Study on the Effects of Biodiesel on Fluorine Rubber Material

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Abstract

The swelling characteristics of biodiesel are important for long term durability of engine parts. The effect of biodiesel, i.e. rapeseed oil methyl ester (RME) and cottonseed oil methyl ester (CSME) on automotive materials, i.e. fluorine rubber is studied by conducting the static immersion test at 55℃ for 60days. Two ways for effect compatibility of fluorine rubber in biodiesel is investigated: blending with 0 petrodiesel (0PD) and treating with antioxidants additives. The study shows that the order of swelling corrosion in fuel upon exposure to fluorine rubber is CSME > RME > 0PD. And blending with 0 petrodiesel (0PD) and treating with antioxidant additives can be reduced to the swelling of rubber to a certain extent.

Keywords

Biodiesel, Fluorine Rubber, Swelling Corrosion, Antioxidants.

1. Introduction

Biodiesel is an alternative diesel engine fuel comprised of alkyl esters of fatty acids derived from renewable feed stock such as vegetable oil and animal fat animal fats or waste cooking oil through the transesterification reaction. [1] Typical biodiesel contains saturated and unsaturated methyl esters or ethyl esters with 14-24 carbon atoms in the carbon chain. However, the composition is related to the feedstock. [2] The use of biodiesel has shown a remarkable increase since the last decade, particularly in Europe, Germany, France and Austria. Lately, it has caught the attention of USA, Canada, Malaysia, Indonesia, India and many other countries. The enormous potential of biodiesel is yet to be realized in China. [3] Due to its excellent solvent properties, biodiesel can dissolve elastomers as well as tank deposits and lead to fuel filter and injector plugging. It leaches aromatics from the elastomer as well as additives designed to prevent hardening and cracking. In fact, biodiesel has been shown to swell trilobutyldiene and nitrile rubber, common automotive seal and gasket material [4-7]. Material compatibility with biodiesel is one of major concerns. Many of materials used in a diesel engine, such as those using in the fuel system, might not be compatible with biodiesel. For an elastomer, its compatibility with a fuel is estimated by its solubility in the fuel. In practice, the extent of compatibility is measured by the volume swell of the elastomer. Biodiesel produced from different feedstocks has difference in molecular structure, such as difference in carbon chain length, degree of unsaturation, and branching of carbon chain, which will influence the physical and chemical properties of the biodiesel and hence its combustion characteristics and material compatibility. Thus, the aim of this study is to compare mass change of fluorine rubber material in rapeseed oil methyl ester (RME), cottonseed oil methyl ester (CSME) and 0 petrodiesel (0PD), in order to investigate the effects of feedstock of biodiesel on its compatibility with fluorine rubber material.

2. Experimental

2.1 Materials.

Homemade RME and CSME are prepared from commercial rapeseed oil and cottonseed oil using an alkali-catalyzed transesterification procedure, in line with GB/T 20828-2007 requirements. 0 petrodiesel (0PD) are purchased from China Petroleum & Chemical Corporation.

2.2 Static immersion test method.

The compatibility of fluorine rubber with RME, CSME and 0PD is assessed by conducting the static immersion test. For each fuel, the immersion test is carried out at 55 ℃ for 60 days. Before measuring the degradation behavior, the fluorine rubber rings are dried by blotting with lint-free cloth followed by air-drying at room temperature for 30 min. The mass, inner and outer diameters of FR are measured before and after the immersion test to obtain the changes. Change in weight is measured by an electronic balance with Eq. (1). Changes in inner and outer diameters are calculated with Eq. (2).

$$\Delta m = \frac{m_i - m_0}{m_0} \times 100\% \quad (1)$$

$$\Delta D = \frac{D_i - D_0}{D_0} \times 100\% \quad (2)$$

3. Results and discussion

3.1 The effect on the mass of the fluorine rubber rings.

(1) RME, CSME and 0PD

Fig.1 shows a comparison of the changes in mass of the fluorine rubber rings immersed in RME, CSME and 0PD at 55 ℃ for 60days.

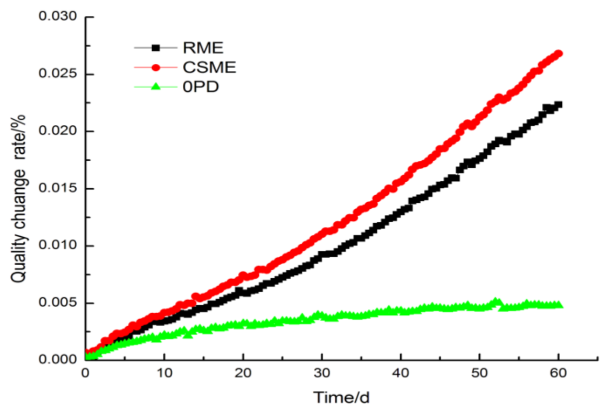

Fig.1 Effect of RME, CSME and 0PD on the mass of the fluorine rubber rings

According to Fig.1, the swelling (increase in mass) the fluorine rubber rings in RME, CSME and 0PD can be seen. The biodiesel results in a larger increase in mass of the fluorine rubber rings samples compared with 0PD. And it is obvious that CSME causes larger increase in mass of the fluorine rubber rings samples compared with RME. The change trend is CSME > RME > 0PD.

(2) RME/0PD and CSME/0PD

Fig.2 and Fig.3 shows respectively a comparison of the changes in mass of the fluorine rubber rings immersed in RME/0PD, CSME/0PD at 55 ℃ for 60days.

From Fig.2 and Fig.3, the swelling (increase in mass) the fluorine rubber rings in RME/0PD, CSME/0PD can also be seen, and biodiesel blending with 0PD can reduce the swelling the fluorine rubber rings. With the increase of 0PD blending ratio, it is possible to observe a decrease in mass change of the fluorine rubber rings.

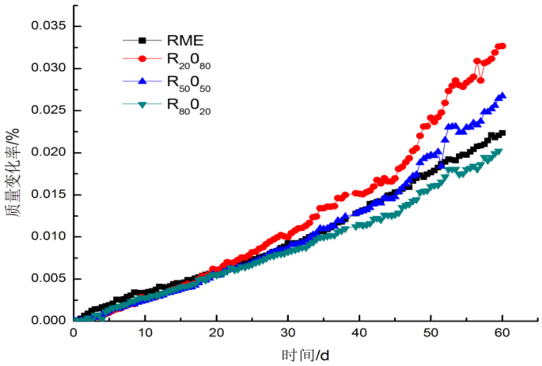

Fig.2 Effect of RME/0PD on the mass of the fluorine rubber rings

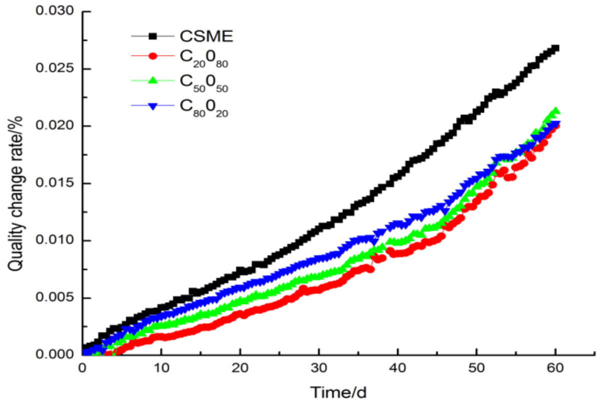

Fig.3 Effect of CSME/0PD on the mass of the fluorine rubber rings

(3) RME, CSME, RME/0PD and CSME/0PD with adding antioxidant

Fig.4 and Fig.5 shows respectively a comparison of the changes in mass of the fluorine rubber rings immersed in RME, CSME, RME/0PD and CSME/0PD treating with TBHQ at 55 ℃ for 60days.

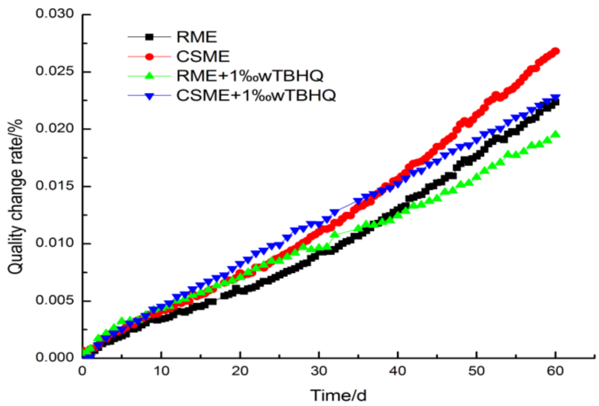

Fig.4 Effect of RME and CSME treating with antioxidant on the mass of the fluorine rubber rings

From Fig.4 and Fig.5, the swelling (increase in mass) the fluorine rubber rings in RME, CSME, RME/0PD and CSME/0PD treating with antioxidant can also be seen, and biodiesel and its blending with adding antioxidant can reduce the swelling the fluorine rubber rings.

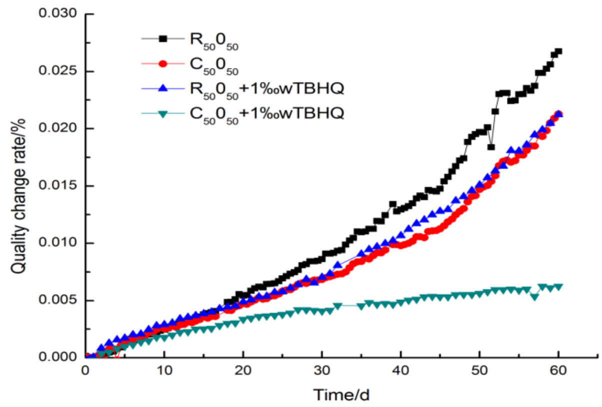

Fig.5 Effect of RME/0PD and CSME/0PD treating with antioxidant on the mass of the fluorine rubber rings

3.2 The effect on inner and outer diameter of the fluorine rubber rings.

Table 1 shows a comparison of the changes in inner and outer diameter of the fluorine rubber rings immersed in sample oils at 55 ℃ for 60days.

Table 1 The change rate of inner and outer diameter of the fluorine rubber rings

Biodiesel	inner diameter	outside diameter
0PD	0.58	0.25
RME	1.49	1.19
CSME	1.30	0.97
$R_{50}0_{50}$	1.14	1.02
$C_{50}0_{50}$	1.12	0.93
RME+1%TBHQ	0.90	1.03
CSME+1%TBHQ	0.88	0.76
$R_{50}0_{50}$+1%TBHQ	0.94	1.01
$C_{50}0_{50}$+1%TBHQ	0.44	0.20

From table 1, like the change in mass, similar trends are found for the change in inner and outer diameter, as shown in Fig. 2. Among the RME, CSME and 0PD, 0PD has the smallest swell in inner and outer diameter. While for the biodiesel blending with 0PD and treating with antioxidant, the inner and outer diameter swell of the fluorine rubber ring samples is reduced.

4. Conclusion

The effects of feedstock of biodiesel on its compatibility with the fluorine rubber ring are investigated in this study through the immersion tests. The changes in mass, the inner and outer diameter of the fluorine rubber ring samples indicate that biodiesel fuel is less compatible with the fluorine rubber than diesel fuel. The sequence of compatibility of biodiesel with the fluorine rubber is found to be in the order of RME and CSME. Blending with diesel fuel and treating with antioxidant additive can reduce the mall, the inner and outer diameter swell of the fluorine rubber.

Acknowledgements

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