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# Biodiesel properties and automotive system compatibility issues

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ABSTRACT

Acceptability of biodiesel by automotive sector is limited due to some of its adverse properties such as cold flow properties, oxidation stability and corrosiveness with automotive fuel system materials. Adverse cold flow properties of biodiesel lead to the problem of plugging and gumming of filters and injectors. There is a concern about the poor oxidation stability of biodiesel, which results in the formation of sediments and gums causing problem in the engine fuel injection system. Biodiesel reacts with automotive fuel system materials adversely resulting in corrosion of metals and degradation of elastomers. Beside these adverse issues, biodiesel possesses incredible inherent lubricity.

This article aims to review the adverse biodiesel properties like cold flow properties, oxidation stability; corrosive and acidic nature resulting in non-compatibility with automotive fuel system materials. It also discusses the excellent lubrication behaviour of biodiesel and its positive impact. An effort has been made to present the review of 145 research papers along with the sharing of our some in-house experimental results. Additive treatment with biodiesel has been found to be suitable for improving the low temperature properties and oxidation stability. Certain metallic and elastomeric components have been reported as compatible/non-compatible with biodiesel. Although attempts have already been made by some researchers on the adverse properties of biodiesel but the scope is rather limited to the properties alone than correlating the same with automotive materials compatibility.



**Contents**



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## 1. Introduction

The relevance of fossil fuels as an energy resource is now widely acknowledged as unsustainable due to exhausting resources and involvement of these fuels in the contamination of the environment [1]. According to International Energy Agency (IEA) report, the world's primary energy demand is proposed to increase by 55% between 2005 and 2030, at an average annual rate of 1.8% per year [2]. If this trend continues, the world will encounter a huge energy crisis. Hence, to resolve these important issues systematically, renewable and carbon neutral biodiesel is essential for environmental and economic sustainability. Biodiesel covers a range of alternative fuels which can be obtained from plant seeds and vegetable oils as well as animal fats.

Besides the major fascinating energy resource, biodiesel is tending to start-up and performance problems when vehicles and fuel systems are subjected to cold climatic temperatures. In winter season, crystallization of high melting saturated fatty acid methyl esters may cause the plugging of filters and fuel tubes [3–5]. Clogging of filter takes place when the temperature falls below the solidification point of biodiesel [6]. The use of biodiesel and its higher blend is restricted due to their poor cold weather performances [7–9]. While most of the characteristics of biodiesel are comparable to fossil based diesel fuel, improvement of its low temperature, flow characteristics still remain one of the major challenges when using biodiesel as a substitute fuel for compression ignition (CI) engines [10].

Moreover, biodiesel is more susceptible to oxidative degradation than fossil diesel fuel. Industries that transport and store biodiesel, hence, are concerned that biodiesel may form sediment and gum during storage. Also, the diesel engine vehicle and equipment operators require a guarantee that sediments and gum will not form during use. Retaining the quality of new fuel formulations such as biodiesel for extensive use as an alternate fuel for application ranging from on and off road diesel engines to locomotives, stationary power, heat generation and aviation, will depend on improvement of technologies to improve its long term storage stability. Biodiesel stability includes oxidation, storage and thermal stability, but usually termed as oxidation stability. The oxidation instability leads to the formation of peroxide or hydroperoxides molecules [11]. The poor oxidation stability of biodiesel increases the peroxide value, viscosity, iodine value; acid number and gum deposits [12]. These bad effects of biodiesel caused a problem in the engine like damage to the fuel delivery system, filter plugging, injector cocking, corrosion, fusion of moving components, hardening of elastomeric components and engine deposits [13–15]. The European standards (EN 14112) for oxidation stability propose a minimum value of 6 h induction period at 110 °C, determined by Rancimat induction apparatus [16]. Many studies have revealed that biodiesel possesses a lower induction period than that proposed by the standards.

Furthermore, biodiesel generally experiences degradation of automotive materials resulting in decrease in life of fuel system components [15,17,18]. Biodiesel is more corrosive than fossil diesel [19]. The blends of biodiesel showed corrosion effect on copperish metals [20]. Also, biodiesel have splendid solvent properties [21]. Hence, any deposits in the filters and in the delivery systems may be dissolved by biodiesel and petroleum diesel forms deposits in a vehicular fuel system. As biodiesel can loosen those deposits, they can migrate and clog fuel lines and filters, resulting in the replacement of the filters. Also, biodiesel will react with some elastomers and metals in a destructive way affecting the engine durability problems like injector cocking, piston ring sticking and severe engine deposits [22–24].

The major obstacle in commercialization of biodiesel is high feedstock cost. In European countries biodiesel is being sold at prices economical compared with petroleum diesel fuel because of the tax benefits given by the government to improve the prospective use of biodiesel in various applications. Due to the lack of such tax relief in other countries, the cost of the biodiesel is very high compared to the petroleum diesel. Therefore, various nonfuel applications of biodiesel must be examined. The advent of ultra-low sulphur diesel fuel ( $<15$ ppm sulphur in US and $<10$ ppm in Europe) has raised concern over the ability of these fuels to sufficiently lubricate diesel engine components in the fuel injection system [25]. One of the most promising alternatives for biodiesel application is its use as a diesel fuel lubricity additive [26]. Due to its incredible inherent lubrication properties, biodiesel is utilized as an additive to improve the lubrication properties of conventional fuels. Such usefulness was also accounted for even lower ( $<1\%$) blend level or higher [27–29].

Though some attempts have already been made by researchers to present a review of some biodiesel issues, but the review exploring the biodiesel properties and its effect on engine system compatibility is rather limited. Therefore, the aim of this article is to present a review of adverse biodiesel properties such as cold flow behaviour, oxidation stability, etc. and its effect on automotive system compatibility. Fig. 1 shows elements considered in literature review. After the introduction, the cold flow behaviour of biodiesel, which has importance in low temperature, is reviewed. This is followed by a section that presents a review of oxidation stability. Further, section presents review on the compatibility