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Table of Contents

Characterization of Domestic Auto Diesel Adulteration with Kerosine up to 20%

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ABSTRACT

As the fuel prices escalates fuel adulteration incidences are reported in domestically and diesel adulteration is most prominently reported specially in private transportation sector. This research was carried out to characterize and estimate the diesel adulteration with kerosine at a maximum range up to 20%. Domestic Diesel and kerosine samples obtained from a fuel station. Parameters: distillation, flash point viscosity were analyzed using ASTM methods. Further more blended samples were analyzed using FTIR to find out their chemical structures. Samples were blended in volume-to-volume ratios. Control samples were taken as original diesel sample and original kerosine sample that taken from fuel station. Samples were prepared as 5K (5% Kerosine + 95% Diesel), 10K (10% Kerosine + 90% Diesel), 15K (15% Kerosine + 85% Diesel), 20K (20% Kerosine + 80% Diesel). According to results, increasing the concentration of kerosene in the blends decreases the kinematic viscosity and IBP in distillation and flash point values of the blended fuel compared with authentic diesel, but increases these values compared with authentic kerosene. Authentic diesel flashed at 86°C, while kerosene flashes at 47.5°C. just adulterating even 5% kerosene causes a colossal 10.5°C drop (down to 75.5°C). By the time adulteration reaches 20%, the flash point plummets to 68.5°C. A lower flash point increases the risk of premature ignition and adversely effects the engine performance. Impact of adulteration observed every 5% increment of kerosene methodically reduces the viscosity (from 3.794 → 3.522 → 3.346 → 3.093 → 3.000 cSt). Fuel pumps and injectors rely on the viscosity of diesel for lubrication. Thinner, low-viscosity fuel resulting from kerosene adulteration could result with increase in friction, fuel pump wear, and injector leakage could be possible. Distillation Profile (IBP and 50% Recovery) Initial Boiling Point (IBP): Authentic diesel boiled at 186.6°C, while kerosene at 161.2°C. When kerosene is added to diesel, the IBP experiences an immediate drop to 185.2°C at a 5% blend, and steadily declines to 175.0°C at a 20% blend. 50% Recovery Temperature (T_{50}): This parameter shows a highly predictable, linear decline. Pure diesel's mid-boiling point is 292.6°C. As kerosene is blended in at 5%, 10%, 15%, and 20%, the T_{50} temperature drops systematically to 289.0°C, 286.8°C, 281.9°C, and 277.7°C correspondingly. There is not very much significance difference between blended samples and control samples. Since the differences between pure diesel and pure kerosene are structural (chain lengths and branching) rather than functional (they contain the same elements), *new* peaks appearing or disappearing was not observed. Overall results shows that diesel adulteration adversely affects on engine performance.

Keywords: Adulteration, Diesel, Kerosine, Distillation, Flashpoint

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INTRODUCTION

Diesel adulteration is a thriving business throughout the globe specially in the Asian region with the existence of significant price differences seen with fuel compared to the adulterants. Establishment of a routine analysis methodology with minimum sample handling steps and absence of cumbersome sample preparation, and separation processes seems to be the most viable solution in monitoring and quantifying the fuel adulterants (Kulathunga & Mahanama, 2013).

Sri Lanka as an Asian country was also affected with escalating price hikes at close frequencies.

These days oil prices are changing mainly due to several factors, including international war, policies of oil-exporting countries, security, the world political situation, and many other natural factors such as depletion of petroleum reserves.

In this light consuming fuel at routine has become costly with an economic burden. Recently several cases were reported specially some private buses were caught on diesel adulteration with adulterant-kerosine.

The literature related to the effect of kerosene on diesel fuel properties shows that kerosene improves the cold flow characteristics of diesel fuel by simply diluting the problematic paraffin waxes present in the diesel fuel distillation curve. Baral & Robert (2009), have reported that the density of the kerosene-diesel blend remains within the prescribed limit even in higher blends and also kinematic viscosity of the blends were decreased with an increase in blend ratio. Bergstrand (2004), has reported that kerosene has a lower cetane number than diesel and giving a longer ignition delay. In Sri Lanka, it is very common that blending small amount of kerosine with diesel to the engine.

Having similar chemical properties, the fuel and the adulterant cannot be distinguished easily leading to complications in identification and quantification of the adulterants. A number of analytical techniques are available ranging from simple density measurements to modern techniques such as gas chromatography/mass spectroscopy for identification of adulterants. The common testing methods for the fuels are density measurements, rate of evaporation, ash content determinations and viscosity measurements (Kalligeros et al., 2003), optical sensors, spectroscopic methods (Canizares & de Castro, 1996; Patra & Mishra, 2001).

The main objective of this study is to characterize the domestically available main auto diesel adulteration with domestically available kerosine using basic parameters: flash point, Kinematic viscosity, Distillation- Initial boiling point (IBP). Further Fourier Transform Infrared Spectroscopy (FTIR) characterization was also used in characterization.

METHODOLOGY

Commercial auto diesel fuel and the kerosene were purchased from local commercial fuel station. The conventional diesel fuel was blended with kerosene in different proportions by manual mixing at room temperature. In this study, 5%, 10%, 15% and 20% kerosene (by volume) were adulterated on auto diesel and denoted hereafter as 5K, 10K, 15K and 20K respectively.

The authentic diesel and authentic kerosene were denoted as D100 and K100, respectively. Properties namely kinematic viscosity, flash point and distillation profile were measured in the laboratory according to the ASTM test methods. Structural changes were investigated by FTIR method. These physiochemical properties are shown in Table 1.

Meterial's flash point is regarded as the lowest temperature at which a liquid produces sufficient vapor to ignite when exposed to a source of ignition. It is regarded as a critical safety characteristic that supports classify flammable liquids, with fuels having a flash point less than 37.8 °C (100.0 °F) considered flammable, while those above this temperature are classified as combustible. Flash point is important for the safe handling and storage of flammable substances, as it designates the potential fire hazards associated with a fuel as well as the degree of combustion in the engine which are potential consequences of using diesel fuel with a low flash point. While engine performance may be affected, the primary concern lies in the safety hazards of handling and transporting the out-of-spec fuel. Lower flash points increase the risk of explosions, making it crucial to address the issue promptly and appropriately. The lower the flash point, the more the risk is increased.

Finding a solution to a low flash point is challenging. While some may consider adding substances to raise the flash point, this approach often adversely affects other fuel properties. Dilution with additional diesel fuel is also impractical, as large volumes would be required to rectify the flash point issue (Bell performance, 2026).

ASTM D 3828-169(2021) method was used for flashpoint testing and SETA:U82000-2U Automatic high temperature closed cup flashpoint tester was used to test the samples.

Viscosity is the resistance to shear or flow in a fluid - and a measure of the adhesive/cohesive or frictional property. Viscosity arising due to internal molecular friction produces the frictional drag effect (Engineering ToolBox, 2001). Kinematic viscosity (ν) is defined as the ratio of dynamic viscosity (η) to the density (ρ) of the fluid. It is typically measured in centistokes (cSt) or square millimeters per second (mm^2/s). The kinematic viscosity of oil is crucial for understanding how it will perform in various applications, particularly in engines and machinery.

Kinematic viscosity was measured using SETA KV-6 viscometer bath and adopting ASTM D 445-24. The Initial Boiling Point (IBP) in distillation is the temperature at which the first drop of vaporized liquid is collected from a mixture as it is heated. Unlike pure substances, which have a single boiling point, complex mixtures such as crude oil or petroleum products boil over a range of temperatures. The IBP marks the start of this boiling range and is critical for understanding the volatility and composition of the mixture.

ASTM D 86-239 method was adopted to measure the samples using Thanaka ad-7 automated atmospheric distillation tester

RESULTS AND DISCUSSION

According to Table 1, increasing the concentration of adulterant- kerosene in the blends decreases the kinematic viscosity and IBP in distillation and flash point values of the blended fuel compared with authentic diesel, but increases these values compared with authentic kerosene.

Table 1: Flash point (^{0}C)/ kinematic viscosity/ Distillation-IBP/ Distillation- Rec. 50%

Fuel blend	Flash point (^{0}C)	kinematic viscosity (cSt)	Distillation-IBP (Initial boiling point) ^{0}C	Distillation-Recovery percentage. 50% (^{0}C)
(Unadulterated Diesel) D100	86	3.794	186.6	292.6
K100 (Unadulterated Kerosine)	47.5	1.260	161.2	194.8
5% kerosene on Diesel	75.5	3.522	185.2	289.0
10% kerosene on Diesel	74	3.346	178.3	286.8
15% kerosene on Diesel	70.5	3.093	178.1	281.9
20% kerosene on Diesel	68.5	3.000	175.0	277.7

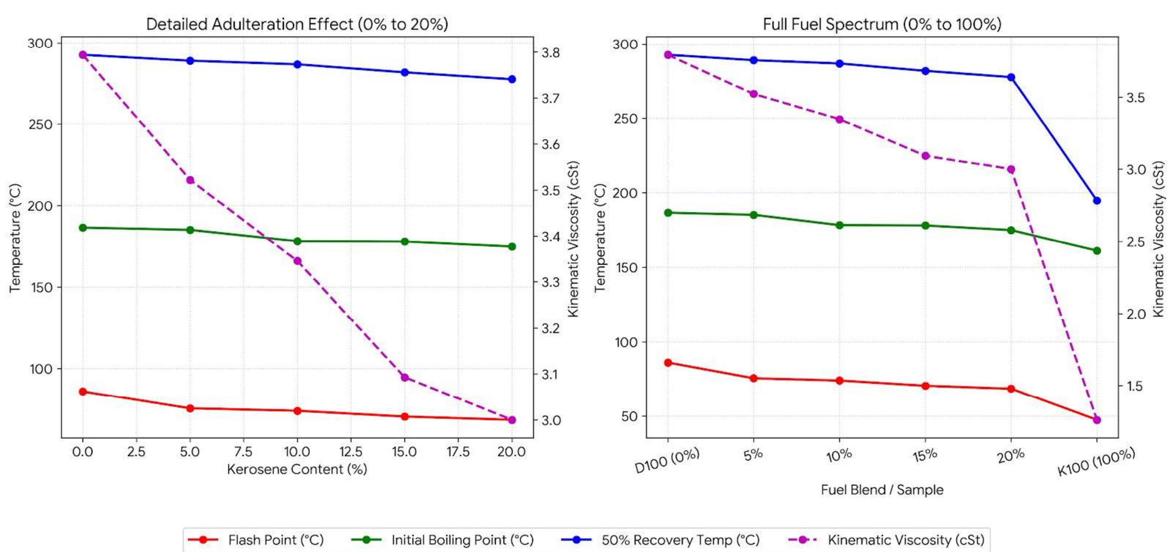

Figure 1: Multi-Curve Analysis of Diesel Fuel Properties under Progressive Kerosene Adulteration

According to the Table 1, and Figure 1the flash point drops suddenly with the introduction of even small amounts of kerosene. Unadulterated diesel observed flashing at 86°C, while unadulterated kerosene flashes at 47.5°C. just adulterating even 5% kerosene causes a colossal 10.5°C drop (down to 75.5°C). By the time adulteration reaches 20%, the flash point plummets to 68.5°C.
Flash point is a critical safety metric for fuel handling and storage. A lower flash point increases the risk of premature ignition and adversely effects the engine performance.

Kinematic Viscosity decreases linearly when kerosene percentage increases. Diesel stands at a higher viscosity, whereas kerosene is much thinner in viscosity comparatively. Impact of adulteration observed every 5% increment of kerosene methodically reduces the viscosity (from 3.794 → 3.522 → 3.346 → 3.093 → 3.000 cSt).
Fuel pumps and injectors rely on the viscosity of diesel for lubrication. Thinner, low-viscosity fuel resulting from kerosene adulteration could result with increase in friction, fuel pump wear, and injector leakage could be possible.

Distillation Profile (IBP and 50% Recovery) Initial Boiling Point (IBP): Pure diesel commences boiling at 186.6°C, while pure kerosene commences at 161.2°C. When kerosene is added to diesel, the IBP experiences an immediate drop to 185.2°C at a 5% blend, and steadily declines to 175.0°C at a 20% blend. 50% Recovery Temperature (T_{50}): This parameter shows a highly predictable, linear decline. Pure diesel's mid-boiling point is 292.6°C. As kerosene is blended in at 5%, 10%, 15%, and 20%, the T_{50} temperature drops systematically to 289.0°C, 286.8°C, 281.9°C, and 277.7°C correspondingly.
Reduction in distillation temperatures demonstrates that the overall fuel mixture is becoming lighter and more volatile. This disrupts the engine’s designed combustion timing, reducing thermal efficiency and potentially increasing harmful emissions.

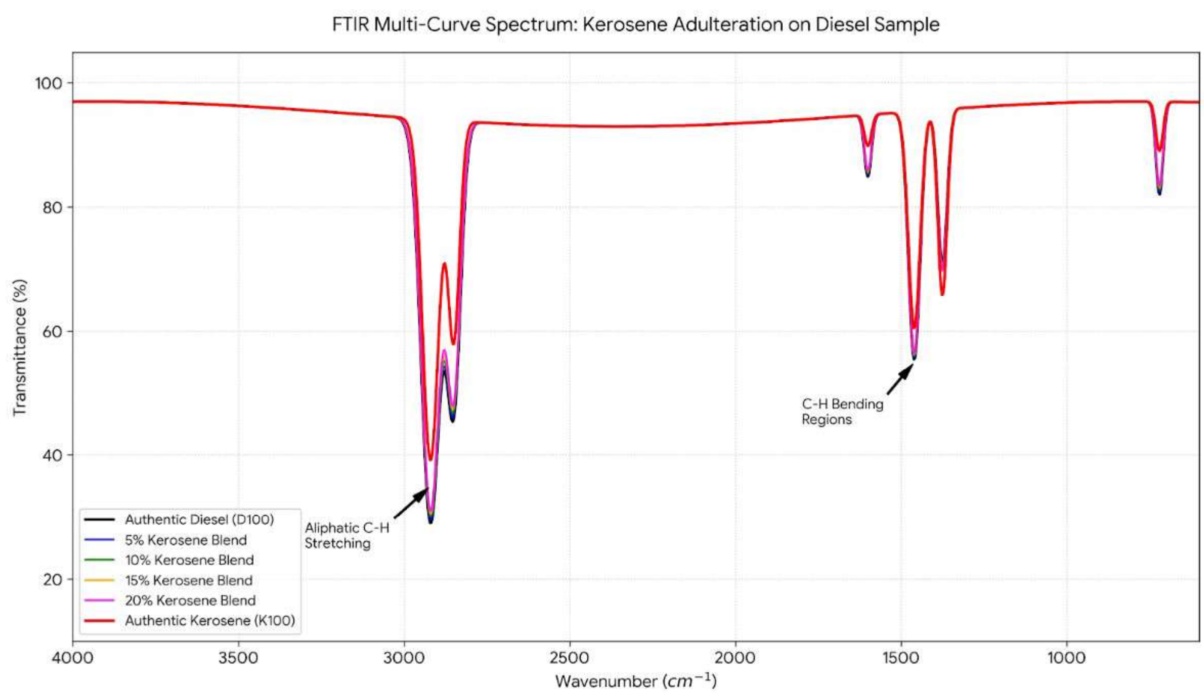

Figure 2: Multi-Curve FTIR Analysis of Diesel Kerosene Adulteration

According to FTIR analysis Significant peaks were observed between 2856 cm -1 and 2936 cm -1, corresponding to the C-H stretching vibrations of methylene (CH2) and methyl (CH3) groups, which are typical for alkanes. The wavelengths between 1451 -1460 cm^{-1} CH_2 bending, and at 1165 -1175 cm^{-1} C-O vibrations can be identified. There is not very much significance difference between blended samples and control samples. Since the differences between pure diesel and pure kerosene are structural (chain lengths and branching) rather than functional (they contain the same elements), *new* peaks appearing or disappearing was not observed.

Instead, the adulteration behaves as a systematic dilution framework. The Figure 2 tracks a mathematically consistent shift in peak heights and area ratios—most reliably at the1375 cm^{-1} methyl bend and the 720 cm^{-1} long-chain.

CONCLUSION

The experimental data clearly demonstrates that kerosene adulteration severely degrades the physical and chemical properties of diesel fuel. High Sensitivity of Flash Point: Flash point is the most immediate indicator of low-level contamination. A simple 5% addition of kerosene compromises fuel safety specifications significantly. Predictable Linear Degradation: Kinematic viscosity and the 50% Distillation Recovery temperature drop in direct, predictable proportion to the amount of kerosene added. This makes them highly reliable metrics for quantifying the exact percentage of adulteration in a suspect sample. Operational Risks: Ultimately, using diesel adulterated with kerosene (even as low as 5% to 20%) will lead to reduced engine lubrication, accelerated component wear, altered combustion cycles, and elevated safety risks due to heightened fuel volatility

A lower flash point may increase the risk of premature ignition and adversely effects the engine performance. Fuel pumps and injectors rely on the viscosity of diesel for lubrication. Thinner, low-viscosity fuel resulting from kerosene adulteration could result with increase in friction, fuel pump wear, and injector leakage could be possible. Reduction in distillation temperatures demonstrates that the overall fuel mixture is becoming lighter and more volatile. This disrupts the engine's designed combustion timing, reducing thermal efficiency and potentially increasing harmful emissions. Further testing is proposed as future work to conclude the overall effects of diesel adulteration with kerosine.

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