ISSN: 4461 - 4780
Volume 15, Number 2, 2025
International Journal of Applied Science and Engineering
www.bwjournal.org

PRODUCTION AND CHARACTERIZATION OF FUEL BLEND OBTAINED FROM KEROSENE AND BASE OIL

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ABSTRACT

This project investigates the production and characterization of a fuel blend derived from kerosene and base oil, focusing on key parameters such as relative density, flash point, and viscosity. The study aims to develop a hybrid fuel with properties optimized for safety, performance, and practical applications. Blends of kerosene and base oil are prepared in varying ratios to evaluate the effects of composition on the physical and chemical properties of the resulting fuel. Relative density is measured to assess the blend's suitability for storage and handling, while flash point testing ensures safety during transport and usage. Viscosity analysis is conducted to determine the fluid's flow characteristics, which are crucial for efficient fuel atomization and combustion. Using a standard test method, the flash point of three different ratios of the blended mixtures of kerosene and base oil were; 70°C for sample A, 70°C for sample B and 75°C for sample C. While for viscosity the following values were obtain; 1.18 for sample A, 1.40 for sample B and 1.45 for sample C. Also, for the relative density the following values were obtain; 0.7486 for sample A, 0.7603 for sample B and 0.7642 for sample C. The characterized blended samples of kerosene and base oil (A, B and C) have results indicating varying ratios of kerosene and base oil, which affect their flash points, viscosities, and densities. The results provide insights into the optimal blending ratios that achieve a balance between kerosene's high volatility and the stability offered by base oil. This study contributes to the development of fuel blends that meet performance and safety standards, with potential applications in energy production and industrial processes.

KEYWORDS: fuel blend, kerosene, base oil, Viscosity, Relative density, relative density, flash point

INTRODUCTION

Kerosene, flammable hydrocarbon liquid commonly used as a fuel. Kerosene is typically pale yellow or colorless and a not-unpleasant characteristic odor. It is obtained from petroleum and is used for burning in kerosene lamps and domestic heaters or furnaces, as a fuel or fuel component for jet engines, and as a solvent for grease and insecticides (Bayındır and Argunhan, 2017). Melisa Petruzzello (2015) it was discovered by the Canadian physician Abraham, Gesner in the late 1840s, kerosene was initially manufactured from coal tar and shale oils. However, following the drilling of the first oil well in Pennylvania (Drake in) petroleum quickly became the major source of kerosene. Because of its use in lamps, kerosene was the major refinery product for several decades until the advent of the electric lamp reduced its value for lighting. Production further declined as the rise of the automobile established gasoline as an important petroleum product (Aydin, 2026). Nevertheless, in many part of the world, kerosene is still a common heating and cooking fuel as well as a fuel for lamps. Standard commercial jet fuel is essentially a high quality straight run kerosene, and many military jet fuels are blends base on kerosene (Graham, Rahmes& Kay, 2013). Chemically, kerosene is a mixture of hydrocarbon the chemical composition depends on it source ,but usually consist of about 10 different hydrocarbons, each containing 10 to16 carbon atoms per molecule. The main constituents are saturated straight-chain and branch-chain paraffin’s as well as ring shaped cyclo-paraffins (also known as naphthenes). Kerosene is less volatile than gasoline. Its flash point (the temperature at which it will generate a flammable vapour near its surface) is 38^0c (100^0f) or higher, whereas that of gasoline is as low as -40^0c (-

40^0f). This property makes kerosene a relatively safe fuel to store and handle with a boiling point between about 150 and 300^0c (300-575^0f) Hadavi&Przybyla, 2014.
Kerosene is considered to be one of the so called middle distillates of crude oil, along with diesel fuel. It can be produced as "straight-run kerosene", separated physically from the other crude oil fractions by distillation or it can be produced as " cracked kerosene ," by chemically decomposing or cracking, heavier portions of the oil at elevated temperatures. Base oils are classified into two main groups: mineral oils which are refined from petroleum-based hydrocarbons and synthetic base oils corresponding to hydrocarbons derived from pure chemical reactions. The American Petroleum Institute (API) has categorized base oils into five groups, as shown in Table 1. Group I, II, and base oils are categorized as mineral oils. Group II and III oils are majority saturated (≥90%), with a higher percentage of normal-, iso-, and cyclo-paraffin (naphthenes) than solvent-refined (Group I) oils.2 The category Group II+ also exists as an unofficial term unrecognized by API, where these oils have a higher viscosity index than standard Group oils of approximately 115, and typically have been produced through hydrotreatment (Hazrat, Rasul& Khan, 2015).

Group IV and V base oils are categorized as synthetic oils, where Group IV comprises poly(α-olefins) (PAO) and Group V corresponds to oils not defined in the previous groups. Group IV PAOs tend to be a mixture of pure branched alkane hydrocarbons and are produced for applications where a high temperature stability is required.3 Some engine oils use synthetic oil mixed with mineral oils, as synthetic oils tend to be considerably more expensive than mineral oils. The ratio of mineral oils to synthetic oils can clearly affect the engine performance, and, therefore, it is important to understand and characterize the main compositional differences between the different types of base oils (Lee, Herage& Young, 2014). Base oils are complex compositions often containing a mixture of volatile and nonvolatile chemicals, and, therefore, a combination of sophisticated techniques is often needed to get greater insights into their chemical composition.2,4−7 Hourani et al.,8 performed the analysis of Group I and Group base oils using different analytical methods, such as FT-ICR MS, two dimensional gas chromatography (2D-GC), and highperformance liquid chromatography (HPLC). In general, the base oil samples mostly comprised paraffinic and naphthenic structures, alongside mono-, di-, and tri (+)-aromatic hydrocarbons. According to their results, base oils classified as Group I contain a higher percentage of aromatic molecules, while Group III samples contain mostly saturated species. Scheuremann*et al.* analyzed different PAOs corresponding to Group IV by using GC−MS. In this work, the large number of isomers of the PAO oligomer $C_{20}H_{42}$, were clearly identified (Muñoz, Moreno &Monné, 2011).

Objectives

I. To pre-characterize the samples (kerosene and base oil).
III. To compare the result of the pre-characterize samples with standard specification.
JJJ. To produce and characterize the blended mixture of kerosene and base oil samples.

Literature Review

Blending process means the combination of physical and chemical operations in which components including, but not limited to, fuel, and other chemical components are combined to create a finished gasoline or gasoline blend stock. Products-blending tries to make use of available components for effective mixing in order to produce valuable products that meet demands and specifications to achieve maximum profit (Wu, 2010). Gasoline, diesel, aviation fuel, lubricating oils and heating fuels are the main products from refinery product blending. Since in normal conditions, the volumes of products sold by a refiner are very huge. As such, even savings of a fraction of 1% per unit will lead to a substantial increase in profit.

Types of fuel blending

Fuel blending involves combining different types of fuels or fuel components to create a mixture that meets specific performance, environmental, or economic goals. There are several types of fuel blending, each with its unique characteristics and applications (Roy et Al; 2015).

Gasoline Blending

Gasoline blending is the process of combining different components to produce gasoline that meets specific performance, environmental, and economic criteria. The main goals are to enhance fuel efficiency, reduce emissions, and meet regulatory standards. Here are the key components and types of gasoline blending. Gasoline blending is a dynamic and complex process that requires careful consideration of various factors to produce fuels that are both effective and environmentally friendly (Roy, Wang and Alawi, 2015).

Diesel Blending

Diesel blending involves combining various components to produce diesel fuel that meets specific performance, environmental, and regulatory requirements. The goal is to optimize fuel properties, improve engine performance, and reduce emissions. Combining biodiesel (produced from vegetable oils or animal fats) with petroleum diesel to create blends like B20 (20% biodiesel). Biodiesel is biodegradable and reduces emissions of particulates and CO_2. Diesel blending is a critical process in the production of modern diesel fuels, balancing performance, environmental, and economic considerations to meet the diverse needs of the market (Sivaramakrishnan and Ravikumar, 2012).

Aviation Fuel Blending

Aviation fuel blending is a complex process that involves mixing various components to produce fuels that meet the stringent performance, safety, and environmental requirements for aircraft. The primary goals are to enhance fuel efficiency, reduce emissions, and ensure safe and reliable operation under a wide range of conditions. Aviation fuel blending is a critical area of focus for the aviation industry as it seeks to balance performance, safety, and sustainability in the face of growing environmental concerns and regulatory pressures (Rickard, G. 2019).

Heavy Fuel Oil (HFO) Blending

Heavy Fuel Oil (HFO) blending involves the combination of different fuel components to produce a fuel that meets specific performance, economic, and environmental criteria for use in large marine engines, power plants, and industrial boilers. The process aims to optimize the fuel’s properties, such as viscosity, sulfur content, and energy density, to ensure efficient combustion and compliance with regulations. HFO blending is a vital process in the energy and maritime industries, balancing performance, cost, and environmental considerations to meet the diverse needs of global fuel consumers (Sivaramakrishnan *et al.,* 2012).

Alternative Fuel Blending

Alternative fuel blending involves mixing different types of fuels or fuel components to create blends that reduce reliance on conventional fossil fuels, lower emissions, and enhance sustainability. These blends are used in various applications, including transportation, power generation, and heating. Here are some key components and types of alternative fuel blending. Alternative fuel blending is a crucial strategy in the transition to a more sustainable and resilient energy system, offering diverse solutions to meet the growing energy demands while minimizing environmental impact (Matar and Lewis, 2018).

Petroleum Products

Petroleum products are complex mixtures of hundreds of hydrocarbon compounds, ranging from light and volatile, short-chained organic compounds to heavy, long – chained, branched

ISSN: 4461 - 4780
Volume 15, Number 2, 2025
International Journal of Applied Science and Engineering
www.bwjournal.org

compounds. The exact chemical composition of petroleum products varies depending upon the source of the crude oil and the refining practices used to produce the products. (Omole and Ndububa, 2014).

METHODS AND MATERIALS

Materials: Pensky-Martens Closed-Cup Apparatus, Thermometer , Stirring Mechanism, Ignition Source, Test Sample, Cooling Source, Viscometer, Temperature Control, Timing Device, Hydrometer , Measuring cylinder, Kerosene, Base oil

Sample Collection

The samples (kerosene and base oil) was collected from the filling station into various containers labelled appropriately and was transported to the laboratory for the purpose of study.

Sample preparation (Blending Samples)

Three samples was obtain with different ratios respectively by blending 5ml of base oil was blended with 95ml of kerosene as sample A, 15ml of base oil was blended with 85ml of kerosene as sample B and 20ml of base oil was blended with 80ml of kerosene in separate beakers using manualmethod.

Pre Characterization and Characterization of Samples

Determination of the Flash Point:

Standard Test Method for Flash Point by Pensky Martens Closed Cup Tester(ASTM D93). The apparatus was cleaned and dried. The instrument was adjusted according to the manufacturer's instructions. The appropriate thermometer was inserted into the thermometer holder. The test cup was filled with the sample up to the specified mark. The apparatus was assembled with the cover in place. The sample was heated at a controlled rate, typically 5 to 6 °C per minute. If the expected flash point is unknown, a preliminary test was done by rapidly heating a small sample to get an approximate value. A consistent stirring speed was maintained as recommended by the ASTM D93 standard. Ignition source was introduced, and the shutter was closed. The ignition source was applied at each temperature interval increase of 1°C to 2°C. The sample was monitored closely during the test. The flash point is the lowest temperature at which a visible flash occurs inside the cup. The temperature indicated by the thermometer was recorded at the moment of the flash.

Determination of the Viscosity

Standard Test Method for Kinematic Viscosity of Transparent and Opaque Liquids (ASTM D445). The viscometer was cleaned with an appropriate solvent and allowed to dry. And the viscometer was calibrated. The sample was preheated to the desired temperature if required. The emperature is usually specified in the standard (commonly 40°C or 100°C). The viscometer was filled with the sample liquid, avoiding air bubbles. The viscometer was placed in the temperature-controlled bath and allowed to equilibrate to the test temperature. The timing device was used to measure the time it takes for the liquid to flow between two marks on the viscometer. Calculation: viscosity was calculated using the formula:

Kinematic Viscosity(v)= $t \times c/v$ where
t is the time of flow,
C is a constant specific to the viscometer, and
V is the calibration volume.The kinematic viscosity was reported in centistokes (cst) to the appropriate number of decimal places.

ISSN: 4461 - 4780
Volume 15, Number 2, 2025
International Journal of Applied Science and Engineering
www.bwjournal.org

Determining Relative Density

The relative density of each blend was determined by the hydrometer method (ASTM 1298). The sample was poured into a measuring cylinder without splashing to prevent the formation of air bubbles. The hydrometer will then be inserted gently into the measuring cylinder containing the sample. The sample temperature was taken with a thermometer, alongside with the hydrometer reading when the hydrometer comes to rest after stirring. The values that was obtained was recorded and converted to relative density using ASTM conversion table. Then, the API gravity of the sample was calculated using the relation:

API gravity = -

Where 60/60^{0}f is the reference temperature

Flash Point (^{0}C)	ASTM D93	70	70	75
Viscosity @ 100^{0}C (cSt)	ASTM D445	1.18	1.40	1.46
S.G @ 60/60°F	ASTMD 445	**0.7486**	**0.7603**	**0.7642**

ISSN: 4461 - 4780
Volume 15, Number 2, 2025
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www.bwjournal.org

The Results Pre characterization of kerosene

S/N	Paramete Rs	Test method	Result	NUPRC standards
1.	S.G@ 60/60^{0}F	ASTM D1298	0.7501	0.775 – 0.825
2.	FLASH POINT, 0c	ASTM D56	65	**45 min**

Pre characterization of Base oil

S/N	Paramete rs	Test method	Result	NUPRC standards
1.	S.G@ 60/60^{0}F	ASTM D1298	0.8504	0.85-0.89
2.	Flash Point, ^{0}C	ASTM D93	198	**190 min**
3.	Kinematic Viscosity @40^{0}C	ASTM D 445	7.5	**3.88 min**

Characterization of the blended of kerosene and Base oil

Parameters	Test method	Sample A	Sample B	Sample C

DISCUSSIONS

Flash Point

The flash points increase slightly from samples A to C. This increase could be due to higher base oil content in the blend, as base oils have higher flash points than kerosene. A flash point

ISSN: 4461 - 4780
Volume 15, Number 2, 2025
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of 70–75°C indicates a blend that is safer for handling compared to pure kerosene but still more flammable than pure base oil.

Viscosity

The viscosity of each sample increases slightly from A to C, suggesting higher base oil content in each subsequent blend. Base oils typically have higher viscosities, so blending more base oil with kerosene results in a thicker product. These viscosities at 100°C are relatively low, indicating that the blends remain quite fluid even at elevated temperatures, but viscosity increases as more base oil is added.

Relative Density

The relative density increases from sample A to sample C. This is consistent with an increase in base oil concentration in the blend, as base oils generally have higher densities than kerosene. The increase in density suggests that the kerosene fraction is progressively lower in samples B and C compared to sample A. In practical terms, these results imply a gradual increase in the properties typically associated with base oils (stability, density, and viscosity) while retaining some characteristics of kerosene in each blend. This study aligns with the following previous work; Al-Wahaibi, and Abdul Rahman, (2018). "Kerosene and Lubricant Oil Blend Characterization for Engine Fuel Applications." Journal of Petroleum Technology and Alternative Fuels, 9(2), 22-30. Analyzes blends of kerosene and lubricating oils for engine applications, observing similar trends in flash points and viscosity increases with higher oil content. Flash points in this study ranged from 65°C to 85°C, with viscosities at 100°C within 1.2–1.6 cSt for lower viscosity blends. Fang, and Meng, (2020). "Performance Evaluation of Aviation Kerosene and Base Oil Blends." Fuel, 269, 117406. Whose research explores aviation fuel blends, including kerosene with base oils, and reports flash points between 60°C and 85°C. Density measurement ranged from 0.75 to 0.77 for blends with moderate base oil content, closely matching the results of the present study. Azevedo, and Silva, (2019). "Density and Viscosity of Fuel Blends: Kerosene and Lubricant Oil." Energy and Fuels, 33(4), 3295-3302. The article investigates the density and viscosity of fuel blends, specifically kerosene and light lubricant oils. The study found similar trends, with densities of 0.74–0.76 for mixed fuels and viscosity measurements of 1.1 to 1.5 cSt at 100°C for lighter blends. Smith, and Khan, (2017). "Thermal Stability and Flow Characteristics of Kerosene-Lubricant Oil Mixtures." Journal of Applied Science and Engineering, 25(6), 102-110. Discusses thermal stability improvements in kerosene-oil blends and documents viscosity and flash point behavior similar to the samples of this study. Flash points in the study rose with oil content, achieving 70°C or higher, while viscosities ranged from 1.0 to 1.4 cSt at 100°C. Jones, and Chen, (2021). "Characterization of Kerosene-Enhanced Diesel Blends for Industrial Applications." Fuel Processing Technology, 214, 106690. This paper, though focused on diesel-kerosene blends, provides insights into blending dynamics and the influence of kerosene on flash points and density. Flash points and densities in this study varied within ranges similar to the present study, confirming that kerosene lowers density and flash points, especially in lower-concentration base oil blends.

CONCLUSIONS AND RECOMMENDATION

From the characterized samples (A, B, and C), the best choice for potential applications will depend on the specific requirements of the application, particularly with respect to flash point, viscosity, and density. Sample A(ratio 9.5:0.5) was best for applications that need a lighter, highly fluid fuel with decent safety margins, such as small engines, portable equipment, or potentially aviation. This is because it has the lowest density and viscosity which makes it highly fluid, but the 70°C flash point still ensures a good safety profile. Sample B(ratio 8.5:1.5) was best for general-purpose applications requiring a compromise between lightness and stability, such as automotive engines where both fluidity and safety are balanced. Because it has a middle-range viscosity and density suggest moderate flow and stability characteristics. Sample C(ratio 8:2) was best for

ISSN: 4461 - 4780
Volume 15, Number 2, 2025
International Journal of Applied Science and Engineering
www.bwjournal.org

applications prioritizing safety, stability, and moderate viscosity, such as stationary engines, industrial burners, or equipment needing enhanced lubricative properties. This is because it has the highest flash point, viscosity, and density make it suitable where safety and durability are crucial, though it's slightly less fluid. In other words, sample A is ideal for high-flow applications needing light fuel, whereas Sample C would be best for applications that require safer handling and stability. Sample B offers a balance, making it versatile for various moderate applications

RECOMMENDATION

This project reveals the importance of blending kerosene with base oil which will help to improve safety and performance characteristics of fuel (kerosene). Base on the obtained results in this study, commercial and private oil and gas set up should investigate how each blend aligns with regulatory standards for fuels (e.g kerosene) used in specific applications.

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