The Compatibility of Rubber Materials in Rapeseed Oil Biodiesel

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Abstract

This paper uses static immersion method. It takes common rapeseed oil biodiesel (RME) as the experimental subject, to study its swelling effect on the fuel system commonly used in nitrile rubber (NBR) and fluorine rubber (FKM). Then, biodiesel with conventional 0# diesel (0PD) performed an equal volume blending ratio to obtain the blended fuel and research whether it can improve rubber swelling properties of biodiesel. Finally, by adding an antioxidant of experimental oil sample to improve the oxidation stability of biodiesel, this paper studies whether biodiesel can be improved swelling properties of rubber by the method. The experiment result shows FKM has a relatively stable chemical properties and its effect of biodiesel on the swelling is far less than that of NBR. Blending with 0PD together and treating with antioxidant tertiary butyl hydroquinone (TBHQ) can be reduced the biodiesel swelling effect of rubber.

Keywords

Biodiesel, Rubber, Swelling Corrosion, Rapeseed Oil.

1. Introduction

Biodiesel is a kind of renewable and clean fuel that is made from rapeseed, soybean, corn, sunflower, palm, etc. Biodiesel has a performance close to that of diesel, and may be used directly in existing diesel engines, or blended to desired proportions with petrochemical diesel [1-3]. However, a number of practical problems have been caused by using biodiesel in diesel engines. 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 [4].

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 material compatibility.[5] Thus, the aim of this study is to compare mass change of nitrile butandiene rubber (NBR) and fluorine rubber (FKM) material in rapeseed oil methyl ester (RME) 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 are prepared from commercial rapeseed oil using an alkali-catalyzed transeste rification 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 nitrile rubber and fluorine rubber with RME 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, outer and cross sectional diameters of rubber are measured before and after the immersion test to obtain the changes. Change in mass is measured by an electronic balance with Eq.(1). Change rate in inner, outer and cross sectional diameters are calculated with Eq.(2), respectively.

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

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

3. Results and discussion

3.1 RME and 0PD

Fig.1 and Fig.2 show a comparison of the changes in mass of the nitrile rubber and fluorine rubber rings immersed in RME and 0PD at 55 ℃ for 60days.

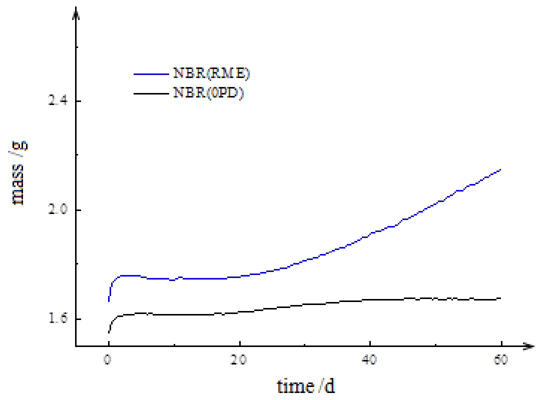


Fig. 1 Mass change for NBR in RME and 0PD

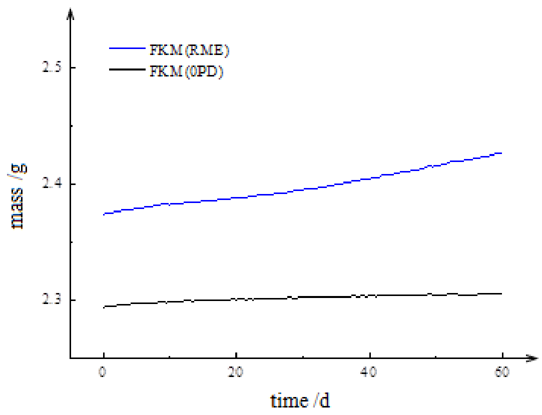


Fig.2 Mass change for FKM in RME and 0PD

According to Fig.1 and Fig.2, the swelling (increase in mass) NBR and FKM in RME and 0PD can be seen. The biodiesel results in an increase in mass of the RME sample compared with 0PD. And it is obvious that RME causes larger increase in mass of NBR samples compared with FKM. Fig.3 shows change rate of NBR and FKM immersed in RME at 55 ℃ for 60days.

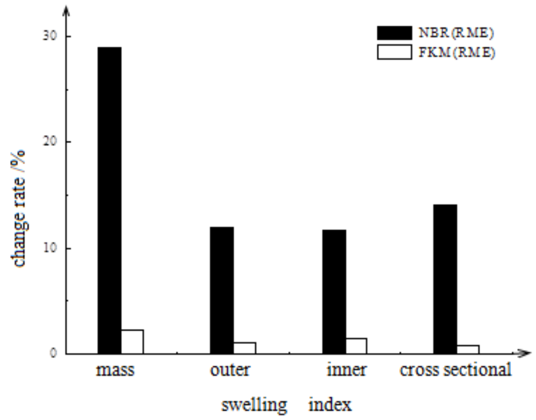


Fig.3 The change rate of NBR and FKM immersed in RME at 55 ℃ for 60days

3.2 RME/0PD

Fig.4 and Fig.5 show respectively a comparison of the changes in mass of the nitrile rubber and fluorine rubber rings immersed in RME/0PD at 55 ℃ for 60days.From Fig.4 and Fig.5, the swelling (increase in mass) NBR and FKM in RME/0PD can also be seen, and biodiesel blending with 0PD can reduce the swelling rubber.

3.3 RME and RME/0PD with adding antioxidant

Fig.6 and Fig.7 show respectively a comparison of the changes in mass of the nitrile rubber and fluorine rubber rings immersed in RME and RME/0PD treating with TBHQ at 55 ℃ for 60days. From Fig.6 and Fig.7, the swelling (increase in mass) NBR and FKM in RME and RME/0PD treating with antioxidant can also be seen, and biodiesel and its blending with adding antioxidant can reduce the swelling rubber.

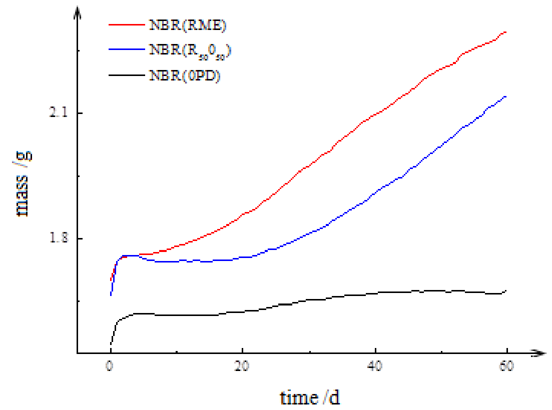


Fig.4 Mass change for NBR in RME/0PD

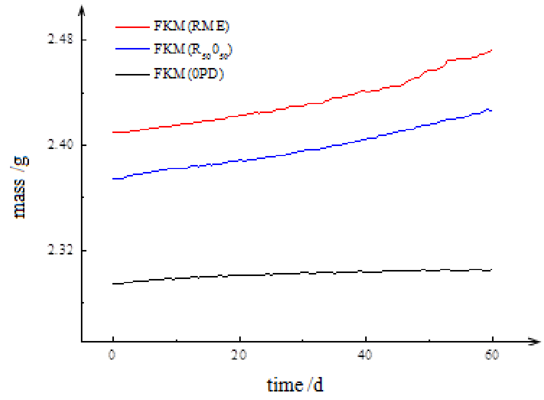
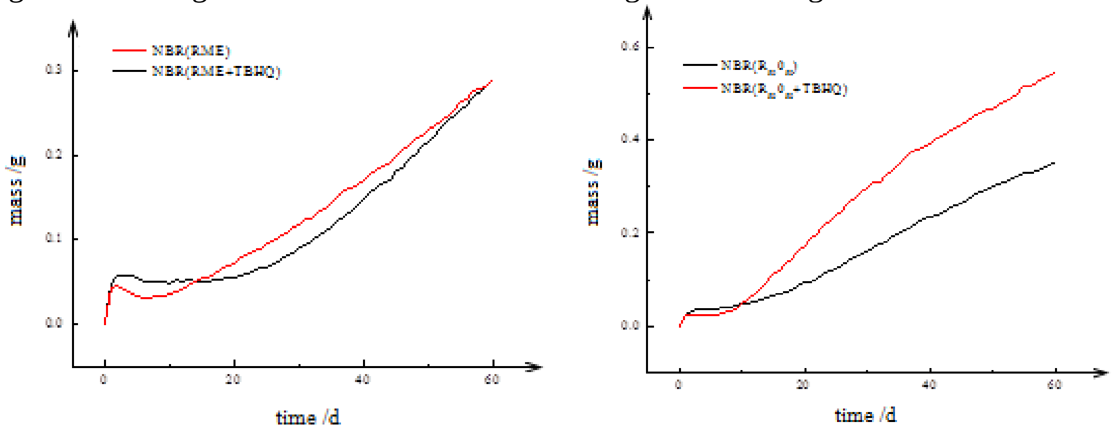
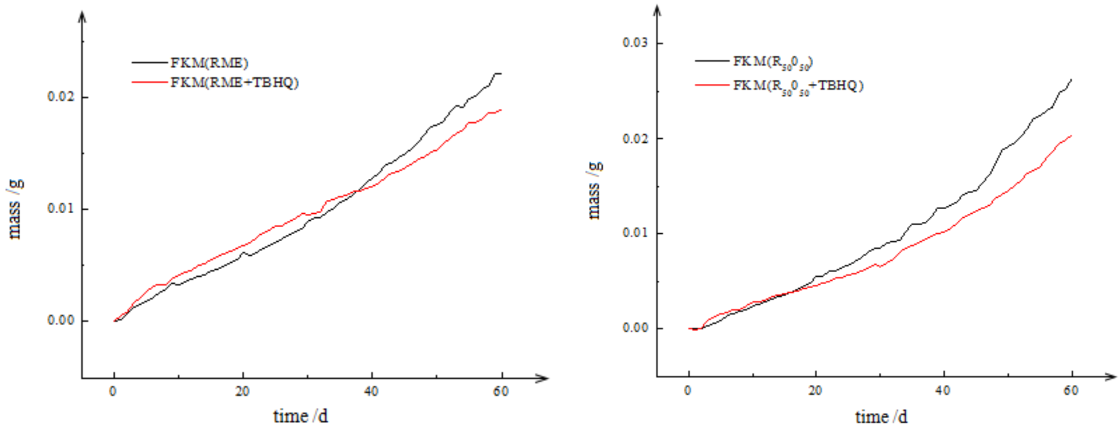


Fig.5 Mass change for FKM in RME/0PD



(1) RME (2) RME/0PD

Fig.6 Mass change for NBR in RME and RME/0PD without/with TBHQ



(1) RME (2) RME/0PD

Fig.7 Mass change for FKM in RME and RME/0PD without/with TBHQ

4. Conclusion

The effects of feedstock of biodiesel on its compatibility with the nitrile rubber and fluorine rubber rings 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 rubber than diesel fuel. The sequence of compatibility of RME with rubber is found to be in the order of FKM and NBR. Blending with diesel fuel and treating with antioxidant additive can reduce the swelling of the rubber.

Acknowledgements

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