Material and chemical stability of using motor gasoline/automotive gasoline in piston engine aircrafts – a review

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Abstract. Piston aircraft engines commonly operate on aviation gasoline (AVGAS) and motor gasoline (MOGAS). Engines such as JABIRU and Lycoming have the capability to run on both types of gasolines. Currently, MOGAS often comprises a specific percentage (3-10%) of bio-alcohol. In this regard, the material and chemical stability of MOGAS must be considered by aircraft operators to understand the possible impact of using this gasoline as aviation fuel. Some aircraft manufacturers recommend MOGAS to power aircraft engines, although AVGAS may still be employed as well. Some manufacturers are currently designing engines capable of operating on both types of fuels because in the future AVGAS would be less available compared to MOGAS. Operating a piston engine aircraft using MOGAS presents several issues owing to the side effects associated with ethanol contained in the blended fuel. This paper studies the factors affecting the use of MOGAS in piston aviation industry as the only approved fuel for piston aviation is AVGAS, a leaded fuel in terms of chemical and material stability and compatibility.

1. Introduction
MOGAS represents a composite blend of hydrocarbons and organic compounds and elements like sulphur and nitrogen [1]. Whenever MOGAS is stored for extended periods before consumption, a number of these compounds and elements react with atmospheric oxygen and with one another to create new dense materials usually called gum. Further, Coordinating Research Council [1] asserts that the capability of a MOGAS to resist such degradation of composition over time is referred to as stability. Based on the Council’s definition, chemical stability of MOGAS refers to its thermodynamic stability. Thermodynamic stability happens when MOGAS is in a state of chemical balance with its environment. This form of chemical thermodynamic balance endures unless the system changes over time. On the other hand, material stability refers to the capacity of a matter to persist unchanged with time under reasonably accepted storage and use conditions. Typically, the conditions, which might affect material instability, are humidity, temperature, contamination, and length of storage time.
Insufficient material and chemical stability of MOGAS during long-lasting storage is an issue that first became remarkably severe during the increased uptake of gasoline owing to the greater adoption of thermal cracking [2]. Federal Aviation Administration [2] claims that the thermally cracked substances oxidise easily compared with straight-run products leading to rapid growth of gum. After evaporation of MOGAS, these gums become visible as a hard or gummy residue that usually deposits in engine’s induction system causing malfunction.

A stable MOGAS is one whose attributes remain unchanged [3]. Aspects that can result in harmful changes in fuel properties comprise exposure to high temperatures and time. Aircraft fuel instability encompasses multi-procedure chemical reactions, a number of which are oxidation counteractions. Hydro-peroxides and peroxides represent the preliminary reaction products. These products are dissolved in the gasoline (MOGAS), but might react with or lessen the lifespan of numerous aircraft fuel system. Stavinoha et al. [3] indicate that other reactions (subsequent reactions after oxidization which produce nondescript compounds containing acid, ester, carbonyl, and sulphur groups) cause the generation of insoluble and soluble gums particulates. The products might block fuel filters limiting flow in small-diameter tubes.

The relationship between material stability and temperature exists. Stavinoha et al. [3] note that a stable material is expected to resist deterioration at high temperatures. In this respect, a stable gasoline should defy breakdown at high temperatures by not forming unwanted degradation products like gum and particulates. Stavinoha et al. [3] assert that trace contaminants contained in gasoline play a huge role in the degradation process. Thus, to increase the stability of MOGAS, fuel manufacturers and distributors ought to minimize contamination of gasoline. Stavinoha et al. [3] also claim that at higher temperatures affect the stability of MOGAS. Prolonged exposure to higher temperature amplifies the thermal stresses on gasoline and its tendency to form deposits. Stavinoha et al. [3] say that the stability of MOGAS is of high importance for aircraft operators intending to use this type of gasoline as an aviation fuel. Aviation fuel acts as a heat sink that cools engine oil, avionics, and other aircraft equipment [3]. The tendency of MOGAS to degrade compared with AVGAS presents challenges to aviators planning to use this type of gasoline as an aviation fuel. This shift presents issues such as increased likelihoods of gum formation, decreased heat transfer, and engine malfunctions. Stavinoha et al. [3] maintain that gum deposits compromise engine performance.

Thermal stability is a critical gasoline property that ought to be considered when using MOGAS as aircraft fuel because the fuel acts as a heat exchange intermediate between airframe and the engine [4]. The study notes that aircraft fuel removes heat from the hydraulic fluid, oil, in addition to air conditioning apparatus. Because of this, the fuel gets heated, accelerating reactions, which results in particulate and gum generation [4]. Particles might deposit in the main engine, fuel injector nozzles, fuel filters, and on heat exchangers. According to Strauss [4], deposits on fuel filters cause pressure drop and a reduction in fuel flow. Deposits on fuel injector nozzles interrupt the spray pattern leading to hot smudges inside the combustion chamber. Similarly, deposits in the engine control disrupt engine system monitor and interfere with the fuel flow. On the other hand, deposits on the heat exchanger cause malfunction in heat transfer and fuel flow mechanisms. These deposits may cause operational difficulties and increased maintenance costs.

Strauss [4] state that thermal stability is an important aircraft fuel property. Instability presents as the development of peroxides, hydroperoxides, gums, and insoluble substances that cover surfaces or create particulates. These substances have polymeric attributes and usually cause unnecessary effects like deposition on the aircraft-engine fuel system that affects its performance. According to Strauss [4], the knowledge about the instability reactions is still under development. These reactions are deemed multi-procedure reactions that comprise of oxidation reactions. The reactants include nitrogen, sulphur compounds, organic compounds, in addition to reactive olefins. Strauss [4] assert that the concentrations of these particular reactants are so low that any detection by the contemporary analytical method is virtually impracticable. In addition, contaminants can also contribute to instability. The existence of some contaminants like copper in MOGAS may accelerate oxidation reactions. Failure of a thermal stability test comprises the development of higher molecular dense compounds having partial fuel solubility. The growth of these insoluble relies on the presence of both bulk and trace fuel qualities. Both the molecular weight and chemistry of any of these reaction
products are influenced by the reactants that are only available in trace amounts. However, after the formation of the reaction products, the fuel’s solvency acts as the primary composition, which influences the solubility of the outputs. Strauss [4] assert that contrary to popular perception, two fuels, which are by themselves stable, may be unstable when blended. Each gasoline type might comprise of a number, but not every, of the reactants needed to create insoluble. Only after blending the fuels, do all existing reactants facilitate the reaction to start. Strauss [4] also suggest that the blend’s solvency may affect the stability of gasoline.

Other studies focused on chemical and material stability of MOGAS have investigated the density of oxidised gasoline. A study by Pereira and Pasa[5] indicated that density of MOGAS rises when fuel oxidises. The presence of gum increases MOGAS’ density. This study was also able to investigate gasoline stability with respect to oxidation reactions based on the fuel contents, radicular mechanism, and the type of olefin present. Pereira and Pasa[5] noted that not all olefins cause the oxidation of MOGAS. Olefins generating more stable intermediates like secondary allelic radicals contribute most to the establishment of gum and have shorter induction periods. On the other hand, olefins that produce primary allelic radicals do not cause the development of gum. The findings by Pereira and Pasa[5] concluded that the production of MOGAS with high stability needs the least addition of petrochemical portions with both conjugated and cyclic olefins. Portions having non-conjugated and linear olefins are sufficient to create high stability MOGAS [5].

Nixon et al. [6] focus on MOGAS material stability, specifically storage stability. The instability of MOGAS used as aircraft fuel is usually not an issue since most aviation fuels are consumed within months or weeks of their manufacture. However, storage stability might present serious issues for small aircraft owners because they do not use a lot of fuel hence end up storing them [6]. MOGAS, used as aviation fuel, ought to remain stable before and when being used to run aircraft engine. Nixon et al. [6] advise that MOGAS stored for a longer period, more than one year, or those subjected to inappropriate storage or management must be assessed to ensure that it satisfies all appropriate specification necessities before use. They also suggest that since reactive components of gasoline influence its material and chemical stability, storage of fuel is determined by fuel composition. It is also affected by storage settings. For instance, instability reactions happen speedily and largely at elevated ambient temperatures.

Based on its source MOGAS have less chemical stability compared to AVGAS resulting in more tendencies to generate gum [7]. The study also points out that MOGAS might hold more sulphur particles, which is a likely cause of corrosion. This fuel also has more percentages of hydrocarbon compounds that cause unnecessary carbon formation and probable detrimental effects on seals. Jeon et al. [7] also claims that MOGAS frequently have additives, which are not permitted for AVGAS, and whose likely impacts on piston engine aircraft are still unknown. According to Jeon et al. [7], MOGAS powers internal combustion engines. It is unstable and inflammable admixture encompassing paraffin, hydrocarbons, and olefins. Other than hydrocarbons, MOGAS also contains small quantities of sulphur, nitrogen, and atmospheric oxygen. While in storage, the hydrocarbons contained in MOGAS react with oxygen and other compounds leading to changes in their material and chemical attributes. Jeon et al. [7] claims that the oxidation reaction continues to react up until they result in non-volatile compounds having high molar mass, which are usually called gum. According to Jeon et al. [7], this gums deposits in the aircraft-fuel system resulting in interference of fuel flow due to blockages. In the admission valves and carburettor, gum deposits accumulate in large quantities interfering with their operation. Gum deposit also causes unsuitable mixture ratio and rich fuel burn. With time, the accumulation of deposits leads to issues such as engine malfunctioning, power loss, and exhaust gas emissions [8]. In agreement with Jeon et al. [7], it is known that the quantities of paraffin, naphthenic, olefins, diolefins influence the stability of MOGAS. For instance, MOGAS with higher olefin quantities triggers high gum content. The study also noted that MOGAS density increases with the oxidation of gasoline owing to the occurrence of gum.

MOGAS designed for modern engines is generated using catalytic reforming distillates. Such fuels have up to 70% hydrocarbon components [9]. The impact of hydrocarbons on MOGAS’ chemical stability is insufficiently studied [9]. Aromatic hydrocarbons are usually oxidised by atmospheric
oxygen leading to the generation of products with anti-oxidation qualities. Thus, Wang et al. [9] suggests that MOGAS stability primarily relies on the quantity of hydrocarbons and their structure.

Studies conducted by Totten et al. [10] indicate that the quality MOGAS ought to be stable for a period of up to five to six months when stored properly. The studies claim that gasoline breaks down gradually over time because of the separation of its components. The study noted that MOGAS stored appropriately for up to one year would more probably be stable, but its stability deteriorates with each passing month until it the gasoline requires to be diluted with fresh fuel [10]. They suggest that if left undiluted the gasoline will cause malfunction of an engine, which may include the engine misfiring. Totten et al. [10] says that MOGAS should be stored in airtight containers to prevent fuel contaminations by water vapour and oxidation elements. It should also be kept at stable, cool temperatures to prevent overload pressure caused by liquid expansion and to lessen the pace of decomposition reactions. Like other authors, Totten et al. [10] claim that improper storage of MOGAS leads to the creation of gums, which corrodes system apparatus and accumulates deposits on wetted surfaces.

2. Evaluation of motor gasoline material and chemical stability

Between the years 1943 and 1945, the U.S. Army undertook three desert tests to determine the material and chemical stability of MOGAS under storage [11]. The findings from this study revealed that MOGAS stability could be assessed with the help of ASTM tests for induction time (D525) in addition to oxidation stability (D873). The tests (D525 and D873) also indicated that 480 minutes was the realistic least selection period requirement for market gasoline of that time. A sustainable relationship existed between the findings obtained through desert storage outcomes and laboratory storage at 43°C [11]. The 480-minute initiation time was to mirror a 4-year storage prerequisite for army gasoline contrasted with the natural commercial gasoline, which has short-storage time necessities.

In another tests program undertaken between the years 1944 and 1945, in the US, MOGAS with gum quantities of 1.5, 7.0, 10.0, 25.0, and 50.0 mg/100 mL were tested in numerous motor vehicles for over 500 hours [11]. The findings revealed that many cars running on MOGAS having 7.0 mg/100 mL gum (or more) experienced engine failures subsequent to a few hours of operation. The malfunctions were due to an extreme intake of gum deposits on valve manifold.

Studies undertaken by the US Bureau of Mines established a “16-hour oven test” at 203°F. Test results were concurrent with 43°C storage under numerous stages of time and were used with a multiplication factor of 950°C (16 hours) and a monograph-relating time of 430°C to attain a selected gum level of 7 [11]. The process was never approved by the automotive or the aviation industries because of its poor gum data accuracy. Nevertheless, a few procedures for assessing material and chemical stability of stored MOGAS samples have been implemented from this study.

Additive called polyether amine might be employed to eliminate fuel injector deposits [12]. Flow interruptions resulting from deposits ranges from 5 to 50% of undulterated injector flow. Bert et al. [12] proposed an additive effectual for deposit eradication in engines, injectors, carburettors, and valves. This additive also eradicated combustion chamber particulates. With the help of fleet and laboratory tests, Bert et al. [12] established that the effect is to some extent engine reliant.

Tupa et al. [13]theoretically constructed a mechanical obstruction mechanism that allows evaporated deposit in boiling-range unstable gasoline to oxidise and polymerise creating form resins and gums slowly. These materials contained an adhesive, which holds other particulate deposits in place. Tupa et al. [13]indicated that gasoline, in the absence of engine impacts, may create gum-type particulates around the pintle area after soaking for almost 18 days under 90°C. They estimated that a deposited coating of 6 micrometres thick deposits on both orifice and pintle areas restricting fuel flow via an injector by 26% [13].

Another study by Bert et al. [12] focused on an experiment on Multiport Fuel Injectors (MPFI) deposits using FTIR spectroscopy and established that the residues were mostly carbon and sulphur. Sulphur was the common inorganic element. The spectra illustrated the existence of unsaturated and oxidised hydrocarbons. Sulphates and existence of sulphonates were also found. Bert et al. [12] used electron spectroscopy together with chemical analysis to demonstrate that deposit outline is consistent.
throughout its whole breadth on the pintle. Their findings illustrated that three stability-connected ingredients of MOGAS (diolefins, sulphur, and hydrocarbons) influence the pace of injector deposit creation. Both olefins (usually contained in modern MOGAS) and diolefins quickly oxidise at storage to create gums and resins.

3. Compatibility of fuel system and engine materials with ethanol content in fuel

Each et al. [14] mentioned that a major issue is the ethanol admixture compatibility of elastomers and most of the aviation oriented elastic hoses are produced from aviation certified Nitrile Rubbers of the various kinds, usually abbreviated with NBR. For pure gasolines or such with only small amounts of admixed ethanol (less than E-5), they are considered appropriate with respect to their material longevity. Exposed to increased ethanol contents they tend to brittle or swell, depending on the individual kind of elastomer. This is, in view of AVGAS or present-day MOGAS usage is favourable. These rubbers (NBR) yield sensible temperature stability with respect to hot conditions they usually outperform the nitrile rubber variants, a low swelling rate and a comparative or even better swelling behaviour. Figure 1 exhibits temperature resistance of elastomers, Figure 2 exhibits Temperature resistance of elastomers and Table 1 exhibits Types of Elastomer for aviation usage and the function.

![Temperature resistance of elastomers](image)

**Figure 1.** Temperature resistance of elastomers [14]
Figure 2. Temperature resistance of elastomers [14]

Table 1. Types of Elastomer for aviation usage[14].

| No | Elastomer | Chemical Name           | Trade Name | Manufacturers                                      | Function / strength                                                                 |
|----|-----------|-------------------------|------------|---------------------------------------------------|----------------------------------------------------------------------------------|
| 1  | ACM       | polyacrylate rubber     | Noxtite-PA | Denki Kagugi Chemicals, Zeon Chemicals, BF Goodrich, EnichemElastomeri, Du Pont Dow Elastomers, Thiokol Chemical Corp. | • only medium strength, low elasticity, disadvantageous low-temperature performance  
  • (very) good ageing, oxidation and ozone resistance  
  • excellent resistance against heat and hot oil  
  • application in automotive industry due to its very good heat resistance and its resistance against highly addivated lubricants |
|    |           |                         | Hytemp     |                                                   |                                                                                   |
|    |           |                         | Nipol AR   |                                                   |                                                                                   |
|    |           |                         | Hycar      |                                                   |                                                                                   |
|    |           |                         | Europrene AR |                                                 |                                                                                   |
|    |           |                         | Cyanacryl  |                                                   |                                                                                   |
|    |           |                         | Vamac      |                                                   |                                                                                   |
|    |           |                         | Thiacril   |                                                   |                                                                                   |
| 2  | AEM       | ethylen-acrylate rubber | Vamac      | Du Pont Dow Elastomers                            | • good resistance against mineral oils, water and cooling agents, good weather and ozone resistance |
|    |           |                         |            |                                                   |                                                                                   |
| 3  | AU EU     | polyurethane rubber     | Pellethane Vibrathane | Dow Chemical Uniroyal Inc., Bayer Compounding Ingredients Uniroyal Inc. Bayer Bayer BF Goodrich American Cyanamid | • very high tear strength, notch and friction resistance, high tensile strength, high breaking elongation, low compression set  
  • EU has better hydrolysis resistance  
  • good resistance against mineral oils, water and cooling agents, very good ageing- and ozone resistance  
  • low expansion when                                                                 |
|    |           |                         | Urepan     |                                                   |                                                                                   |
|    |           |                         | Elastothane |                                                   |                                                                                   |
|    |           |                         | Adiprene   |                                                   |                                                                                   |
|    |           |                         | Desmopan   |                                                   |                                                                                   |
|    |           |                         | Vulkollan  |                                                   |                                                                                   |
|    |           |                         | Estanev    |                                                   |                                                                                   |
|    |           |                         | Cyanaprene |                                                   |                                                                                   |
| No | Type | Rubber Name | Company | Properties |
|----|------|-------------|---------|------------|
| 4  | BIIR | bromobutyl rubber | No Record | • good resistance against acids, glycol brake fluids and hot water |
| 5  | CIIR | bromchloride rubber | Esso Butyl H10 | Esso | • good resistance against acids, glycol brake fluids and hot water |
| 6  | CO  | epichlorohydrine rubber | Hercor C | Hercules Chemicals | • good high temperature properties |
|    |     |                          |         |             | • good weather and ozone resistance |
|    |     |                          |         |             | • good resistance against gasoline and mineral oils and mineral oil greases |
| 7  | CSM | Hypalon | Hypalon Noralon | Du Pont Dow Elastomers Denki Kagugi Chemicals | Properties depending on chlorine content: |
|    |     |                          |         |             | • low chlorine content: best heat resistance and low-temperature flexibility, fair oil resistance |
|    |     |                          |         |             | • high chlorine content: better resistance against oils, less heat resistance and low-temperature flexibility |
|    |     |                          |         |             | • abrasion-resistant |
|    |     |                          |         |             | • good chemical, ageing and ozone resistance |
| 8  | ECO | Epichlorhydrine-copolymere rubber | Hydrin Hercor H Gechron | Zeon Chemicals Hercules Chemicals | • good low-temperature flexibility, good high temperature properties |
|    |     |                          |         |             | • good resistance against gasoline and mineral oils and mineral oil greases |
| 9  | EPR / EPDM | ethylene-propylene-diene rubber | Dutral Keltan Vistalon Buna EP / AP Nordel Royalene Epcar Epsyn Polysar-EPDM | Montedison, USA DSM / Sabic Exxon Chemical Co. Chemische Werke Hüls Du Pont Dow Elastomers Uniroyal, Inc. Goodrich Copolymer Rubber Bayer | high elasticity, good low-temperature behaviour |
|    |     |                          |         |             | • good resistance against hot water, very good ageing, weather and ozone resistance |
| 10 | FFKM / FFPM | perfluoro rubber | Isolast Celrez Kalrez Simriz Chemraz Perlast | Trelleborg Sealing Solutions CKD Dichtungstechnik Du Pont Dow Elastomers Simrit Greene Tweed Precision Polymer Engineering | • combines the high temperature toughness of a fluorocarbon elastomer with the chemi-cal inertness of Teflon |
|    |     |                          |         |             | • very good mechanical properties even at high temperatures, high tearing strength |
|    |     |                          |         |             | • mechanical properties |
|   |     |                      |                           |                                                                 |                                                                                                             |
|---|-----|----------------------|---------------------------|-----------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------|
|11 | FKM | fluoro rubber        | Dai-El                    | Daikin Industries 3M Company (Dyneon) Montedison, USA Du Pont Dow Elastomers Denki Kagugi Chemicals 3M Corporation Asahi Glass Co., Ltd. | • very good mechanical properties even at high temperatures, high tearing strength • very good resistance against oils and chemicals, heat resistant |
|12 | FVMQ| fluorsilicone rubber | Silastic LS FSE           | Dow Corning General Electric                                   | • good compression set, low strength, bad abrasion properties, good low-temperature flexibility • FVMQ combine the good temperature properties of the silicones with the good chemical resistance of the fluorocarbons [F0E0?] advanced resistance against fuels and oils • high thermical resistance, ageing, ozone and weather resistant |
|13 | MQ  | silicone rubber      | No Record                 | No Record                                                       |                                                                                                              |
|14 | VMQ | methyl-vinyl silicone rubber | Rhodorsil Silastic Silopren Silplus | Rhone Poulenc Dow Corning Bayer General Electric |                                                                                                              |
|15 | IIR | butylene rubber      | Esso Butyl Exxon Butyl Polysar Butyl Enjay Butyl BucarButal Petro-Tex Butyl | Esso Exxon Chemical Co. Bayer Enjay Columbia Carbon Co. Petro-Tex Chemical Co. | good resistance against acids, glycol brake fluids and hot water as well as good oxygen, chemicals, ozone and solvent resistance |
|16 | NBR | nitrile rubber       | Breon Chemigum Elaprim Hycar Nysyn Butakon | BP Chemicals Goodyear BF Goodrich DSM Copolymer, Inc. Revertex | • good combination of low compression set, high tensile strength and good abrasion resistance, high shock resistance, low-temperature flexibility, however, properties depend on ratio butadiene:acrylonitrile (e.g. increasing butadiene content: resistance increases but low temperature flexibility decreases) • X-NBR is more abrasion resistant than NBR • HNBR: advanced mechanical properties |
|17 | X-NBR| carboxilated nitrile rubber | Butacril Buna N Perbunan N / NT Paracril Krynac Europrene N Nipol N | Was UGINE KUHLMANN Chemische Werke Hüls Bayer Uniroyn Bayer EnichemElastomeri Zeon Chemicals |                                                                                                              |
|18 | HNBR| hydrogenated nitrilebutadiene rubber | Therban Zetpol Tornac | Bayer Zeon Chemicals Bayer |                                                                                                              |
| 19 | NR | natural rubber | Crepe SMR SIR Natsyn | Goodyear | • good mechanical strength and elasticity, high flexural fatigue strength, very good abrasion resistance, low compression set, high tensile strength, high abrasion resistance and tear resistance • good resistance against organic acids, alcohol and brake fluids, bad resistance against e.g. sunlight, ozone and gasoline • flammable |
| 20 | SBR | styrene-butadiene rubber | Buna Hüls Buna S Europrene Polysar S Phioflex Phiolite Stereon Solprene Rhodorsil Clariflex S Plioflex Carom | Chemische Werke Hüls Chemische Werke Hüls EnichemElastomeri Bayer Goodyear Fina Chemicals Rhone Poulenc Goodyear ChemischesKombinat | • advanced abrasion and ageing resistance, good low and high temperature resistance • good resistance against brake fluids |

4. Failure mode and effect analysis (FMEA)

“A failure mode and effect analysis (FMEA) conducted by Safety Implication of Biofuels In Aviation Research Project EASA 2008/6 found major issues, divided into 5 different categories and concluded that FMEA has prompt a re-examination of the significance and error potential of the fuel delivery. Handling of the small amounts of fuel used for airplane operation makes new dangers when utilizing ethanol-admixed fuels [15]. Due to the altered properties of the new ethanol-admixed gasolines a differentiated view is needed. The associated individual threats (phase separation, vapour locking, icing, material compatibility) were confirmed and risks are deadly dangerous if not adequately and pro-actively handled. Additional authority actions are recommended especially for the field of the compatibility of the aircraft’s constructive materials. A general re-examination of fuel compatibility is recommended for all materials potentially in-tact with new ethanol-admixed gasoline types. This procedure might be lightened if individual selections of materials are sponsored by similar decisions in the car business however ought to as a rule be required for aviation industry. The physio-substance
property changes of ethanol-admixed fuels with respect to previous hydrocarbon only fuels are somewhat having many implications if used in aviation. Along these lines not all encounters assembled from vehicle use can be exchanged to aviation. In like manner, new research exercises have been recognized that should pinpoint subjectively known dangers in a more quantitative way.

5. Conclusion
Based on the above literature review, it is apparent that there are a few studies focusing material and chemical stability of using motor gasoline/automotive gasoline in piston aircraft engine. Additional authority actions are recommended especially for the field of the compatibility of the aircraft’s constructive materials. A general reassessment of fuel compatibility is suggested for all materials potentially meeting new ethanol-admixed gasoline types. This process may be alleviated if respective choices of materials are backed by comparable choices in the automotive industry but should in general be mandatory.

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