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Degradation of physical properties of different elastomers upon exposure to palm biodiesel

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1. Introduction

Since past few decades, biodiesel, as a renewable alternative fuel is receiving much attention to substitute diesel partially or completely. It is composed of fatty acid alkyl esters derived from vegetable oils or animal fats [1,2]. Biodiesel having very close property to that of diesel fuel provides some technical advantages over traditional diesel. These include reduced exhaust emission, higher cetane number, higher flash point, better lubricity etc. [3–5]. However, compatibility of biodiesel with automotive materials is being considered as a rising concern [6–8]. Elastomers as one of the most important groups of materials, used in fuel system are of particular concern [9]. This is because the elastomers are vulnerable attack by various chemicals and can undergo degradation of their physical properties and stability [10].

Bessee and Fey [11] investigated the effect of different blends of methyl soyester and diesel on hardness, tensile strength, elongation and swelling of several common elastomers. They observed that nitrile rubber, nylon 6/6, and high-density polypropylene exhibited change in physical properties while Teflon®, Viton® 401-C and Viton® GFLT were unaffected. In another study, methyl esters have been found to cause swelling of trilobutyl-dilene and nitrile rubber [12]. Such effects were found even for lower biodiesel blend (e.g. B10) on acrylic rubber and hydrogenated nitrile rubber (HNBR) [13]. The later researchers, Trakarnpruk et al. [13], found a decrease in volume of NBR/PVC (Nitrile rubber/Polyvinylchloride) and NBR with immersion time in B10 (palm biodiesel). On the other hand, Frame and McCormick [14] reported that NBR swelled by 14–18% volume when immersed in B20 soy-biodiesel blend. The interaction of biodiesel with elastomers is complicated. Sometime apparently contradictory results are found for the same polymer e.g. NBR in the literature [13,14].

Under the circumstances of exposure of elastomers in biodiesel, the extent of fuel absorption as well as the extraction of soluble components such as plasticizers is different for different types of elastomer [13]. A full clarification of observed phenomena will require in-depth investigations in this area. Currently, the most common elastomer materials that are used in gasket, fuel hose, o-ring etc. are nitrile rubber (NBR), polychloroprene (CR), ethylene propylene diene monomer (EPDM), silicone rubber (SR), polytetrafluroethylene (PTFE) etc. These are rival materials for their uses in diesel engine fuel systems because of their flexibility, excellent barrier, physical properties and ease of fabrication. Fundamental studies on the compatibility of these elastomers in palm biodiesel are scarce. The present study aims to characterize the comparative degradation of physical properties for different elastomers in palm biodiesel and its different blends.

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2. Experimental

The palm biodiesel used in this study was supplied by Weshchem Technology Sdn Bhd, Malaysia. The analysis report provided by the supplier is summarized elsewhere [15]. The compatibility of five different elastomer materials viz, EPDM, NBR, CR, SR and PTFE with palm biodiesel was assessed by conducting static immersion tests in B0 (diesel), B10 (10% biodiesel in diesel), B20, B50 and B100 (100% biodiesel). The investigated elastomers were supplied by Malaysian Rubber Board.

For each elastomer, test was carried out at room temperature (25 °C) for 1000 h. At the end of immersion, degradation behavior of different elastomers was characterized by measuring changes in weight, volume, hardness and tensile strength. Samples for tensile tests were prepared in the form of dumbbell shape with gauge length of 30 mm. Changes in weight were measured by balance with 4 decimal accuracy. Volume was calculated by measuring the height, width and length of the sample. Upon immersion, before measuring weight and volume, samples were dried by blotting with lint-free cloth followed by air drying by keeping on clean places at room temperature for 30–40 min. The value of tensile strength was measured according to ASTM D412 (strain rate of 500 mm/min) by using Instron Tensile Tester (5 kN). The hardness value of the sample was determined using Cogenix Dead Load Hardness Tester Model H-14. A 2.5 mm ball indenter was pressed on the sample and the hardness value was automatically

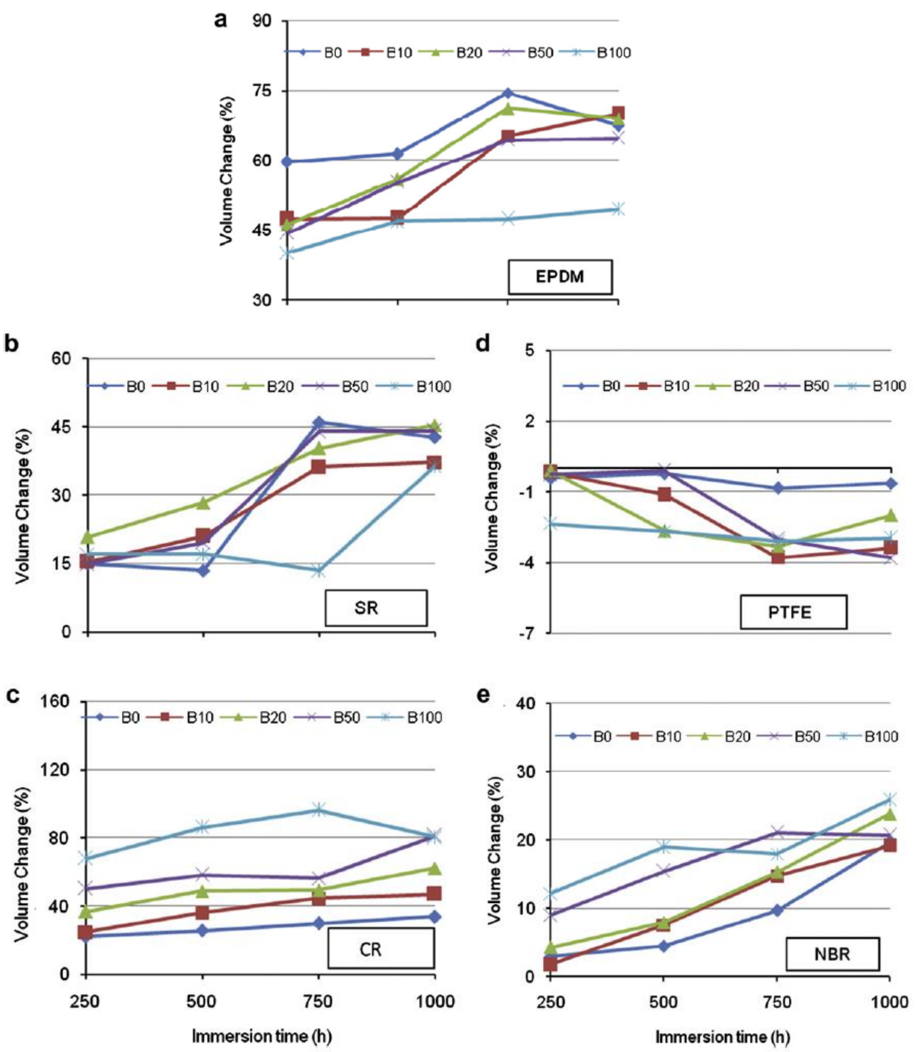

Fig. 1. Changes of volume for different elastomers after immersion at room temperature.

(computerized) recorded. Compositional changes in biodiesel were determined by conducting Gas chromatography mass spectroscopy (GCMS).

3. Results

Fig. 1 shows the changes in volume of different elastomers upon exposure into different fuels. It is seen that biodiesel and its blends cause a grater swelling of CR and NBR compared with that caused by diesel. On the other hand, EPDM and SR swelled to a greater extent in diesel compared with that in biodiesel and its blends. It is also seen in Fig. 1 that PTFE showed a reduction in volume with an increase in the concentration of biodiesel. Like changes in volume, similar trends were found for the changes of weight for respective elastomers (Fig. 2). PTFE showed a slight weight loss, while all other materials show considerable weight gain.

Fig. 3 shows a comparison of different elastomers in terms of their respective volume and weight changes. It is seen that the compatibility, in terms of changes in weight and volumes, for both EPDM and SR are higher in biodiesel as compared to that in diesel. On the other hand, CR and NBR are less compatible with biodiesel. This can be attributed to the higher polarity of ester components in biodiesel which allows the more polar elastomers to dissolve to a greater extent.

Fig. 4 shows that upon exposure to biodiesel, tensile strength values are decreased to a greater extent for EPDM, CR, NBR than SR

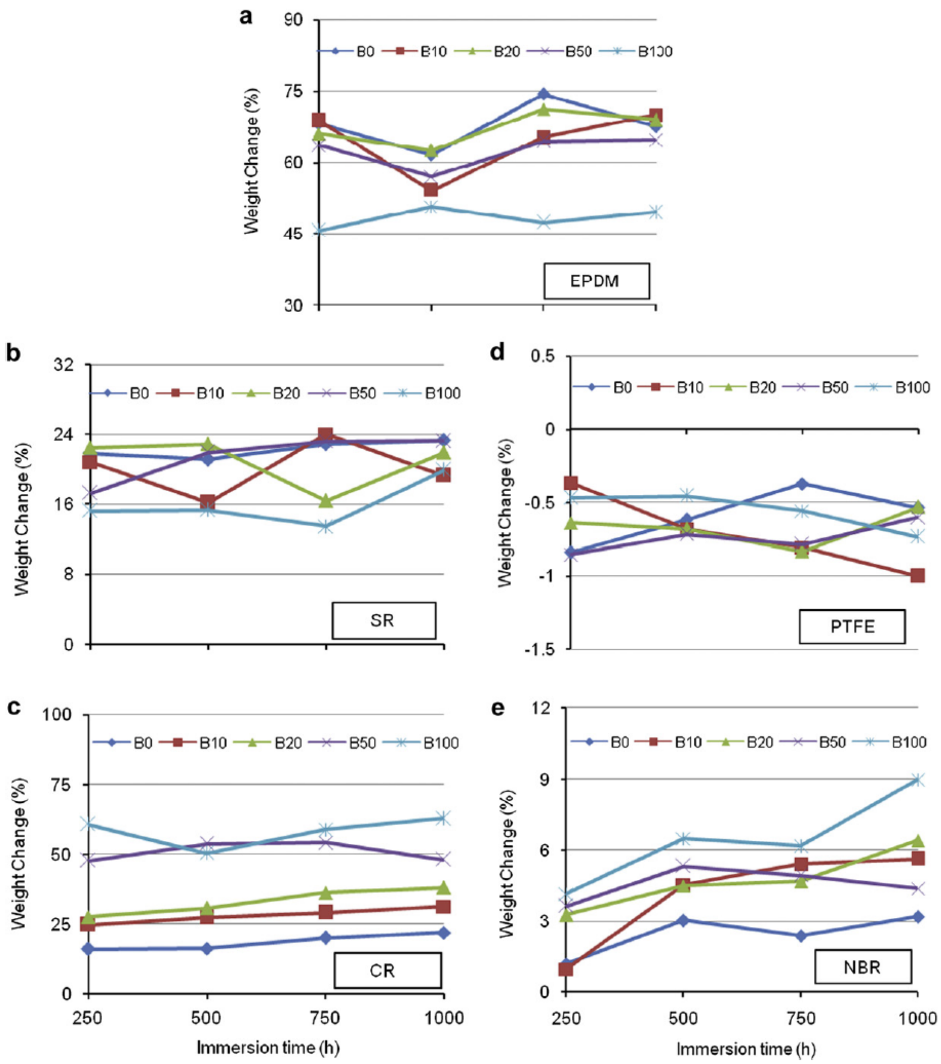

Fig. 2. Changes of weight for different elastomers after immersion at room temperature.

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