449
7	90	10	-	796	43394
8	80	10	10	788	43481
9	90	5	5	781	43556

**J* = Jet A-1, *DGK* = Domestic Grade Kerosene, nh = n-hexane, *LSE* = Lower Specific Energy

From the Fig. 3, it is clear that the lightest fuel has the highest specific energy. n-hexane being the lightest among the fuel samples has the highest specific energy i.e. 44 692 kJ/kg. Only the fuel blends with 80 % Jet A-1 – 20 % n-hexane and 90 % Jet A-1 – 5 % *DGK* – 5 % n-hexane shows the specific energy greater than the neat Jet A-1 fuel i.e. 43 813 kJ/kg and 43 556 kJ/kg, respectively. This slight increase in the specific energy value may be due to the addition of paraffin in the Jet A-1, as the specific energy of the *DGK* fuel is lesser than the neat Jet A-1. The blend of *DGK* alone with the Jet A-1 further decreases the specific energy. The choice of fuel for aircraft depends on specific limitations – whether it is tankage space, as in military aircraft, or fuel weight, as in freight planes [24].

Having found the lower specific value, we can find the values of the lean-limit and rich-limit concentration of the fuel-air mixtures. An atomizer breaks the bulk liquid in smaller droplets, which mixes with the air and makes a combustible mixture. flammability limits tell us the minimum (lean) and maximum (rich) concentration of the fuel which is needed to initiate the combustion in the mixture of air and fuel. Knowing these values makes it more crucial for the safety handling and transportation of the aviation fuels.

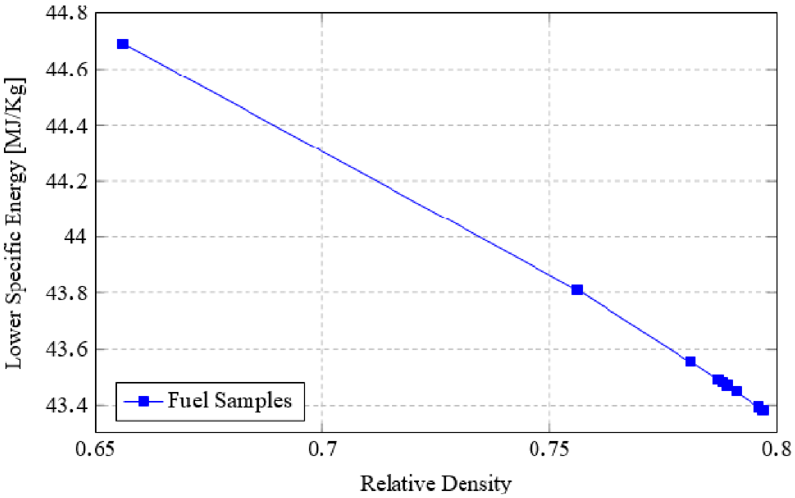

Fig. 3 Dependence of lower specific energy on relative density

The lean limit for the fuels at 1 atm can be obtained by this formula.

$$L = \frac{4349}{LSE \cdot MM} \tag{15}$$

where L is the lean limit [percent by volume], MM is the molecular mass of the fuel sample and LSE is the lower specific energy in MJ/kg.

The Eq. (15) can also be expressed in the form of lean limit (fuel-air ratio).

$$L_{\mathrm{f/a}} = \frac{L \cdot M}{28.97(100 - L)} \tag{16}$$

Here $L_{f/a}$ is the lean limit concentration (fuel-air ratio), L is the lean limit concentration [percent by volume].

$$R = L + \frac{143}{MM^{0.3}} \tag{17}$$

$$R_{\mathrm{f/a}} = \frac{R \cdot M}{28.97(100 - R)} \tag{18}$$

Here R is the rich limit [percent by volume] and $R_{f/a}$ is the rich limit (fuel-air ratio). Tab. 5 contains the lean limit concentration (L), lean limit concentration (fuel-air ratio) ($L_{f/a}$), rich limit [percent by volume] (R) and rich limit (fuel-air ratio) ($R_{f/a}$).

Tab. 5 Lean and Rich limit concentration of the fuels

S. no.	***J* [%]**	***K* [%]**	**nh [%]**	***L***	***L*$_{f/a}$**	***R***	***R*$_{f/a}$**
1	100	–	–	0.631	0.0347	4.755	0.273
2	–	100	–	0.600	0.0348	4.575	0.277
3	–	–	100	1.131	0.0339	7.458	0.239
4	80	–	20	0.732	0.0417	5.333	0.264
5	80	20	–	0.625	0.0348	4.719	0.274
6	90	–	10	0.618	0.0347	4.682	0.275
7	90	10	–	0.603	0.0348	4.593	0.276
8	80	10	10	0.628	0.0348	4.737	0.274
9	90	5	5	0.650	0.0347	4.865	0.271

* J = Jet A-1, K = Domestic Grade Kerosene, nh = n-hexane, L = lean limit [percent by volume], $L_{f/a}$ = lean limit (fuel-air ratio), R = rich limit (percent by volume), $R_{f/a}$ = rich limit (fuel-air ratio)

3.4 Evaporation Constant

Droplet lifetime was measured in atmospheric pressure at 90 °C, 120 °C and 150 °C by giving heat flux from sides of the droplet. All samples were hung on the form diameter ring structure made of a 1 mm thick spring steel wire, creating a perfect hemispherical shape. We used the characteristics diameter D_0 [26] mentioned in equation below.

$$D_0 = \sqrt[3]{D_h^2 D_v} \tag{19}$$

D_h and D_v are the horizontal and the vertical diameter of the droplets, respectively (Fig. 4).

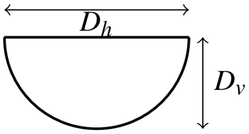

Fig. 4 Schematic representation of semi-circular droplet

The droplet lifetime values of each sample in three different temperature conditions is given in Tab. 6. The droplet lifetime is decreasing with the increasing temperature. From the Eq. (5), we can find the evaporation constant (λ) from the values of droplet lifetime t_e and the initial diameter of the droplet D_0.

The droplet lifetime is decreasing with the increasing temperature. From the Eq. (5), we can find the evaporation constant λ from the values of droplet lifetime t_e and initial diameter of the droplet D_0. The evaporation constant λ for each fuel sample is given below in Tab. 7.

Tab. 6 Droplet lifetimes of fuel samples

S. no.	***J***	***K***	**nh**	**Droplet lifetime [s]**		
	[%]	[%]	[%]	90 °C	120 °C	150 °C
1	100	–	–	201	85	50
2	–	100	–	119	68	28
3	–	–	100	38	24	19
4	80	–	20	253	82	43
5	80	20	–	277	76	36
6	90	–	10	242	55	28
7	90	10	–	133	88	37
8	80	10	10	179	45	32
9	90	5	5	320	105	49

* *J* = Jet A-1, *K* = Domestic Grade Kerosene, nh = n-hexane

The evaporation constant λ is a measure of how quickly a fuel droplet evaporates. As shown in Tab. 7, the evaporation constant λ increases with temperature for a given fuel sample. At elevated temperatures, such as 150 °C, fuel blends like 80 % Jet A-1 with 20 % n-hexane and 90 % Jet A-1 with 10 % n-hexane exhibit high evaporation constants, with values of 1.57 and 1.29, respectively.

Tab. 7 Evaporation constants of fuel samples

S. no.	***J* [%]**	***K* [%]**	**nh [%]**	**D_0 [mm]**	**Evaporation Constant (λ) [mm^2/s]**		
					90 °C	120 °C	150 °C
1	100	–	–	6.00	0.18	0.42	0.72
2	-	100	–	6.10	0.31	0.54	1.33
3	-	–	100	5.90	0.92	1.45	1.83
4	80	–	20	6.00	0.14	0.44	1.57
5	80	20	–	6.00	0.13	0.47	1.00
6	90	–	10	6.00	0.15	0.65	1.29
7	90	10	–	6.03	0.27	0.41	0.98
8	80	10	10	6.00	0.20	0.80	1.13
9	90	5	5	6.00	0.11	0.34	0.73

* *J* = Jet A-1, *K* = Domestic Grade Kerosene, nh = n-hexane, D_0 = Initial diameter of droplet

Fig. 5 shows the graphical representation of the evaporation constant (λ) of different samples with three different ambient temperatures i.e. 90 °C, 120 °C and 150 °C.

4 Conclusions

In the present work, various properties of fuel blends based on Jet A-1, n-hexane and *DGK* were experimentally investigated to get the basic idea about the use of samples for military aviation purposes. The physical properties such density, dynamic viscosity, calorific value and rate of evaporation were determined experimentally and theoretically. Properties like API gravity, molecular mass and the lean-rich limit mixture was derived by the relations among properties. From the density measurements, it is evident that blending n-hexane with Jet A-1 results in a fuel mixture with a lower density than standard jet fuels used in both civil and military aviation. The blend containing 80 % Jet A-1 and 20 % n-hexane exhibits the lowest density at 753 kg/m^3, which enhances fuel flow efficiency into the combustion chamber. Additionally, the sample compromising 90 % Jet A-1, 5 % *DGK*, and 5 % n-hexane have a density of 778 kg/m^3, slightly lower than that of standard Jet A-1 fuel, which has a density of 784 kg/m^3.

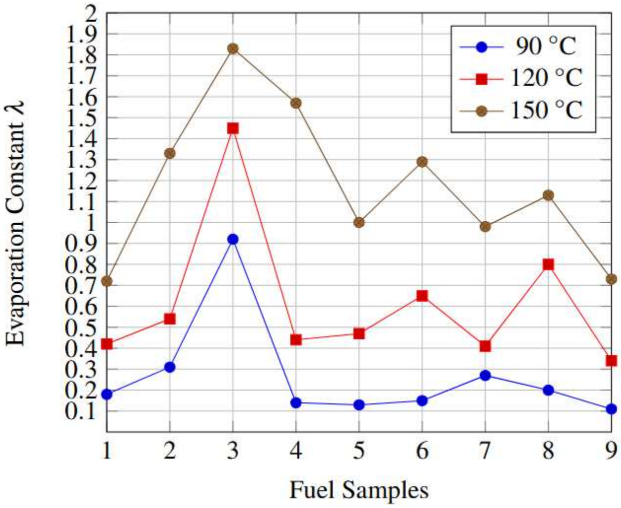

Fig. 5 Evaporation constant λ for fuel Samples

n-hexane has the lowest dynamic viscosity among the fuel samples. It is evident from its viscosity value that blending n-hexane with neat Jet A-1 reduces the overall dynamic viscosity of the mixture, resulting in a thinner, less viscous fuel blend. From this experimental investigation, we can conclude that mixing of low density of n-hexane with Jet A-1, regardless of its concentration in the sample, indeed have an effect on the fuel's viscosity. The sample with 80 % Jet A-1 and 20 % n-hexane shows 0.900 mPa·s dynamic viscosity which is significantly lower than the viscosity of neat Jet A-1 fuel (1.165 mPa·s). The samples having 80 % Jet A-1, 10 % n-hexane & 10 % *DGK* and 90 % Jet A-1, 5 % n-hexane & 5 % *DGK* also show lower values i.e. 1.027 mPas and 1.03 mPa·s respectively.

From lower specific energy calculations, we conclude that the lighter fuels have the high values of lower specific energy. Fuel blend having 90 % Jet A-1, 5 % *DGK* and 5 % n-hexane has the lower specific value greater than that of the neat jet fuel i.e. 43 556 kJ/kg.

At temperature 150 °C, the evaporation constant λ of every fuel blend is greater than the neat Jet A-1. Especially, 80 % Jet A-1 & 20 % n-hexane, 90 % Jet A-1 & 10 % n-hexane and 80 % Jet A-1, 10 % *DGK* & 10 % n-hexane has improved evaporation constant i.e. 1.57 mm/s^2, 1.29 mm/s^2 and 1.13 mm/s^2 respectively. Basically, the addition of n-hexane is improving the evaporation in the fuel.

Several criteria must be met for a fuel to be suitable for aviation use. Based on the conducted experiments, the addition of n-hexane to Jet A-1, long with *DGK*, demonstrates promising properties. Fuel blends such as 80 % Jet A-1, 10 % *DGK* and 10 % n-hexane; 90 % Jet A-1, 5 % *DGK*, and 5 % n-hexane; and 90 % Jet A-1 with 10 % n-hexane show potential for application in both military and civilian aviation.

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