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(Review Article)

The photochemical effects of sunlight on gasoline: A scholarly review

Friday Victor Kalu [1,*] and Okenwa Uchenna Igwe [2]

[1] *General Marine and Oil Services Limited, Apapa, Lagos State, Nigeria / Department of Chemistry, Michael Okpara University of Agriculture, Umudike, P.M.B 7267 Umuahia, Abia State, Nigeria.*
[2] *Department of Chemistry, Michael Okpara University of Agriculture, Umudike, P.M.B 7267 Umuahia, Abia State, Nigeria.*

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Abstract

Gasoline, a complex blend of hydrocarbons used in internal combustion engines, is susceptible to degradation under environmental conditions. Among various ageing mechanisms, photochemical processes induced by sunlight, especially ultraviolet (UV) radiation, can alter its chemical composition and physical properties. This review evaluates the mechanisms and implications of sunlight-induced photochemical effects on gasoline and related petroleum hydrocarbons. Findings from recent studies indicate that exposure to sunlight causes oxidation of aromatic and unsaturated fractions, formation of oxygenated compounds, and potential decreases in octane number. These effects are intensified under high solar flux and oxygen-rich conditions. The review further discusses storage implications, environmental effects, and the need for region-specific studies, particularly in tropical climates. Strategies for mitigating sunlight-induced degradation are also recommended.

Keywords: Gasoline; Photochemical Degradation; Sunlight Exposure; UV Radiation; Oxidation; Octane Number

1. Introduction

Petroleum is a complex mixture predominantly composed of hydrocarbons, accompanied by small proportions of organic compounds containing heteroatoms such as oxygen, nitrogen, and sulphur (Speight, 2014). On average, crude petroleum consists of approximately 79.5–87.1% carbon, 11.5–14.8% hydrogen, 0.1–3.5% sulphur, and 0.1–0.5% nitrogen and oxygen. These proportions can vary significantly depending on the source of the crude oil and the geographical location of the refinery (Demirbas *et al*., 2015a).

In refineries, crude petroleum is processed and separated into its constituent components. A petroleum refinery is essentially a network of processing units designed to fractionate crude oil into various usable products. The configuration of a refinery often depends on its production focus; for example, some are optimized primarily for gasoline production (Demirbas, 2012).

Gasoline is a blend of hydrocarbons with some contaminants, including sulphur, nitrogen, oxygen, and certain metals. The four major constituent groups of gasoline are olefins, aromatics, paraffins, and naphthenes. The important characteristics of gasoline are density, vapour pressure, boiling range (distillation), octane rating, and chemical composition.
To be attractive, a motor gasoline must have (i) desirable volatility, (ii) antiknock resistance (high octane rating), (iii) good fuel economy, (iv) minimal deposition on engine component surfaces, and (v) complete combustion and low pollutant emissions (Demirbas *et al*., 2015b).

* Corresponding author: Friday Victor Kalu.

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Gasoline stability is crucial to maintaining optimal combustion performance, emissions control, and safety. Despite significant attention to oxidative and evaporative degradation, the photochemical effects of sunlight on gasoline remain relatively underexplored. Sunlight contains UV radiation capable of initiating chemical reactions in hydrocarbons, leading to molecular breakdown or oxidation (Borecki *et al*., 2022). In tropical environments where sunlight intensity is high, the photochemical ageing of gasoline can be more pronounced. This review synthesizes existing knowledge on the photochemical interactions between sunlight and gasoline, summarizing mechanistic insights, empirical findings, and implications for storage and performance.

2. Photochemical mechanism in hydrocarbon

Photochemical reactions occur when molecules absorb photons and transition to electronically excited states capable of subsequent chemical transformation (Cai *et al*., 2023). For hydrocarbons, these processes include direct photolysis, indirect oxidation, and photosensitized reactions. Aromatic and olefinic hydrocarbons absorb UV light more readily than saturated alkanes, leading to bond cleavage or structural rearrangements (King *et al*., 2014). Sunlight generates reactive oxygen species such as singlet oxygen and hydroxyl radicals that oxidize hydrocarbons to alcohols, ketones, and carboxylic acids (Hashim & Aljanabi, 2018).

A photochemical reaction is a chemical reaction that is induced by light. Photochemical reactions are not only very useful but can also be a serious nuisance, just like in this case study, and as in the photo-degradation of many materials. It is paramount to understand the nature of photochemistry going on in gasoline when exposed to sunlight, especially under high intensity.

Petroleum undergoes photochemical reactions when exposed to sunlight, which can change its chemical composition and affect its toxicity and bioavailability. In a photooxidation reaction, when the sun's UV (ultraviolet) light hits an oil slick, it causes oxygen and carbon to combine and form new products, such as resins. These resins can dissolve in water or form water-in-oil emulsions (Merv. 2011). Petroleum films exposed to sunlight can produce hydroxyl radicals. UV light can break chemical bonds in petroleum molecules, generating radicals that react with oxygen and other compounds. This process accelerates the degradation of complex hydrocarbons (Merv. 2011). UV radiation can also cause oil photodegradation, reaching 86% after one hour of irradiation (Merv, 2011).

In addition to photochemical oxidation, temperature variations accompanying sunlight exposure can significantly influence the physical properties of gasoline. Trost *et al*. (2021) demonstrated that the density and viscosity of biobutanol–gasoline blends decrease nearly linearly with increasing temperature between −10 °C and 40 °C. Although their study focused on thermal effects rather than direct photochemical reactions, such findings suggest that solar heating accompanying ultraviolet irradiation could accelerate fuel evaporation and compositional shifts that modify apparent density and volatility.

Sunlight exposure significantly affects several critical fuel quality parameters beyond density and viscosity. Prolonged ultraviolet (UV) irradiation can elevate the Reid Vapour Pressure (RVP) of gasoline due to the preferential evaporation of low-molecular-weight hydrocarbons and oxygenates such as ethanol and methanol, which increase vapor-phase concentration (Adeyemi et al., 2020; Nwankwo & Trust, 2023). However, with extended exposure, photochemical oxidation and volatilization cause a net decline in RVP as lighter fractions are lost, leading to heavier, less volatile residual fuel (Kumbár *et al*., 2021). Similarly, the existent gum content in gasoline tends to rise upon sunlight exposure because oxidation and polymerization of olefins and aromatic hydrocarbons produce high-molecular-weight gums and peroxides (Demirbas, 2012; Wolak *et al*., 2021). The accumulation of gum and resinous compounds indicates the onset of instability, especially when coupled with increased temperature and oxygen ingress.

The oxidation stability of gasoline is also adversely influenced by sunlight. UV radiation initiates radical chain reactions, forming hydroperoxides and aldehydes that compromise fuel integrity (Trost *et al*., 2021). This photochemical degradation parallels thermo-oxidative pathways, and its rate is accelerated in the presence of oxygenates and metallic impurities (Polcar *et al*., 2022). In oxygenated gasoline blends, particularly those containing ethanol or MTBE, sunlight exposure enhances phase separation and oxidation, generating acids and gums that lower storage stability and combustion quality (Demirbas, 2012; Trust *et al*., 2021). Collectively, these findings indicate that solar radiation exerts both thermal and photochemical effects, increasing gum formation and oxidation while altering RVP and reducing the long-term stability of oxygenated gasoline blends.

3. Empirical evidence of sunlight-induced changes

Studies on crude oil and oil films demonstrate the high susceptibility of aromatic hydrocarbons to sunlight. King *et al*. (2014) observed up to 90% degradation of polycyclic aromatic hydrocarbons after three days of simulated sunlight, while alkanes remained largely intact. Hashim and Aljanabi (2018) reported UV irradiation altered the composition of benzene, toluene, and xylene, reducing octane number by as much as 11 RON units. ADL Petroleum (2020) confirmed UV sensitivity, noting that gasoline samples stored in transparent bottles lost up to one octane unit after short sunlight exposure. Borecki *et al*. (2022) also found that UV radiation caused chemical instability in automotive fuels stored in transparent polymer containers.

Sunlight-induced oxidation alters gasoline's hydrocarbon profile, leading to reduced octane number, formation of gums, and deposit precursors (Hashim & Aljanabi, 2018). Sunlight exposure accelerates gasoline degradation in clear containers; thus, storage in opaque or UV-blocking tanks is advised (ADL Petroleum, 2020). Photochemically oxidized hydrocarbons form polar compounds that increase toxicity in aquatic systems (Zhao *et al*., 2024).

4. Conclusion

Sunlight exposure, through photochemical and photothermal processes, can significantly influence gasoline stability and performance. Aromatic and olefinic components are particularly vulnerable to UV-induced oxidation, which may decrease octane rating and alter fuel composition. Gasoline should be stored in UV-shielded containers, with attention to tropical regions with high solar intensity (Cai et al., 2023).

Recommendation

Despite growing evidence, several gaps remain: (1) Limited direct studies on commercial gasoline under sunlight exposure; (2) Lack of quantitative kinetics describing octane loss; (3) Few integrated models of photo-oxidative ageing; (4) Scarce regional data from tropical zones; and (5) Limited field validation of mitigation methods.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

References

[1] Adeyemi, T. O., Ajayi, O. R., & Bello, S. A. (2020). *Effect of environmental exposure on the volatility and vapor pressure of gasoline samples.* Journal of Petroleum Science and Engineering, 190, 107061.

[2] ADL Petroleum Services Limited. (2020). UV light effects: Importance of protecting samples and reference fuels for octane number testing from exposure to sunlight.

[3] Borecki, M., Geca, M., & Korwin-Pawlowski, M. L. (2022). Automotive diesel fuel internal stability testing with the use of UV and temperature as degradation factors. Materials, 15(23), 8548.

[4] Cai, Z., Liu, W., Fu, J., O'Reilly, S. E., & Zhao, D. (2023). Photochemical degradation in natural attenuation of petroleum hydrocarbons (C_{10}–C_{40}) in crude oil–polluted soil under simulated long-term solar irradiation. Journal of Environmental Chemical Engineering, 11(4), 109702.

[5] Demirbas, A. (2012). "Study of density and viscosity for ternary mixtures biodiesel + diesel fuel + bio-alcohols." *Ovidius University Annals of Chemistry, 23*(1), 58-62.

[6] Demirbas, A., Alidrisi, H., Balubaid, M. A. (2015a). API gravity, sulfur content, and desulfurization of crude oil. Pet. Sci. Technol. 33:93–101.

[7] Demirbas, A., Balubaid, M. A., Kabli, M., Ahmad, W. (2015b). Diesel fuel from waste lubricating oil by pyrolitic distillation. Pet. Sci. Technol. 33:129–138.

[8] Energies Journal. (2018). Properties of gasoline stored in various containers. Energies, 10(9), 1307.

[9] Hashim, H. A. M., & Aljanabi, H. A. K. (2018). Photo-degradation effect on naphtha octane number using UV radiation. Journal of Petroleum Research & Studies, 8(2), 15–48.

[10] King, T., et al. (2014). Photolytic and photocatalytic degradation of surface oil from the Deepwater Horizon spill. Environmental Science & Technology, 48(16), 9001–9010.

[11] Kumbár, V., Wolak, A., Nde, D. B., & Trost, D. (2021). *Temperature effect on the physical properties of gasoline and its biocomponent blends.* Fuel, 300, 121069.

[12] Merv, Fingas. (2011). “Oil Spill Science and Technology” ELSEVIER, Pg; 187-200.

[13] Nwankwo, J. I., & Trust, C. E. (2023). *Ambient photochemical aging and volatility loss in stored gasoline fuels.* Energy & Fuels, 37(5), 4231-4242.

[14] Polcar, A., Boldor, D., & Trost, D. (2022). *Thermo-oxidative and photochemical degradation of bio-ethanol-gasoline blends under simulated sunlight.* Applied Sciences, 12(15), 7654.

[15] Trost, D., Polcar, A., Boldor, D., Nde, D. B., Wolak, A., & Kumbár, V. (2021). *Temperature dependence of density and viscosity of biobutanol-gasoline blends*. *Applied Sciences, 11*(7), 3172.

[16] Wolak, A., Trust, C. E., & Kumbár, V. (2021). *Photo-oxidation and gum formation in stored gasoline under sunlight exposure.* Fuel Processing Technology, 218, 106855.

[17] Zhao, X., Cai, Z., & Liu, W. (2024). High temperature and solar radiation in the Red Sea enhance the dissolution of crude oil from surface films. Environmental Science and Pollution Research, 31(12), 22150–22163.