STUDY THE EFFECT OF THE MIXTURE OF BIODIESEL FUEL AND PETROLEUM DIESEL ON THE WEIGHT OF SOME ALLOYING MATERIALS BY TIME

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TÓM TẮT

NGHIÊN CỨU ẢNH HƯỞNG CỦA HỖN HỢP NHIÊN LIỆU SINH HỌC BDF VÀ DẦU MỎ ĐẾN TRỌNG LƯỢNG CỦA MỘT SỐ VẬT LIỆU HỢP KIM THEO THỜI GIAN

Trong quá trình sử dụng dầu diesel và nhiên liệu diesel sinh học, các vật liệu kim loại, hợp kim được dùng để sản xuất thùng nhiên liệu, đường ống, máy bơm, piston và các bộ phận khác của động cơ đốt sẽ có thể bị ăn mòn. Để khảo sát ảnh hưởng của nhiên liệu sinh học (BDF) với các kim loại, phổ biến nhất là đồng, hợp kim đồng, nhôm và hợp kim nhôm, thép và hợp kim thép không gỉ, nghiên cứu này đã tiến hành khảo sát sự hao tổn trọng lượng của một số vật liệu hợp kim khi tiếp xúc với các hỗn hợp hai loại nhiên liệu BDF và dầu mỏ khác nhau là B0 (dầu diesel), B5 (5% BDF trong dầu diesel), B10 (10% BDF trong dầu diesel), B20 (20% BDF trong dầu diesel) và B100 (100% BDF). Nhiệt độ thí nghiệm là 40^oC; thời gian tiếp xúc là 50 tuần. Sáu mẫu kim loại là Nhôm đúc (AC2A), Hợp kim nhôm (A2024P), Đồng (C1100P), Đồng kẽm 20% đồng thau (C2680P), Thép (JISG 3141) và Thép không gỉ (SUS 304). Kết quả cho thấy nhiên liệu diesel sinh học có tác dụng làm hao tổn trọng lượng kim loại nhiều hơn so với dầu diesel. Sự hao tổn trọng lượng này tỷ lệ theo thời gian ngâm tĩnh trong hỗn hợp nhiên liệu và tăng theo tỷ lệ phần trăm của nhiên liệu diesel sinh học. Tuy nhiên, sự hao tổn trọng lượng do nhiên liệu diesel sinh học gây ra không quá lớn. Kim loại bị ăn mòn nhiều nhất là đồng, tiếp theo là hợp kim đồng, nhôm, hợp kim nhôm, thép và hợp kim thép.

***Keys words:** Biodiesel fuel (BDF), petroleum diesel, metals, corrosion.*

1. INTRODUCTION

Corrosion is defined as the gradual destruction of a metal by chemical or electrochemical reactions with its environment. The corrosion on surface of metal depends on composition of materials, environmental characteristics, temperature, time and pressure[1)]. There are two types of corrosion: electrochemical and chemical.

Biodiesel fuel (BDF), generally defined as liquid fuels derived from biological materials, can be made from plants, vegetable oils, forest products, or waste materials. The raw materials can be grown specifically for fuel purposes, or can be the residues or wastes of existing supply and consumption chains, such as agricultural residues or municipal garbage[2)]. Now a day, about 50 countries worldwide product and employ in different levels, with the top of U.S., Brazil and E.U… Global biodiesel production is expected to increase to almost 42 bnl by 2020. The European Union is expected to be by far the major producer (51%) and user (57%) of biodiesel[3]. BDF has many advantages, such as: easy decomposition, non-toxic, renewable, reduced emissions and so on[4,5]. However, BDF has generally a higher level of (poly-unsaturates) olefinic components than petroleum diesel which very susceptible to oxidation[6,7]. These are corrosive and can attack metals. Fuel tanks, pipelines and pumping equipments which are very important in the process of storage and utilization are usually made of copper, aluminum, steel, etc. and will be able corroded due to fuel exposures. There are some of studies on the corrosion behavior of metals upon exposures to BDF made from different raw materials. Proc Keneth et al.[8] investigated the corrosiveness of palm BDF on copper alloys of the fuel pump, gaskets, fuel injector, filters, fuel liners, bearing, piston, piston rings, etc. Meenakshi H. N. Parameswaran et al.[9] studied on the corrosion behavior of copper and its alloy in pongamia pinnata oil. Daniel P. Geller et al.[10] observed that copper alloys are more prone to corrosion than iron alloys. The corrosion of metals in various fuels such as palm oil, Jatropha curcas BDF, pongamia pinata BDF, etc. were inspected with different concentrations of fuel (B2, B5, B50 and B100). The corrosion can occur even in the concentration of 2% BDF in petroleum diesel (B2)[11] and increases with the percentage of BDF in petroleum diesel.

In addition, M.A. Fazal et al[1] investigated the corrosion behavior of mild steel at three different temperatures such as room temperature, 50 and 80ºC. Results showed that the corrosion of mild steel in both petroleum diesel and BDF increases with increases of temperature, but corrosion attack of BDF is more than petroleum diesel.

The studies also showed the results of the corrosion rate of metals. The research of Savita Kaul et al.[12] concluded that the corrosion rate of aluminum alloys in BDF from Jatropha curcas is 0.0177 mpy, two times as high as petroleum diesel. However, the corrosion rate of copper in BDF from palm is higher than aluminum alloys. A.S.M.A. Haseeb et al[13] calculated that the corrosion rate of copper in palm BDF is higher than leaded bronze, the corrosion at 60ºC is higher than the room temperature. The average corrosion rate of copper in 20 years is 0.054 mpy in an industrial atmosphere, 0.050 mpy in a marine atmosphere and 0.017 mpy in a rural atmosphere[14].

The present study aims to investigate the corrosion of aluminum cast, aluminum alloy, copper, copper alloy, steel and stainless steel in the mixture of BDF and petroleum diesel with the concentration of 0, 5, 10, 20 and 100% corresponding to B0, B5, B10, B20 and B100 at the temperature of 40ºC.

2. MATERIALS AND EXPERIMENTS

2.1. Materials

BDF used in the study is produced from Jatropha a curcas seed in the framework of project"Multi-beneficial Measure for Mitigation of Climate Change by the Integrated Utilization of Biomass Energy in Vietnam and Indochina Countries" belongs to JST-JICA SATREPS (2011-2016). We inspected its properties, it showed that the eater content is 97.8%, water content is 433ppm, methanol content is 1.2%, total glycerine is 1.8%. These are below the limit of EN 14214 standard. The mixtures of BDF and petroleum diesel were mixed following rates: B0 (pure diesel), B5 (5% BDF and 95% petroleum diesel), B10 (10% BDF and 90% petroleum diesel), B20 (20% BDF and 80% petroleum diesel), B100 (100% BDF).

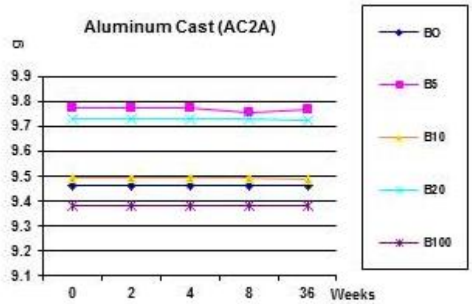
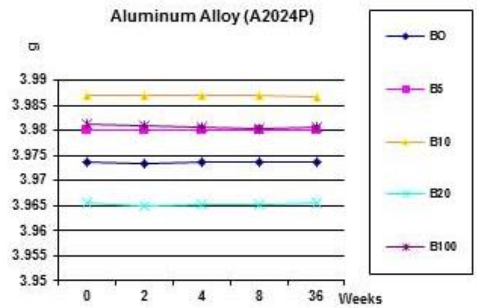
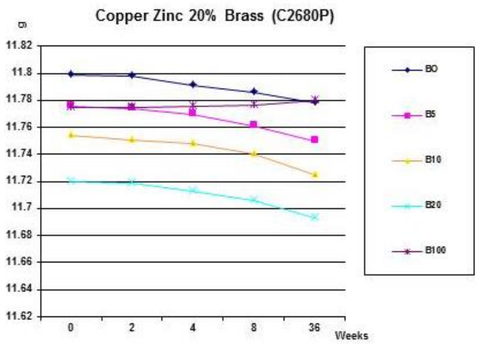


Figure 1. The weight change of Aluminum Alloy (A2024P) and Aluminum Cast (AC2A) during the test period.

The metal test coupons were Aluminum Cast (AC2A), Aluminum Alloy (A2024P), Copper (C1100P), Copper Zinc 20% Brass (C2680P), Steel (JISG 3141) and Stainless Steel (SUS 304), were supplied by Nippon Test Panel Conpany. Their sizes were 30 mm x 40 mm x 1.2mm thickness. For hanging the metal coupons into the test mixtures, there was a hole of diameter 6.5 mm near the edge of each specimen.





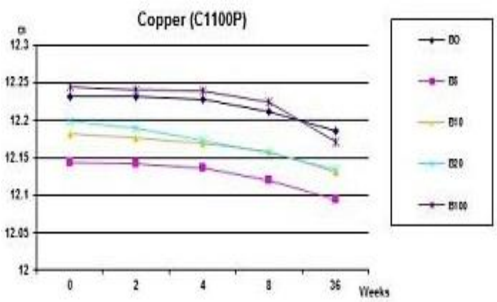
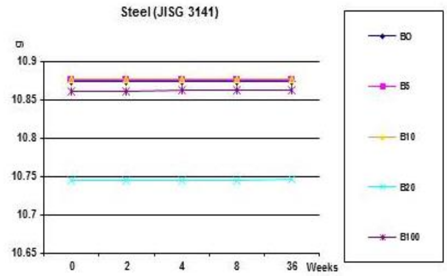
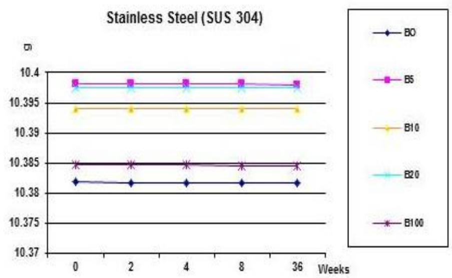


Figure 2. The weight loss of Copper (C1100P) and Copper Zinc 20% Brass (C2680P) during the test period.

2.2. Experimental description

The metal test coupons were immersed in the test fuel in glass-beakers, positioned by fishing line. Two duplicate coupons were immersed in each test fuel. The volumn of fuel (cm^3) was 5 times greater than or equal to surface area of matel coupons, so glass-beakers (600mL) contained 400mL fuel. Before immersion, the metal coupons were weighted by a balance with four decimal accuracys. During the immersion time of metal coupons in fuel, the glass-beakers were covered by film wrapper and were placed into incubators at the temperature of 40oC.





Keep still for 2 weeks, the metal test coupons were taked out of glass-beakers, removed the fishing line and rinsed each metal coupon by 3 kinds of solutions: (1) n-Hexane, (2) mixture of methanol (95%) and distilled water (5%), (3) acetone; dried the metal test coupons, waited to cool in the excicator for 15 minutes and weighted. After weighted the metal coupons, made them clean and immersed them again in the test fuel. Repeat this process three times with exposure time of each time 4 weeks, 8 weeks, 36 weeks respectively. Total of soaking time was 50 weeks.

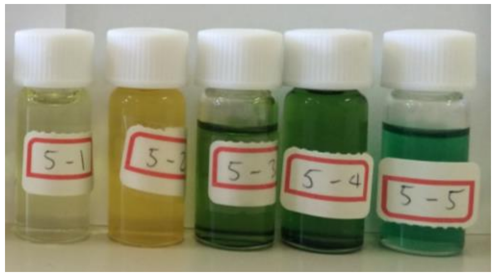


Figure 3. The fuel after immersion of Copper

(C1100P) 5-1: B0; 5-2: B5; 5-3: B10; 5-4: B20; 5-5: B100

3. RESULTS AND DISCUSSION

3.1. Corrosion of test metals

Fig. 1 shows the Aluminum Alloy (A2024P) was more resistance to all concentrations of BDF. The weight of all aluminum alloy coupons was not changed during the experimental period. Besides, the Aluminum Cast (AC2A) had a slight corrosion in the test fuel. Their weight was not changed so much over the time, around 0.0040 gram (Table 1).

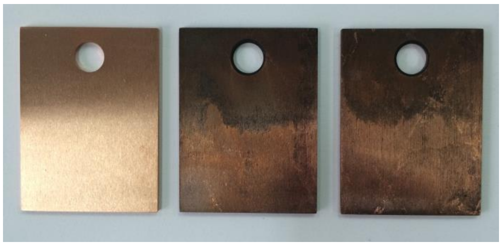


Figure 4. The damage of corrosion of Copper (C1100P).

Copper (C1100P) coupons and Copper Zinc 20% Brass (C2680P) coupons showed the greatest weight loss than the other test metals. The results are shown in the Fig. 2. Copper (C1100P) showed more visible corrosion, expercially in the high concentration of BDF (Fig. 3) and a photograph of this damage on cleaned corrosion coupons is shown in the Fig. 4. This is reasonable because the copper and copper alloys are metallic elements are relatively susceptible to corrosion when exposed to reducing environments, such as the presence of hydrogen and sulfur.

Steel is an alloy consisting mostly of iron and carbon which create a very sustainable structure. The influence of the environment as oxygen or other oxidizing agents is often not significant effect on steel. The steel samples in the experiment were Steel (JISG 3141) and Stainless Steel (SUS 304). The results are shown in Fig. 5. The weight of Steel (JISG 3141) was increased in the B100 but not so much, only 0.0005 gram (Table 1).

Figure 5. The weight change of Steel (JISG 3141) and Stainless Steel (SUS 304) during the test period.

Table 1. Corrosion coupon data

Metal	Percent BDF	Initial weight (g)	Final weight (g)	Weight change (g)
Aluminum Alloy (A2024P)	0	3.9737	3.9736	0.0001
	0	3.9820	3.9822	-0.0002
	5	3.9801	3.9800	0.0001
	5	3.9722	3.9722	0
	10	3.9869	3.9867	0.0002
	10	3.9874	3.9877	-0.0003
	20	3.9654	3.9654	0
	20	3.9583	3.9584	-0.0001
	100	3.9813	3.9808	0.0005
	100	3.9522	3.9523	-0.0001
Aluminum Cast (AC2A)	0	9.4649	9.4611	0.0038
	0	9.4601	9.4562	0.0039
	5	9.7710	9.7668	0.0042
	5	9.8374	9.8339	0.0035
	10	9.4951	9.4920	0.0031
	10	9.6463	9.6431	0.0032
	20	9.7321	9.7269	0.0052
	20	9.7079	9.7045	0.0034

	100	9.3811	9.3799	0.0012
	100	9.5111	9.5095	0.0016
Copper (C1100P)	0	12.2321	12.1855	0.0466
	0	12.2321	12.1822	0.0499
	5	12.1443	12.0947	0.0496
	5	12.1986	12.1497	0.0489
	10	12.1818	12.1309	0.0509
	10	12.2321	12.1709	0.0612
	20	12.1993	12.1341	0.0652
	20	12.1682	12.0860	0.0822
	100	12.2449	12.1611	0.0838
	100	12.2051	12.1293	0.0758
Copper Zinc 20% Brass (C2680P)	0	11.7991	11.7782	0.0209
	0	11.9680	11.9462	0.0218
	5	11.7759	11.7495	0.0264
	5	11.6148	11.5899	0.0249
	10	11.7541	11.7246	0.0295
	10	11.8129	11.7887	0.0242
	20	11.7194	11.6928	0.0266
	20	11.6906	11.6574	0.0332
	100	11.7745	11.7497	0.0248
	100	11.7560	11.7257	0.0303
Stainless Steel (SUS 304)	0	10.3818	10.3815	0.0003
	0	10.4159	10.4156	0.0003
	5	10.3981	10.3979	0.0002
	5	10.3917	10.3916	0.0001
	10	10.3941	10.3939	0.0002
	10	10.3493	10.3492	0.0001
	20	10.3975	10.3972	0.0003
	20	10.3298	10.3299	-0.0001
	100	10.3847	10.3845	0.0002
	100	10.3882	10.3882	0
Steel (JISG3141)	0	10.8747	10.8746	0.0001
	0	10.9243	10.9243	0
	5	10.8758	10.8758	0
	5	10.8842	10.8842	0
	10	10.8781	10.8779	0.0002
	10	10.8779	10.8781	-0.0002
	20	10.7451	10.7459	-0.0008
	20	10.8491	10.8689	0.0002
	100	10.8614	10.8619	-0.0005
	100	10.8564	10.8570	-0.0006

Fig. 6 shows the comparison of weight change of the test metals during the experimental period. The weight of Copper (C1100P) and Copper Zinc 20% Brass (C2680P) were changed.

3.2. Corrosion rate

The corrosion rate was investigated by using the following formula (1)[15].

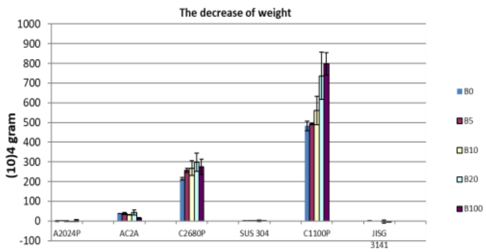


Figure 6. The weight change oftest metals during the experimental period.

$$\text{Corrosion rate (mpy)} = \frac{W \times 534}{D \times T \times A} \quad (1)$$

Where the corrosion rate mpy stands for mils per year, W is the weight loss (mg), D is the metal density (g/cm^3), A is the exposed surface area (square inch) and T is the exposure time (h).

According to the survey results, the corrosion of aluminum alloy and steel alloy did not happen or happened negligible, so we calculate only the corrosion rate of copper and brass.

The size of coupons was 30 mm x 40 mm x 1.2mm thickness with a hole of diameter 6.5 mm near the edge. The exposed surface area of coupon is 4258 mm^2, equal 6.6 in^2.

The density of Copper is 8.96 g/cm3 and the density of Copper Zinc 20% Brass is 8.75 g/cm3.

Survey time is T = 24 $\times$ 7 $\times$ 50 = 8400 (h)

Regarding the formula (1), we calculated the corrosion rate of copper and brass, the results are shown in Table 2.

4. CONCLUSION

The corrosion behavior of six metals in different concentration of BDF in petroleum was inspected by immersion test.

The mixtures of BDF and petroleum diesel are capable corrosive impacts of various metals. For the Steel, Stainless Steel and Aluminum Alloy, the corrosion was not found. The corrosion of Aluminum Cast was in low level. Copper and Copper Zinz 20% Brass are affected significantly by the corrosiveness of fuel.

The survey results show that petroleum diesel is capable lowest corrosion, the corrosion increased proportional to the concentration of BDF in the test fuel.

Table 2. The corrosion rate of copper and brass in different fuels at 40^{o}C

Metal	Percent BDF	Weight changed (mg)	Corrosion rate (mpy)
Copper (C1100P)	0	46.6	0.051
	0	49.9	0.055
	5	49.6	0.054
	5	48.9	0.054
	10	50.9	0.056
	10	61.2	0.067
	20	65.2	0.072
	20	82.2	0.090
	100	83.8	0.092
	100	75.8	0.083
Copper Zinc 20% Brass (C2680P)	0	20.9	0.022
	0	21.8	0.023
	5	26.4	0.028
	5	24.9	0.027
	10	29.5	0.032
	10	24.2	0.026
	20	26.6	0.029
	20	33.2	0.037
	100	24.8	0.027
	100	30.3	0.033

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