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Article review: Comparison of octane booster additive for gasoline

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ABSTRACT

Gasoline is a petroleum-derived liquid that is most typically used in internal combustion engines, especially those utilizing spark ignition. Gasoline is a hydrocarbon blend that contains sulfur, nitrogen, oxygen, and other metals. Olefins, aromatics, paraffin, and naphthenes are the four main components of gasoline. An octane number is a unit of measurement for the ignition quality or flammability of gasoline. It is frequently referred to as the research octane number (RON), and it is calculated using a ratio of isooctane to n-heptane. The octane number can be decreased by lengthening the hydrocarbon molecule chain and increasing by branching the carbon chain. Another method is to use an octane number increaser for gasoline as an addition. These are classified as oxygenate, ether, antiknock agent, nanoparticles, and aromatic compounds. Numerous studies have been conducted to establish the influence of additives in gasoline on engine performance metrics such as braking power, thermal brake efficiency, volumetric efficiency, fuel consumption efficiency, and their impact on the environment. This review article aims to assess and compare the effects of various gasoline additives on the performance and emission characteristics of ignition engines.

ABSTRAK

Bensin adalah cairan yang berasal dari minyak bumi yang paling banyak digunakan sebagai bahan bakar di mesin pembakaran internal, khususnya mesin menggunakan percikan pengapian. Bensin adalah campuran hidrokarbon dengan beberapa kontaminan, termasuk belerang, nitrogen, oksigen, dan logam tertentu. Empat kelompok penyusun utama bensin adalah olefin, aromatik, parafin, dan naften. Angka oktan adalah ukuran kualitas pengapian atau mudah terbakarnya bensin, biasa disebut *Research Octane Number* (RON) yang dapat diukur menggunakan perbandingan antara campuran isooktana dengan n-heptana. Angka oktan dapat berkurang dengan bertambahnya panjang rantai dalam molekul hidrokarbon sedangkan angka oktan dapat meningkat dengan membuat percabangan rantai karbonnya. Cara lain untuk meningkatkan angka oktan adalah ditambahkan peningkat angka oktan bensin sebagai aditif, yang terbagi pada kategori oxygenat, eter, agen *antiknock,* nano partikel dan senyawa aromatik. Banyak penelitian tentang penggunaan aditif dalam bensin untuk menentukan pengaruhnya terhadap ukuran kinerja mesin seperti daya pengereman, efisiensi rem termal, efisiensi volumetrik, efisiensi konsumsi bahan bakar, dan efeknya terhadap lingkungan. Tujuan dari artikel review ini adalah untuk mengevaluasi serta membandingkan berbagai aditif pada bensin dan pengaruhnya terhadap kinerja dan karakteristik emisi mesin pengapian.

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1. Introduction

For more than a century, fossil fuels have contributed more than 80% of global energy consumption. At the same time, renewables are anticipated to expand at the highest rate, and fossil fuels will probably continue to dominate energy usage at least through 2050. Fossil is still owing to the rising global demand for energy, their higher energy intensity and reliability, and the enormous quantities that underscore the world's reliance on non-renewable fossil fuels [1]. Fossil fuels are one of the world's primary energy sources today. Global energy consumption is increasing daily as a result of the world's constantly growing population. Prices of fossil fuels are growing in response to increased demand, which harms countries' economies with little fossil fuel output. Fossil fuels are environmentally harmful and contribute to acid rain, ozone layer depletion, and the greenhouse effect. As a result, international research on alternate fuel sources for engines is being conducted [2]. Global energy consumption is anticipated to increase by 54% between 2001 and 2025, from 404 quadrillion British thermal units (Btu) in 2001 to 623 quadrillion Btu in 2025 [3]. In 2001, the world's ultimate energy consumption was 39% oil, 23% natural gas (NG), 24% coal, 6% nuclear, and 8% other [4]. The world's energy usage is depicted in Table 1.

Table 1. World total enegy comsuption (quadrillion Btu)

Region	1990	2001	2010	2025
Industrialzed countries	182.8	211.5	236.3	281.4
EE/FSU	76.3	53.3	59.0	75.6
Developing countries	89.3	139.2	175.5	265.9
Asia	52.5	85.0	110.6	173.4
Middle East	13.1	20.8	25.0	34.1
Africa	9.3	12.4	14.6	21.5
Central and South America	14.4	20.9	25.4	36.9
Total world	348.4	403.9	470.8	622.9

Transportation is a massive and strategically vital industry. Given that transportation is the primary user of petroleum products, the transportation sector consumes around 30% of total energy [5]. Gasoline is the most widely used petroleum product and accounts for the lion's share of the product obtained per barrel of crude oil. The process by which the internal combustion engine consumes fuel in a regulated manner is referred to as deflagration [6]. Gasoline is a petroleum-derived liquid that is most typically used in internal combustion engines, especially those utilizing spark ignition. Gasoline is a hydrocarbon blend that contains sulfur, nitrogen, oxygen, and other metals. Olefins, aromatics, paraffin, and naphthenes are the four main components of gasoline. Gasoline is composed of alkanes and cycloalkenes in the C5–C12 range (naphthenes). Gasoline is primarily composed of hydrocarbons extracted from petroleum by fractional distillation, which are then improved with different additives. The density, vapor pressure, distillation rates, octane number, and chemical makeup of gasoline are all significant properties. Gasoline has several disadvantages, and it is never utilized without altering the original. For instance, at a petrol station, it may notice the various octane ratings for gasoline: 88, 90, 92, 98, and 100.

The octane rating is a measure of gasoline's ignition quality or flammability. The research octane number (RON) measures highway performance under normal conditions with an inlet temperature of 65.6ºC and revolutions per minute (600 rpm). Motor octane number (MON) indicates performance at high speeds when the intake temperature is high (148.9ºC) and the RPM is high (900rpm) [7]. The automated igniting of the fuel causes the gasoline engine to knock. Typically, regular gasoline burns too rapidly in the cylinder, resulting in an explosion. The research octane number (RON) value describes the gasoline engine's resistance to knocking. The research octane number (RON) value is determined using a scale in which isooctane (2,2,4-trimethylpentane) equals 100 (minimum beats), and n-heptane equals 0. (bad beats). The research octane number (RON) value was determined compared to a combination of isooctane and n-heptane [8]. Today's gasoline varies significantly in quality. Not all gasoline is created equal. Gasoline is not a single chemical compound. It is a complicated combination of components whose physical and chemical characteristics vary considerably. While crude oil includes both straight-chain and branched alkanes, it lacks the branched alkanes necessary to give it a high octane number (ON). The fractionated gasoline obtained from the fractionating column is an inefficient fuel. On the other hand, straight-run gasoline has an octane number (ON) of around 70 [8].

A great deal of attention has been paid to the influence of motor vehicle fuels on air quality, particularly concerning the criterion pollutants. Carbon monoxide (CO) and lead are the primary criterion pollutants controlled as direct health risks. Lead is used as an octane booster in gasoline and is released from the tailpipe as inorganic lead halides (>90 percent) and organolead compounds to a lesser degree [9]. Due to the health and environmental consequences of particulate matter (PM) emissions from internal combustion engines (ICE), environmental protection authorities have made them a priority [10-11]. Transportation sector emissions are a significant source of PM in metropolitan regions' atmospheres. The three most common causes of PM emissions from light-duty vehicles are fuel composition, rich combustion, and lubricating oil. Particulate matter (PM) emissions from these sources are categorized according to their physical condition as solid, volatile, or semi-volatile particulate matter (PM) or their chemical makeup as organic and inorganic particulate matter (PM) [12].

Numerous additives are added to gasoline to improve performance and lower pollutants. Eco-friendly additives (bio-additives) and chemical-based additives are the two broad types of additives. Ethanol, turmeric leaf oil, and algae oil are the primary bio-additives. Whereas chemically-based additions are mainly divided into the following categories:

a. Oxygenates: Dimethyl carbonate, Propyl alcohol, Butyl alcohol, Isopropyl alcohol, t-butyl alcohol of gasoline grade.
b. Ethers: Methyl tertiary-butyl ether, Tertiary amyl ethyl ether, Ethyl tertiary butyl ether, Tertiary amyl methyl ether, Tertiary hexyl methyl ether.
c. Antiknock agents: Dimethyl methyl phosphate, Toluene, Isooctane, and Triptane, among others.
d. Nano particles: Fe_2O_3, TiO_2, etc.
e. Aromatic compound: Naphthalene Compound.

2. Literature Review

Gasoline additives boost the octane rating of gasoline or function as corrosion inhibitors or lubricants, enabling higher compression ratios for increased efficiency and power. Fuel system cleaners, injector cleaners, metal deactivators, corrosion inhibitors, oxygenates, antioxidants, and friction modifiers are all examples of additives octane boosters [8].

2.1. Oxygenates

Oxygenated fuel is simply fuel that has an oxygen-containing chemical component. It aids in the efficient combustion of fuel and helps minimize some forms of air pollutants. Additionally, it has the potential to minimize lethal carbon monoxide emissions and smog production. Oxygenated fuel works by allowing for more thorough combustion of gasoline in automobiles. Because a more significant proportion of the fuel is burned, fewer hazardous substances are discharged into the atmosphere [13].

2.1.1. Dimethyl Carbonate

Dimethyl Carbonate, frequently abbreviated as DMC, is a flammable, transparent liquid that boils at 90 degrees Celsius. It is a carbonate ester that has recently been discovered to be effective as a methylating reagent. Additionally, the US EPA designated it as an exempt substance under the criteria of volatile organic compounds in 2009. Its primary advantage over other methylating reagents such as iodomethane and dimethyl sulfate is significantly less harmful and biodegradable. It is currently synthesized using catalytic oxidative carbonylation of methanol with carbon monoxide and oxygen rather than via phosgene. This qualifies dimethyl carbonate as a green reagent [14-15].

Table 2. The main properties of Dimethyl Carbonate (DMC)

Properties	**DMC [32-34]**
Chemical formula	C3H6O3
Molar mass (g/mol)	90.08
Carbon content (%)	40
Hydrogen content (%)	6.71
Oxygen content (%)	53.28
Carbon to oxygen ratio (by mass)	0.75
Stoichiometric air-fuel ratio	4.57
Melting point (°C)	4.6
Flash point (°C)	21.7

Properties	**DMC [32-34]**
Auto-ignition temperature (°C)	195
Density (kg/m3 at 20°C)	1069.4
Kinematic viscosity (cSt, 20°C)	0.63
Net lower-heat value (MJ/kg)	15.78
Latent heat of evaporation (kJ/kg)	369
Research octane number (RON)	101-116
Cetane number	35
Water solubility (g/L)	139

The following are possible downsides of Dimethyl Carbonate (DMC). Dimethyl Carbonate (DMC) has a low heat value in comparison to other oxygenated fuels and conventional hydrocarbon fuels (15.78, 26.9, 35.2, 22.4, 42.9, and 42.5 MJ/kg for Dimethyl Carbonate (DMC), ethanol, Methyl Tertier Butyl Ether (MTBE), Dimethoxymethane (DMM), gasoline, and diesel, respectively, resulting in more fuel consumption to achieve the same power output. This process shows that the load on the oil supply system will grow. Additionally, Dimethyl Carbonate (DMC) can absorb a large amount of water from the environment, resulting in low fuel quality. Additionally, because Dimethyl Carbonate (DMC) has a higher latent heat of evaporation and a lower cetane number than diesel fuel, it presents significant challenges when used directly in diesel engines (ignition process) [16-19]. As noted previously, Dimethyl Carbonate (DMC) has a lower H/C ratio (16.78%) and a lower heat value (15.78 MJ/kg) than ethanol (25.18 percent and 26.9 MJ/kg), implying that it can provide a higher rate of energy conversion when added to gasoline [20]. Additionally, Dimethyl Carbonate (DMC) has superior qualities as an oxygenated gasoline addition, including a high octane number, a low Reid vapor pressure (RVP), and a very high density [21]. Determined that when compared to ethyl-tert-butyl ether, DMC and ethanol have the most potent strain to increase the research octane number in the ethyl-tert-butyl ether (ETBE). Additionally, Dimethyl Carbonate (DMC) contains the most oxygen (53.28 weight percent), which enhances the Anti-Knock Index value (RON) + Motor Octane Number (MON)/2 in mixed fuels. Dimethyl Carbonate (DMC) or gasoline blends have a higher sensitivity (response of the fuel's knock characteristics to engine geometry, S = RON MON) than ethanol/gasoline blends.

The effect of adding Dimethyl Carbonate (DMC) to gasoline on the performance of a SI engine was explored. The research was conducted on a four-cylinder, water-cooled, four-stroke engine operating at variable engine speeds (700, 1000, 1300, 1600, and 1900 rpm) and a constant load of ten kilograms. The engine was run on pure base fuel, D5, D10, D15, and D20. According to the study, the thermal efficiency of the brakes was enhanced when compared to base fuel. At 1500 rpm, the thermal efficiency of the brakes was increased from 0.5 percent to 2.5 percent for D5, D10, D15, and D20. This finding could result from the higher octane number in blended fuels and the optimal combustion process. Found that HC, CO, CO2, and NOx emissions were all the same [22-23]. Pure Dimethyl Carbonate (DMC) can be used directly in internal combustion engines without modification. Dimethyl Carbonate (DMC) spray had superior properties to diesel fuel. Due to DMC's low boiling point, the duration of combustion is reduced. Engine emissions are lowered while carbon monoxide emissions are maintained at a near-identical level. Additionally, the brake thermal efficiency increases (2–3%) for moderate and high loads but drops somewhat at low loads. Additionally, the effects of Dimethyl Carbonate (DMC) as an additive to diesel/gasoline fuels are similar to those of pure DMC to a degree. However, NOx emissions are a topic of contention [24].

2.2. Ethers

Before the 1970s, gasoline was modified to enhance its octane rating by adding tetraethyl lead as an antiknock agent. However, when the Clean Air Act of 1970 was adopted, the use of this antiknock compound was prohibited. This legislation mandated dramatic reductions in automotive emissions, prompting automobile manufacturers to develop a catalytic converter to meet the requirements of the regulation. As a result, automobiles equipped with catalytic converters required unleaded gasoline to avoid poisoning the catalyst system by the tetraethyl lead [25]. Thus, methyl tert-butyl ether (MTBE) was added into gasoline at low amounts (1–3 vol percent) to replace tetraethyl lead as an octane booster. Methyl tert-butyl ether (MTBE) was commonly utilized as an octane booster in gasoline components before 1979 [26].

2.2.1. Ethyl Tert-Butyl Ether (ETBE)

In 1996, the United States Geological Survey stated that methyl tert-butyl ether (MTBE) was regularly detected in groundwater samples from urban areas [25]. Methyl tert-butyl ether (MTBE) pollution was primarily caused by leaks from underground storage tanks and pipelines. Because methyl tert-butyl ether (MTBE) is highly water-soluble, challenging to biodegrade, and does not readily adsorb to soil particles, it travels faster and farther than other gasoline constituents in the event of a leak. Additionally, in 2000, both the International Agency for Research on Cancer (IARC) and the United States Environmental Protection Agency (EPA) identified methyl tert-butyl ether (MTBE) as a health hazard [27]. While using methyl tert-butyl ether (MTBE) as an oxygenate addition may reduce pollutants released into the atmosphere due to complete combustion, its adverse effects on water quality have become a point of contention. According to a global market report, demand for methyl tert-butyl ether (MTBE) climbed progressively from 20.6 million tons in 1994 [27] to 21.0 million tons in 1999 and 22.0 million tons in 2002 [25, 28]. However, due to MTBE's adverse environmental effects, ethyl tert-butyl ether (ETBE) has grown in popularity as a substitute oxygenate additive for gasoline. Ethyl tert-butyl ether (ETBE) possesses superior qualities to MTBE. Ethyl tert-butyl ether (ETBE) was first used in 1992 in France. In 2002, France and Spain contributed 568,000 t to the European Union's ethyl tert-butyl ether (ETBE) production capacity [29]. Between 2005 and 2007, the capacity of ethyl tert-butyl ether (ETBE) production expanded from 2 million to 4 million tons [28], [30]. Ethyl tert-butyl ether (ETBE) is primarily utilized in numerous European nations, including France, the Netherlands, Germany, Spain, and Belgium, as a fuel additive [30-32]. Japan frequently manufactures ethyl tert-butyl ether (ETBE) utilizing bio-ethanol as a reactant [33]. In 2010, the Japanese oil industry began blending 7% bio-ethyl tert-butyl ether (ETBE) into automotive fuel under the Kyoto Protocol's Implementation Plan [34].

Ethyl tert-butyl ether (ETBE) has a higher octane rating, a higher boiling point, a lower flashpoint, a lower Reid vapor pressure during blending, and a relatively high oxygen content [35-39]. Additionally, it has lower volatility and water solubility than methyl tert-butyl ether (MTBE) [40-41]. The characteristics of ethyl tert-butyl ether (ETBE) and methyl tert-butyl ether (MTBE) are compared in Table 3. Due to the beneficial features of ethyl tert-butyl ether (ETBE), it contributes less pollution to the environment than any other gasoline additive. When combined with fuel, Ethyl tert-butyl ether (ETBE) helps reduce environmental air pollution by allowing for complete combustion of the fuel. As a result, it emits fewer nitrogen oxides and other airborne pollutants, such as formaldehyde and carbon monoxide, than methyl tert-butyl ether (MTBE) does [42]. Determined that substituting ethyl tert-butyl ether (ETBE) for methyl tert-butyl ether (MTBE) in blended gasoline resulted in a net greenhouse gas decrease of 1.94 kg CO2/GJ fuel blend [43].

Table 3. The main properties of ethyl tert-butyl ether (ETBE) & methyl tert-butyl ether (MTBE)

Properties	ETBE	MTBE
Octane rate	112	109
Boiling point	69-70 oC	55.2 oC
Flash point	-19 oC	-10 oC
Blending Reid vapor pressure	27.56 kPa	55 kPa
Oxygen content	15.7 %	18.2 %
Water solubility	23.7 mg/L	42 mg/L

Ethyl tert-butyl ether (ETBE) as an oxygenate additive is a viable alternative to methyl tert-butyl ether (MTBE) for reducing air pollution without compromising human health. Ethyl tert-butyl ether (ETBE) exhibits potential qualities and characteristics, such as decreased volatility and water solubility, which aids in mitigating environmental pollution by emitting fewer nitrogen oxides and other airborne pollutants formaldehyde and carbon monoxide. Ethyl tert-butyl ether (ETBE), which may be manufactured from renewable sources like bioethanol, cellulose, biomass, and other agricultural materials, outperforms methyl tert-butyl ether (MTBE) as an octane enhancer [44-45].

2.3. Anti Knock Agents

The antiknock properties of gasoline are determined mainly by its chemical composition. Thus, gasoline generated via direct distillation, high in regular and long-chain hydrocarbons, is typically the most prone to self-ignite and has a low octane number rating. By contrast, types of gasoline derived from catalytic reforming (which contain a high proportion of aromatic and isoparaffin) and catalytic or thermal cracking (which contain a high proportion of olefins) exhibit a low tendency for self-ignition. They do have a high octane number value [46]. Because octane is a primary indicator of gasoline's susceptibility to self-ignition, the type of hydrocarbons or oxygenates added affects the engine's performance. The automotive industry has made continuous technological advancements in its products throughout the years, necessitating higher-quality fuels. It is worth noting that the quality of gasoline is frequently a trade-off between its many attributes, including volatility, antiknocking power, solvency, and oxygen, sulfur, olefin, and aromatic content.

2.3.1. Ferrocene

Significant research has been performed in recent years to speed the substitution of hazardous ethyl fluid with metalloorganic manganese and iron-containing antiknock compounds. The use of these antiknock compounds is the least expensive and only feasible method of increasing the production of high-octane unleaded gallons of gasoline in Russia very quickly [47]. Ferrocene [$Fe(C_5H_5)_2$] is an octane enhancer that is used to boost the octane number of gasoline. Ferrocene is a less expensive alternative to Methylcyclopentadienyl Manganese Tricarbonyl (MMT). It is also utilized in iron mills as a substitute for Tetra Ethyl Lead (TEL) due to the presence of a precipitate generated from ferrosene that can form a conductive layer on the spark plug surface [47-48]. Among the commercially available iron-organic compounds in Russia, pentacarbonyl iron is frequently utilized as an antiknock agent. Compared to ferrocene series compounds, they are more readily accessible and amenable to production due to their reduced wear characteristics and cheaper manufacturing costs [49-50]. However, it is not commercially available due to its high toxicity (at the level of ethyl alcohol) and limited efficacy as an antiknock at the allowed iron concentrations [49, 51]. Between 1950 and 1970, ferrocene was intensively researched in Russia and worldwide as an antiknock agent [49], [52-54]. Because studies were conducted with high quantities of iron in the fuel, which was equivalent to the concentration of lead frequently used at the time, this study was geared toward commercialization. Iron-containing antiknock compounds primarily prevent the production of iron oxides during the combustion process in engines; these oxides are deposited in the combustion chamber as scale, reducing fuel combustion and collecting in the oil and on engine components, resulting in increased wear. When continuation trials are utilized, a specific deposit amount in the machine is recorded [47-48].

Iron-containing antiknock agents are used in practice to prevent the formation of iron oxides during combustion, and these oxides are deposited in the combustion chamber as scale, reducing the serviceability of candle ignition, and accumulate in the oil and on the rubbing surfaces of engine components, resulting in increased wear of engine components. However, a reduction in the number of deposits in the engine is noted when many derivatives are used [52-53]. Later research [55-56] demonstrated that the magnitude of the antiknock agent's negative effect is proportional to its concentration in gasoline. When the concentration (in converting to iron) is reduced to 37 mg of Fe/liter, this effect is reduced to levels found in commercial gasoline. Ferrocene is most effective at low concentrations.

The relationship under research is nearly linear in this concentration region. With rising iron content, an inflection forms on the curve depicting the connection, and it deviates in the direction of the abscissas axis. Ferrocene occurs at a certain iron content, determined by the naphtha base stock's hydrocarbon composition and octane rating. Low iron concentrations, which have the most robust acceleration characteristics, are involved in deactivating the least thermally stable paraffin hydrocarbons and their conversion products. Reduced paraffin hydrocarbon content and increased aromatic hydrocarbon content in naphtha result in a lower iron concentration. An inflection on the investigated curve and its maximum deviation in the direction of the abscissas axis are noticed. Tests should be conducted to determine the appropriate ferrocene concentration for usage as an antiknock agent in a gasoline vehicle with varying hydrocarbon compositions.

2.4. Nano Particles

Nanomaterials can operate as a catalyst for combustion, accelerating the rate of combustion and promoting clean combustion when applied to liquid fuels. CeO_2 nanoparticles, for example, have been evaluated for use as a gasoline additive to improve combustion [57-60].

2.4.1. Multi-walled carbon nanotubes (MWNTs)

Our group synthesized multi-walled carbon nanotubes (MWNTs) from the Research Institute of Petroleum Industry (RIPI) with a purity of 90–95 percent using a CVD technique over a Co-Mo/MgO catalyst [61]. The nanotubes' average diameter is between 10 and 20 nm, and their length is between 5 and 15 mm. The gasoline used in the octane number measurement (MTBE-free, Research octane number 85) was manufactured at the Tehran refinery. Merck Company provided 90 percent octadecylamine, 98 percent dodecylamine, and 99 percent thionyl chloride. This figure illustrates how adding amido-functionalized MWNTs to gasoline enhances the octane number. Additionally, octadecylamine has a more significant effect on boosting the octane number of gasoline than dodecylamine when functionalizing amido-functionalized MWNTs.

Additionally, increasing the number of additives increases the octane number. However, the additives must be added at a concentration of up to 7 ppm. At higher concentrations, the solubility of functionalized MWNTs is not stable over an extended length of time. Octane number analysis revealed that adding amido-functionalized carbon nanotubes to gasoline boosted its octane number. Our findings indicate that gasoline, including additives, remains stable for more than eight weeks.

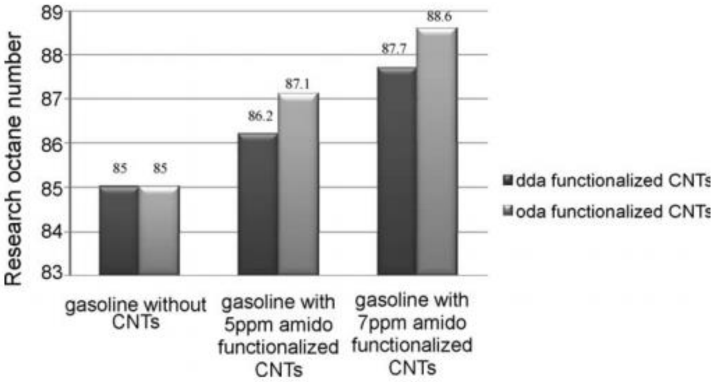

Figure 1. Reaserch octane number of the samples obtained using ASTMD2699: (A) gasoline withoutCNTs; (B) gasiline with 5 ppm of amido-functionalized CNTs; (C) gasoline with 7 ppm of amido-functionalized CNTs.

2.5. Aromatic Compound

Gasoline is a combination of hundreds of chemicals with varying boiling points produced in crude oil refineries. There are four active groups found in gasoline compounds: aromatic, isoparaffinic, paraffinic, and naphthenic. All of these active groups contribute to the gasoline's Octane rating [62]. Mendes et al. concluded that several of these active groups, such as isoparaffin and aromatic, contribute to the high octane gasoline [63]. Any compounds containing these active groups result in chemical reactions such as alkylation, reformation, and isomerization, all of which increase the Octane number of the gasoline [63]. The molecular structure has a significant effect on the igniting tendency. Compared to long-chain compounds such as paraffin, short-chain compounds such as isoparaffin exhibit excellent resistance to the self explosion [62].

2.6. Naphtalene Compound

Naphthalene, often known as Albocarbon, is an aromatic hydrocarbon having the chemical formula C10H8. Naphthalene is a crystalline solid that is soluble in organic liquids and water. Consider the naphthalene molecule as a double-bonded benzene ring [64]. Naphthalene is derived from two sources: coal tar or oil refining. Naphthalene may be considered as a substitute for bio-additives. The aromatic compounds with chemical components comparable to gasoline and cheap manufacturing costs imply a high octane number, homogenous combination with gasoline, minimal erosion impact, not low energy, and economically viable. Indeed, naphthalene is not a novel addition; it is the oldest substance utilized as an octane booster, having been used for two centuries without being quantified or understanding how it works or impacts engine performance or engine components.

Four mixes have been produced to study the probable consequences of incorporating naphthalene into gasoline motor fuel. Blend Gi is entirely gasoline, while N1, N2, and N3 are mixtures of gasoline and Naphthalene at a rate of 0.001, 0.004, and 0.008 percent, respectively. They were mixed immediately by dissolving solid Naphthalene balls in a predetermined quantity of gasoline and allowing it to mix over time and shaking. The evaluation procedure was separated into four different phases to study and appreciate the effects and causes completely. The four mixes were created by mixing Gasoline and the appropriate concentration of Naphthalene immediately and allowing the mixture to rest. The first blend (N1) contained no undissolved Naphthalene, but the N2 and N3 blends contained visible free solid Naphthalene particles.

Table 4. Octane number analysis data

	RON	MON	AKI
G	92.6	83	88
N1	93.2	83.9	88.5
N2	93.2	83.8	88.5
N3	92.6	83.5	88.1

Different concentrations of naphthalene were blended with a gasoline base. Numerous studies and experiments have been conducted to determine the various features of the mixtures, their effect on power generation, and their possible impact on the environment. On Octane numerical values alone, a very slight increase was permitted following many tests on the IFONA equipment. It demonstrated that this improvement does not require a high additive concentration; on the contrary, increased concentration has been shown to have detrimental impacts on the other attributes. Another beneficial impact of naphthalene on gasoline engines is a modest increase in the amount of heat produced by the fuel. Gas Chromatography-Mass Spectrometry (GCMS) and Fourier Transform Infrared Spectroscopy (FTIR) studies indicate that several chemicals have increased in concentration due to the presence of naphthalene. When these substances are burned at higher concentrations, they can release a large amount of energy. Overall, the benefits of utilizing naphthalene as an addition result from a slight increase in freed power and a mild boost in Octane number, which increases output power. On the environmental front, naphthalene appears to be a promising substance for reducing pollutants caused by gasoline engines, particularly those caused by lingering hydrocarbons and CO2 in exhaust gases. A slight increase in CO content was observed, attributed to a lack of oxygen entering the combustion chamber. Despite this, the data indicate that naphthalene remains a promising potential pollutant reduction. In general, naphthalene can be used to increase the thermal performance of gasoline engines and to lessen the detrimental effects of exhaust gases, but only when the required concentration is calculated correctly to avoid the inverse effects of overdue rates.

3. Conclusion

Today's gasoline varies significantly in quality. Not all gasoline is created equal. Gasoline is not a single chemical compound, and it is a complex blend of components whose physical and chemical properties vary considerably. However, the quality can be measured from the octane number of the gasoline. So scientists made a breakthrough aimed at increasing the octane number. One of them is by adding an additive to gasoline, commonly referred to as an octane enhancer. Many types of octane number enhancers have been found, categorized into several categories: oxygenate, ether, anti-nock agent, nanoparticles, and aromatic compounds. In this article review, the author chooses one that is popular from the above categories, such as:

Oxygenate: Improves brake thermal efficiency resulting in reduced smoke as additives are added and reduced Hydrocarbon (HC) and Carbon monoxide (CO) emissions. In addition to being expensive and presently unavailable, the additive has a drawback, and besides that, it can increase NOx emissions due to high temperatures driven by combustion and oxygen enrichment. Two studies are necessary to make DMC usable in an IC engine: (1) study on DMC/hydrocarbon fuel mixes for the interaction chemistry; and (2) updating the primary reaction constants in the current dimethyl carbonate (DMC) kinetic model by recognizing the first decomposition routes and low-temperature oxidation.

Ether: Ethyl tert-butyl ether (ETBE) as an oxygenate additive is a viable alternative to MTBE for reducing air pollution without compromising human health. Ethyl tert-butyl ether (ETBE) exhibits potential qualities and characteristics, such as decreased volatility and water solubility, which aids in mitigating environmental pollution by emitting fewer nitrogen oxides and other airborne pollutants formaldehyde and carbon monoxide. Ethyl tert-butyl ether (ETBE), manufactured from sustainable resources like bioethanol, cellulose, biomass, and other agricultural materials, outperforms MTBE as an octane enhancer. Antiknock agent: Ferrocene combined with MTBE or ethanol has a high antiknock impact in gasoline containing up to 40% aromatic hydrocarbons. It is economically viable to employ it in the commercial production of gasoline at concentrations of up to 37 mg of Fe/liter. Ferrocene is most economically successful at lower iron concentrations – up to 20 mg of Fe/liter – in high-octane gasoline with more than 40% aromatic hydrocarbon content.

Nanoparticle: Carboxylation, acyl-chlorination, and amidation are the usual methods for amido-functionalized MWNTs. The presence of a bond at 1650 cm1, which corresponds to the amide carbonyl group, indicates the amide group's presence in the processed samples. TGA analysis revealed derivative peaks in the region of 280–360 8C, resulting from amine combustion. According to XPS analysis, 3.5 percent of the nanotubes' sites are connected to octadecylamine molecules. Octane number analysis revealed that adding amido-functionalized carbon nanotubes to gasoline boosted its octane number. Our findings indicate that gasoline, including additives, remains stable for more than eight weeks.

Aromatic Compound: Increased quantities of naphthalene molecules can generate a large amount of energy when burned. Overall, the benefits of utilizing naphthalene as an addition result from a slight increase in freed power and a mild boost in Octane number, which increases output power. On the environmental front, naphthalene appears to be a promising substance for reducing pollutants caused by gasoline engines, particularly those caused by lingering hydrocarbons and CO2 in exhaust gases. A slight increase in CO content was observed, attributed to a lack of oxygen entering the combustion chamber. Despite this, the data indicate that naphthalene remains a promising potential pollutant reduction. In general, naphthalene can be used to increase the thermal performance of gasoline engines and to lessen the detrimental effects of exhaust gases, but only when the required concentration is calculated correctly to avoid the inverse effects of overdue rates. After reviewing this article, the author hopes to get an octane number increase to improve the quality of gasoline and reduce the resulting emissions. Likewise, its availability and affordable prices can be immediately applied to the current quality of gasoline.

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