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Performance of Commercial and Natural Antifouling Embedded in Rosin Modified Coated on Wood Surface

Asmalina Mohamed Saat, Syajaratunnur Yaakup, Syarmela Alaauldin, Hanisah Johor, Fatin Zawani Zainal Azaim, Md Salim Kamil, Suhaimi Samsudin, Muhamad Taufiq Razak, Mohd Iqbal Lokman

Abstract: Rosin based paint is one of natural source of paint matrix essential in combination of natural biocides for greener and efficient antifouling paint. Performance of new natural lemon biocides and commercial biocides embedded in rosin modified antifouling paint were evaluate by referring to ASTM 3623 – 78a for 30 days. Natural lemon biocides with concentration of 2%, 4% and 6% observed that increase in biocides concentration reduce the percentage of marine growth. Natural lemon biocides with 6% concentration observed similar performance as in commercial antifouling on wood surface due to good interaction. This concluded that natural lemon biocides have a great potential as new natural biocides on wood vessel hull surface.

Index Terms: Natural Antifouling; Immersion; Marine Growth; Rosin Modified

I. INTRODUCTION

Antifouling coating or also known as underwater hull paint commonly used to protect and slowing the microorganism growth, plant and animal that attached to the ship bottom hull. This microorganism has detrimental effects on the performance and endurance of vessel by increased the hull surface roughness, results to drawback in power increase up to 10-16% and 86% at cruising speed for light fouling diatom slimes and heavy fouled respectively [1]. Analysis conducted earlier reported that approximate maintenance cost of hull fouling system (coating, cleaning for heavy slime fouling level) for Arleigh Burke DDG-51 destroyers was $56 million per annum [2].

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* Correspondence Author
Asmalina Mohamed Saat*, Universiti Kuala Lumpur, Malaysian Institute of Marine Engineering Technology, Lumut Perak.
Syajaratunnur Yaakup, Universiti Kuala Lumpur, Malaysian Institute of Marine Engineering Technology, Lumut Perak.
Syarmela Alaauldin, Universiti Kuala Lumpur, Malaysian Institute of Marine Engineering Technology, Lumut Perak.
Hanisah Johor, Universiti Kuala Lumpur, Malaysian Institute of Marine Engineering Technology, Lumut Perak.
Fatin Zawani Zainal Azaim, Universiti Kuala Lumpur, Malaysian Institute of Marine Engineering Technology, Lumut Perak.
Md Salim Kamil, Universiti Kuala Lumpur, Malaysian Institute of Marine Engineering Technology, Lumut Perak.
Suhaimi Samsudin, Universiti Kuala Lumpur, Malaysian Institute of Marine Engineering Technology, Lumut Perak.
Muhamad Taufiq Razak, Universiti Kuala Lumpur, Malaysian Institute of Marine Engineering Technology, Lumut Perak.
Mohd Iqbal Lokman, Bina Integrated Industries Sdn Bhd, Bandar Baru Bangi, Selangor, Malaysia.

Ships with steel hull increase in cost due to frequent dry docking needed [3]. However, in the near coastal voyage such for cruise ship, wooden boat and composite fiberglass boat, hull scrubbing is not possible, effective antifouling material is critical for fuel saving and sustaining a clean near coastal environmental [4]. The antifouling paint are divided into soluble, insoluble and biocides matrix. Insoluble matrix paint also known as contact leaching or continuous contact-based polymer that does not polish or erode in seawater. Example of commercial insoluble based paints are insoluble vinyl, epoxy, acrylic or chlorinate rubber polymer [1]. This type of paint dissolved in seawater penetrating the film diffuse through the interconnecting pores formed after dissolution of soluble pigments. The dissolved pigment ion diffuses through thick leached layer with minimum dissolution rate required to prevent fouling. Insoluble based are generally mechanically strong, cot susceptible to cracking and resistance to oxidation and photo degradation. The lifetimes duration for insoluble are between 12 to 18 months thus limited usage by number of vessels only. Meanwhile biocides matrix paint is developed from triorganotin (TBT) derivatives due to their wide range activity, no galvanic corrosion on aluminum hulls and colorless. The TBT derivative such as bis-oxide (TBTO) and the fluoride (TBTF) are used both soluble and insoluble matrix-based shows biology activity of TBT compounds is independent These biocides base types are easily handled, solvent miscible liquid toxicant, compatible with many other biologically active compounds thus perfect for effective leaching with good control of both plant and animal fouling types. However plasticizing effect is an important drawback of biocides matrix and limits the amount that can be added. Other than that, it usually insoluble in common paint solvents and tend to behave as solvent that migrates to the surface, thus lead to rapid weakening. The third antifouling matrix soluble paint was developed in order to avoid loss in antifouling efficiency due to binder during immersion in seawater. Classic paint system contains high proportion of natural sources rosin obtained from pine tree and compatible with resin. Natural rosin-based paint consists about 85-90% of acidic types with two double bonds and carboxyl group. This double bond stabilized the rosin and make it oxidable when exposed to air. The carboxyl group reacted with sodium and potassium ion in the present of seawater and affected high solubility of rosin-based paint.

The brittleness and high dissolution rate of rosin improved by blending the paint with plasticizer and co binders thus giving the required properties of film forming, mechanical strength ad suitable dissolution rate. However, in static conditions with no vessel activity bubbles formed with calcium and magnesium affected the dissolution rate of soluble paint [5]. Rosin based, cannot prevent seawater from penetrating the polymer matrix through hydrophobic interaction, thus resulted more than 50µm leached layers due to continues dissolution of copper (I) oxide pigments of also reported cannot prevent seawater from penetrating into polymer matrix. Behavior under static conditions enhanced the possibility of pore blocking by insoluble salts and influence the release of biocides. Seidel, 2013 also reported other than static condition, the erosion of the paint also increase as the vessel speed increase [1]. The usage of rosin-based paint despite of its environmentally friendly have a challenge to improve its depletion rate in precise and adequate manner. However, rosin-based paint observed minimum marine growth at stationary periods and low speed voyage which suggest suitable for near coastal vessel. Antifouling technology started in early 300 before century in the form of lead and copper sheet applied on wooden boats to prevent marine growth. This heavy metal was continuedly used until 1960 after Tributyltin (TBT) was found to have better efficiency in preventing marine growth. However in 2008, International Maritime Organization (IMO) banned the usage of TBT due to effect of TBT produce abnormal growth on oyster shell [3]. Antifouling development now are going in both direction of self-polishing antifouling (biocides prevent establish of fouling) and fouling released (slippery, nontoxic coat) [4]. The banned of TBT generated a lot of interest to search efficient natural biocides that combined with the fouling release system. Recent research challenged especially to near coastal voyage is to produce antifouling coating with less toxic and effective. Other than that antifouling performance also varies due to seawater condition, location and types of vessel [4]. The interaction between natural or commercial antifouling on wood coated surface also still in limited understanding [6]. Current research highlighted on development of antifouling focused challenge to produce future antifouling that contributed 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. Natural biocides reported are extracted from seaweed, soft corals, sponges, mangroves and others. Current research observed natural biocides extracted from fished and algae both are used in vinyl chloride-vinyl acetate copolymer and epoxy matrix reactively both from insoluble matrix based. However, the usage of soluble matrix based was not found in current research findings. Meanwhile the potential of lemon as natural biocides in pharmaceutical are well known however not in marine industries although it have similar antibacterial of saponins, alkaloid, phenolic, terpenoid and flavonoid needed in marine sources biocide [7]. Thus, this research focused to evaluate the performance of commercial and natural lemon biocides embedded in the natural based matrix (rosin modified) coated on wood vessel structure that suitable for near coastal vessel applications.

II. METHODOLOGY

Chengal wood with $1625m^2$ surface area sanded with 120 grit sand paper before application of 3 and 2 layer of primer and various antifouling coating respectively referring to ASTM 3623 – 78a [8]. Six panels were prepared with primer, mixture primer with natural and commercial antifouling are summarize in Table 1. Primer used was from Jotun Primer for wood surface, rosin modified antifouling paint was from BINA PAINT SEAGUARD 06, commercial antifouling was Diuron, Preventol A6 from Lanxess and natural antibacterial fresh lemon juice was obtained filtration of cleaned squeezed lemon. The panels were immersed for 30 days and recorded every 5 days to evaluate the percentage of marine growth and weight change. Regression analysis was conducted to analyses the correlation between performance of antifouling and time.

III. RESULTS AND DISCUSSION

Figure 1 shows pH of seawater and the percentage of marine growth on wood surface coated with primer (A), natural antifouling (B, C and D) and commercial antifouling (E and F) immersed in sweater for 30 days. All samples uncoated and coated with antifouling paint observed slime attachment as early as 5 days. The percentage of marine growth increase significantly as time in days increase especially sample coated only with primer with 44% area affected to marine growth after 30 days due to no antifouling protection. Lemon natural antifouling observed good fouling properties with low percentage of marine growth for 30 days. Natural antifouling with 6% concentration shows similar percentage of marine growth performance as in commercial antifouling. The lemon juice with 2.1 pH is compatible with rosin modified base that also have acidic properties. Mixture of both base and biocide have a good interaction on Chengal wood surface with promising inhibit marine growth properties. The performance of both natural and commercial coating although at high pH value 8.4 observed in day 10 due to oil spills from nearby vessel were excellent in protecting the wood surface. Samples coated with 2%, 4% and 6% natural antifouling observed 35%, 12% and 10% of marine growth respectively. Meanwhile commercial antifouling with 2% and 4% concentration observed 5% and 7% of marine growth respectively. This variation of the observation for both types antifouling were due to growth of fouling material depends on organic content, pH, salinity, current flow and coating performance [9]. Figure 2 shows the water temperature and performance of weight change on wood surface coated with primer, natural and commercial antifouling. The seawater temperature maintains between 30 to 37ºC throughout 30 days of immersion. Sample A that coated only with primer shows highest percentage of weight change 5.20% due to less coated and protection on wood surface. The coating easily damages, thus leave the wood surface unprotected and absorb certain amount of seawater. However, in both commercial and 6% natural antifouling coating, weight change shows less than 3% value which in good agreement as observed in percentage of marine growth.

Natural lemon antifouling also observed similar trend as percentage marine growth that percentage of weight change reduced as antifouling concentration increase. The percentage weight changes also increased due to growth of animal fouling that contribute to increased weight of the panels. Regression analysis shows that all samples observed p value less than 0.05, hence the relationship between antifouling and time are highly significant. Both observation on percentage marine growth and weight change shows high percentage (>80%) of R square fit the linear equation for all types of antifouling. However, for sample without biocides the R square observed less than 80% shows that inadequate performance of fouling protection. The variation in the performance of antifouling was due to antifouling performance depends on location, seawater conditions and types of vessels [4]. Table 1 summarize the percentage of marine growth and weight change on wood surface coated with primer, commercial antifouling (CA) and natural antifouling (NA).

Fig. 1 Percentage of marine growth on wood surface coated with primer (A), natural antifouling (B, C and D) and commercial antifouling (E and F)

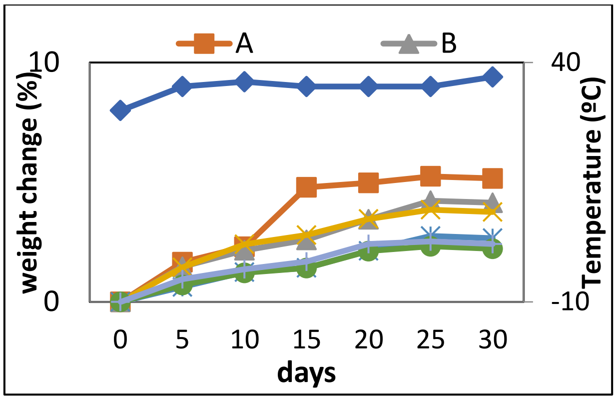

Fig. 2 Percentage of weight change on wood surface coated with primer (A), natural antifouling (B, C and D) and commercial antifouling (E and F)

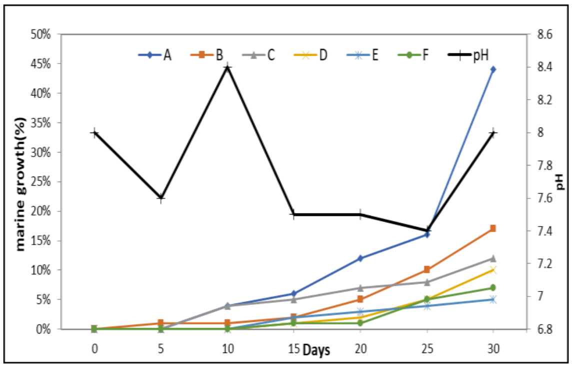

Table. 1 Summary of percentage of marine growth and weight change on with primer (A), natural antifouling (B, C and D) and commercial antifouling (E and F)

Types	Label	Descriptions	p-value	R-square	Coefficient Correlation	Linear Equation
% of marine growth	A	primer	0.0209	77%	0.8796	y = 0.0749x – 0.2002
	B	primer +2% natural antifouling	0.0092	85%	0.9205	y = 0.0314x – 0.0814
	C	primer +4% natural antifouling	0.0008	95%	0.9767	y = 0.0211x – 0.0351
	D	primer + 6% natural antifouling	0.0131	82%	0.9049	y = 0.0189x – 0.0549
	E	Wood surface + primer +2% commercial antifouling	0.0004	97%	0.9833	y = 0.0109x – 0.0255
	F	primer + 4 % commercial antifouling	0.0123	82%	0.9078	y = 0.0143x – 0.0410
% of weight change	A	primer	0.0191	78%	0.8849	y = 0.1515x + 1.3689
	B	primer +2% natural antifouling	0.0007	96%	0.9781	y = 0.1168x + 0.9606
	C	primer +4% natural antifouling	0.0033	91%	0.9530	y = 0.0947x + 1.2974
	D	primer + 6% natural antifouling	0.0011	95%	0.9725	y = 0.0884x + 0.2607
	E	primer +2% commercial antifouling	0.0033	91%	0.9527	y = 0.0648x + 0.5165
	F	primer + 4 % commercial antifouling	0.0055	88%	0.9391	y = 0.0660x + 0.7375

IV. CONCLUSION

Both percentage marine growth and weight change shows decreased observation as concentration of antifouling increased. Natural lemon antifouling with 6% concentration observed similar performance as commercial biocides in both percentage of marine growth and weight change. Thus, concluded that natural lemon antifouling have good interaction with rosin modified matrix and wood surface.

This finding also enhanced the potential of natural lemon as new biocides in marine for wood structure surface.

V. CONFLICT OF INTEREST

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

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