Evaluation of Antifouling Coating Performance with Commercial and Lemon Natural Biocide on Composite Fiberglass Surface

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Abstract: **Marine growth is a common problem for a near coastal marine vessel including composite fiberglass boat. Natural antifouling coating for composite fiberglass hulls towards efficient, cleanliness, sustainability and greener oceans are crucial especially in near coastal area. Antifouling performance of commercial and natural lemon biocide were analyzed by referring to ASTM 3623 – 78a for 30 days in seawater. Both commercial and natural biocide coating shows no marine growth occur within 30days of immersion due to good interaction between biocide and gelcoat. Natural biocide with 6% concentration observed similar performance as 4% commercial biocide, thus it shows lemon has a great potential of lemon as new natural biocide in marine antifouling paint.**

Index Terms: **natural antifouling, lemon biocide, gelcoat, coating, composite**

I. INTRODUCTION

Ships have been used as a mode of transportation for hundreds of years. Woods, fiberglass and steel are the most common materials that were used to build a ship. All types of hull vessel are detrimental to the marine growth from thousands of years. Marine growth is a natural phenomenon that occurs on ship propeller and hull that affects performance of a ship such as increase in ship resistant (86%), reduce in speed loss approximately 2% and increase in fuel consumption up to 40-50% [1]. Free marine growth hull leads to increase of fuel efficiency thus reduce the percentage of CO_2 global greenhouse gas emission produced from shipping industry [2]. The marine growth on steel hull will increase maintenance cost due to frequent dry docking needed [3]. However, in the cruise ship, hull scrubbing is not an option, thus effective antifouling material is a critical challenge.

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Cruise ships also face important challenge for fuel saving and credential of good environment to sustain a spotless waterline [2]. Biocides are chemical substances commonly added in antifouling paint to deter or kill the microorganisms from marine growth. Historically, lead and copper were primarily used as antifouling to protect wooden vessel. Then, the usage of heavy metal continues until TBT was introduced as biocides in 1960. TBT reported to have efficient performance inhibiting the biofouling and minimize the frequency of dry docking for vessels. However, an abnormal of oyster shell growth reported in 1974 due to TBT usage, later this leads to banned of TBT by International Maritime Organization in 2008. The banned of TBT has generated a lot of interest to search efficient antifouling, from development of fouling release antifouling (slippery, nontoxic coat) [2], self-polishing antifouling (biocides prevent establish of fouling) and combination of both systems [3]. Current challenges on the development of antifouling are to produce future antifouling that contributes to the great concern in cleanliness, sustainability of oceans, less toxic and effective (fuel efficiency and less emission CO_2) especially to near coastal ship. Other challenges face in development of antifouling that need to be considered are the various type of vessels, operation profiles and locations [2]. Development of effective nontoxic antifouling also requires understanding of interaction between marine growth and coated surface which is still lack behind [4]. Most common commercial biocides used in antifouling paints founded are chlorothalonil, dichlofluanid, DCOIT (4,5-dichloro-2-n-octyl-4-isothiazolin-3-one, Sea-nine 211®), Diuron, Irgarol 1051, TCMS pyridine (2,3,3,6-tetrachloro-4-methylsulfonyl pyridine), zinc pyrithione and Zineb [5]. Meanwhile common natural biocides usually extracted from marine sources such as soft corals, seaweed, sponges, mangroves and etcetera. They are reported to have antibacterial such as carotenoids, furanones, alkaloids, peptides, lactones, steroid and terpenoids [6]. The alternative of natural biocide earlier reported on the extract of fishes used in (vinyl chloride–vinyl acetate) copolymer [7] algae embedded in epoxy matrix[8] [9]. Lemons are also reported to have biocide properties due to the content of saponins, alkaloid, phenolic, terpenoid and flavonoid which is similar to the one found in marine sources biocides [10].

Thus, it is interesting to explore the potential of lemon as biocides in antifouling paint. This research is focused on analyzing the performance of newly developed natural antifouling paint apply on fiberglass surface immerse in a seawater.

II. METHODOLOGY

Composite fiberglass panels with two types of surface, gelcoat and polyester resin were prepared as uncoated (reference) and coated by rosin modified antifouling paint contained commercial and natural biocide. Antifouling coating was prepared using rosin modified base and it was obtained from BINA Integrated Sdn Bhd. Meanwhile natural biocide fresh lemon juice was obtained from cleaned squeezed lime after filtration process. Five mixtures of antifouling were prepared with 2%, 4% and 6% of natural biocide and 2% and 4% of commercial biocide and then stirred thoroughly. The specimen was coated with two layers of antifouling coating materials and left to dry for three days as recommended by the manufacturer before second layer of antifouling was applied. The panels were then immersed in seawater for marine growth exposure at shallow submerge according to ASTM D3623 – 78a[11]. Visual inspection for percentage marine growth and weight change conducted for 30 days and recorded every 5 days. Regression method of statistical analysis was conducted for all samples in correlation to the change occur every 5 days.

III. RESULTS AND DISCUSSION

Figure 1 shows the pH of water and percentage of marine growth on composite fiberglass polyester resin surface in uncoated and coated with commercial (2% and 4% CA) and natural biocide (2%, 4% and 6% NA). Percentage of marine growth on resin surface after 30 days of immersion for uncoated specimen observed was 29.61%. Coated specimen with natural biocide 2%, 4% and 6%, percentage of marine growth 2.96%, 1.97% and 0.99% respectively. Higher concentration of natural biocides observed better inhibition properties with less percentage of marine growth. Meanwhile commercial biocide observed slightly less percentage than 6% natural antifouling with 0.49% of marine growth. Natural lemon biocides 6% observed similar performance as 4% commercial biocides in both observations. This shows that lemon natural antifouling produces similar rate of inhibition from marine growth as commercial biocide. Thus, proves good interaction between natural biocides with polyester resin surface. Natural and commercial biocides in antifouling paint observed better inhibition properties coated on gelcoat surface compared to polyester surface. Coated specimen on fiberglass gelcoat surface observed better inhibition behavior with no marine growth occur within 30 days of immersion as summarized in Table 1. The natural biocides coated on gelcoat surface observed a slight of slime adhered compared to uncoated gelcoat surface occurred 4.48% of marine growth. This agrees with other studies that microfouling biofilm formed at initial stage before animal type fouling occurred within 7 days of immersion[12]. The percentage of marine growth was slow with the combination of gelcoat and antifouling, thus delaying the occurrence of marine growth compared to uncoated gelcoat. Both natural and commercial biocides antifouling paint coated on both polyester resin and gelcoat surface on fiberglass also observed stable condition in variable of pH from 7.6 to 8.4 with no significant effect in the percentage of marine growth. This finding similar reported earlier that biofouling are stable during fluctuating environmental conditions despite changes in salinity and in dissolved oxygen within 7 days of immersion [4]. Figure 2 shows the water temperature and performance percentage of weight change on composite fiberglass uncoated and coated with commercial (2% and 4% CA) and natural biocide (2%, 4% and 6% NA). The seawater temperature varies between 30 to 37 ℃ throughout 30 days of immersion. Uncoated fiberglass sample observed highest weight changes with 1.95% increased. The weight of specimen increases in linear relation as days of immersion increased. Total of weight changed after 30 days of immersion for natural biocide specimen with 2%, 4% and 6% ratio observed value of 0.48%, 0.49% and 0.51% weight increased respectively. Meanwhile commercial biocides observed similar weight change for 2% and 4% ratio with 0.50% and 0.51% of weight increased. The percentage of weight increased due to growth of animal types marine growth that contributes to increased weight of the panels. Natural biocides antifouling with 6% ratio shows similar inhibition performance as commercial biocides 4% in both percentage of mariner growth and weight change. Both percentage marine growth and weight change observed increase in percentage as number of days increased. Regression analysis observed p-value less than 0.05 for uncoated specimen in percentage marine growth and weight change shows its relationship with number of days are highly significant. Coated specimen shows significant relation with similar p-value less than 0.05 in percentage marine growth; however, in percentage of weight change the p-value shows less significant. Coefficient correlation observed positive values due to increase in both percentages of marine growth and weight change as number of days increased. Meanwhile, observation on percentage marine growth shows high percentage (>80%) of R square fit the linear equation for natural biocides antifouling and uncoated specimen. The non-significant value observed in coated specimen at polyester resin shows that the marine growth and performance of both antifouling coating affected by other factors such as location of immersion, seawater conditions and types of vessels [2]. Other than that, the performance of antifouling coating was also affected by the organic content, current flow, water pH, salinity and coating surface [5].Table 1 summarizes the percentage growth and weight change in composite fiberglass uncoated and coated with commercial (2% and 4% CA) and natural biocide (2%, 4% and 6% NA). This finding shows that both commercial and natural antifouling coating have good interaction with gelcoat surface and give better inhibition properties to the composite fiberglass hull.
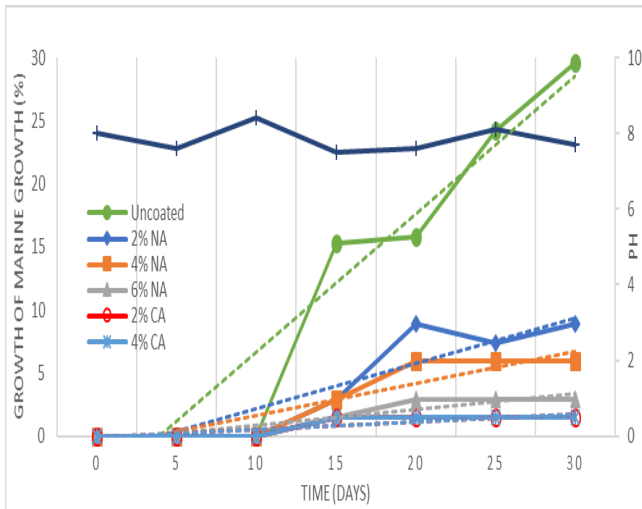
Fig. 1 Percentage of marine growth on composite fiberglass polyester resin surface in uncoated and coated with commercial (2% and 4% CA) and natural biocide (2%, 4% and 6% NA)
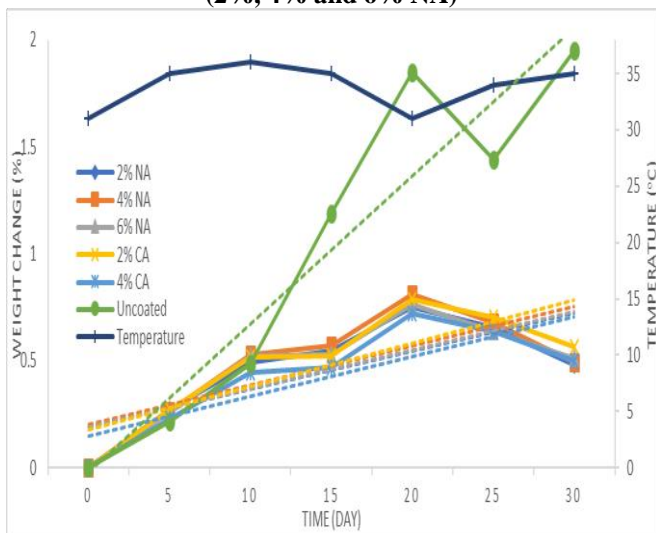

Fig. 2 Percentage of weight change on composite fiberglass uncoated and coated with commercial (2% and 4% CA) and natural biocide (2%, 4% and 6% NA)

Table 1. Summary of percentage growth and weight change in composite fiberglass uncoated and coated with commercial (2% and 4% CA) and natural biocide (2%, 4% and 6% NA)

Descriptions	Types	p-value	R-square	Coefficient Correlation	Linear Equation
Percentage marine growth on polyester resin surface	2% NA	0.0040	84%	0.1198	y = 0.5992x - 1.0573
	4% NA	0.0028	86%	0.0423	y = 0.4229x - 0.7049
	6% NA	0.0028	86%	0.0423	y = 0.2115x - 0.3524
	2% CA	0.0117	75%	0.0211	y = 0.1057x - 0.1410
	4% CA	0.0117	75%	0.0211	y = 0.1057x - 0.1410
	Uncoated	0.0008	91%	1.0926	y = 5.4629x - 9.7274
Percentage marine growth on gelcoat surface	2% NA	NIL			
	4% NA				
	6% NA				
	2% CA				
	4% CA				
	Uncoated	0.0070	80%	0.1797	y = 0.8986x - 1.3134
Percentage of Weight change	2% NA	0.2409	57%	0.0277	y = 0.2457x + 278.55
	4% NA	0.2770	53%	0.0288	y = 0.2557x + 277.30
	6% NA	0.2176	59%	0.0293	y = 0.2521x + 278.95
	2% CA	0.1327	69%	0.0356	y = 0.275x + 272.740
	4% CA	0.1332	69%	0.0355	y = 0.2621x + 282.43
	Uncoated	0.0095	92%	0.1879	y = 0.9307x + 268.80

IV. CONCLUSION

Both commercial and natural lemon biocides antifouling coating show great interaction with gelcoat fiberglass surface with no marine growth observed within 30 days of immersion. Higher concentration of biocides shows better antifouling performance with low percentage of marine growth and weight change observed. Natural lemon biocides 6% observed similar performance as 4% commercial biocides in both observations. This concludes that natural lemon biocides antifouling has good inhibition with both gelcoat and polyester resin in composite fiberglass. Thus, shows that it has great potential as new biocide in marine antifouling coating for application in composite fiberglass surface. However, the performance of this new natural lemon biocides still need physical and chemical analysis as well as further observation of antifouling performance evaluation factor as discussed earlier. It is also interesting to explore the new natural lemon biocides antifouling hydrodynamic performance.

V. CONFLICT OF INTERESTS

The authors declare that there is no conflict of interests regarding the publication of this paper.

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