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Analysis of Coir Fiber/Wood Paint as Composite Anti-Weathering Coatings on Traditional Fishing Boats

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ABSTRAK

Ketahanan yang rendah dari kayu sebagai bahan rangka perahu nelayan tradisional terhadap percikan air laut, kelembaban serta fluktuasi temperatur yang tinggi dikaji dalam penelitian ini dengan menambahkan serat sabut kelapa kedalam cat kayu, dimana pencampuran ini akan menjadi material komposit pelapis anti pelapukan. Untuk membuat kompatibilitas antara serat dari sabut kepala yang bersifat menyerap air (hydrophilic) dan cat alkyd yang bersifat menolak air (hydrophobic), penulis memberikan perlakuan khusus pada serat sabut kelapa melalui proses pre-treatment acetone dan alkali panas (hot alkali treatment) dengan merendam serat dalam 10% laruran sodium hidroksida NaOH yang bersuhu tinggi. Perendaman dalam larutan ini mampu memodifikasi serat yang memilki permukaan kasar serta mengurangi ikatan hidrogen sehingga memperbaiki ikatan antar muka antara serat dan pengisi dalam komposit. Hasil yang didapat bahwa penambahan serat dengan fraksi berat 3.40 wt% terhadap matrik cat alkyd menjadikan komposit sebagai pelapis anti pelapukan yang paling optimal.

ABSTRACT

The low resistance of wood as a frame material for traditional fishing boats against splashing sea water, humidity, and high-temperature fluctuations was studied in this study by adding coconut coir fiber to wood paint, where this mixture will become an anti-weathering composite material. To make compatibility between the fibers from coir which are water-absorbing (hydrophilic) and alkyd paints which are water-repellent (hydrophobic), the author gives special treatment to the coco fibers through an acetone pre-treatment process and hot alkali (hot alkali treatment) by soaking fiber in 10% high-temperature sodium hydroxide NaOH solution. Soaking in this solution is able to modify fibers that have a rough surface and reduce hydrogen bonding thereby improving the interfacial bond between the fiber and the filler in the composite. The results obtained were that the addition of fiber with a weight fraction of 3.40% to the alkyd paint matrix made the composite the most optimal anti-weathering coating.

1. INTRODUCTION

The Riau Archipelago Province consists of hundreds of islands scattered from the Natuna Islands in the north to Crocodile Island in the southern part of Galang Island. Access between islands, especially remote islands using a fishing boat with a diesel motor placed at the stern, traditional fishermen call it pong pong. This fishing boat is an income-generating tool for traditional fishermen families [1], hence its existence must always be ready to travel to the middle of the sea as transportation in finding fish and also to visit families on another island [2].

The problem faced by fishermen is that the construction of this fishing boat is generally made of wood. Meanwhile, the quality of the wood used in the manufacture of these boats varies depending on the age of the trees when they are felled as well as the type and drying process so that some boats only last no more than two years. Routine maintenance which is expensive by replacing the hull structure when it starts to rot/rot is a burden for traditional fishermen in their lives.

This work provides an alternative solution to traditional fishing communities in extending the life of the wood used in making fishing boats so as to prolong its service life. The solution offered is to provide a coating on the wood in the form of coconut fiber mixed with wood paint [3]. This mixture becomes a composite material with reinforcement/fiber from coconut fiber and filler/matrix from wood paint. Comparison of the weight fraction of the fiber and matrix will be studied to obtain optimal mixing [4] which will ultimately increase the resistance of the boat structure to weathering/porous processes due to splashing of seawater, very high hot & cold temperature differences on the coast as well as fluctuations in humidity and rainfall.

The choice of coconut coir was made considering the ease of obtaining raw materials where there are abundant coconut trees in the Riau Archipelago and the effectiveness in processing it into fine fibers. Besides that, the material from coconut coir is an environmentally friendly bio-degradable material that can be used to make various products, for example as particle board in the manufacture of speaker boxes for small industries [5] and can also be used as a gypsum filler in the manufacture of ceiling sheets with a polyurethane binder [5]. The application of coconut coir fiber in civil engineering science, for example as fine aggregate in concrete mixes [6]. Even the use of coconut coir fiber can be expanded as a medium for husk charcoal to accelerate plant growth hydroponically and also as a carbon source [7][8]. Studies on coconut coir as a composite material as reinforcement/fiber can be found in several articles, especially those that discuss mechanical strength with various types of fillers/matrices. [9]. Several techniques for making fishing boats from composite materials, for example, made from plywood reinforced with coconut fiber/polyester resin [10], palm fiber [11], and also from hemp fiber [12].

The choice of alkyd paint which is oil paint as a filler/matrix is due to economical reasons which are cheap, easy to obtain and easy to apply to products. This paint is resistant to moisture which causes fungus on wood [13] although not as good as paints with other base materials such as epoxy, acrylic, polyurethane, or bituminous resin where these four base materials are also resistant to chemical environments compared to alkyd paints.

To the best of the author's knowledge, mixing of coconut coir fiber and wood paint into a composite material that functions as an anti-weathering coating material to extend the life of wood and not as a frame has never been done. The main problem with using coconut coir fiber is its high water absorption (hydrophilic) properties with a moisture regain of around 13% which will reduce the interfacial bonding between the fiber and the filler in the composite [14][15][16]. To make compatibility between coir fibers and hydrophobic alkyd paints, the authors carried out special treatment of coconut coir fibers through a hot alkali treatment by soaking the fibers in 10% high-temperature sodium hydroxide NaOH solution. The hypothesis above is the basis of the work which the authors continue by conducting a series of tests.

2. Material and Methods

2.1 Preparation of coconut coir fiber and matrix composite

In other studies, the use of bio-degradable fiber materials as composite reinforcement has a variety of applications and its characteristics are similar with synthetic composites [17][18]. In this work, the bio-degradable material is coconut coir fiber taken from coconuts in Batam. The fiber preparation is done by drying the coconut coir under the hot sun for three hours which is done in a span of five days to reduce the

water content, remove impurities and crushed it until it becomes powder and then filter it using a 0.30 mm sieve (mesh 50). The fiber obtained was soaked in acetone solution for 30 minutes then washed using distilled water and dried at room temperature for 24 hours. Meanwhile, the wood paint used are the "Avian" brand with specifications: high gloss enamel made from alkyd material with a 750-deep ocean blue color that been purchased from a local store in Batam. Alkyd paint is an oil paint as a filler which is inexpensive, easy to use and relatively resistant to moisture which causes fungus on wood [13] which is suitable for painting fishing boats.

2.2 Improvement of coir fiber characteristics

The obtained coir fiber was soaked in 10% sodium hydroxide solution for 3 hours at 50ºC then cooled to room temperature for 24 hours, followed by washing with distilled water and then drying in an oven at 40ºC for 4 hours.

2.3 Composite preparation (as a coating)

The coconut coir powder obtained is then put into a measure to determine the weight and then mixed with paint in a certain ratio for the composite weight fraction to be studied which consists of coir fiber as reinforcement/fiber and paint as filler/matrix. The process of mixing the materials for the three types of composite weight fractions was carried out in a metal container/can and then stirred thoroughly for five minutes using an automatic stirrer, so that three types of coating variants were obtained from the composite as follows: a). coir fiber 3.40 wt%/paint filler 96.50 wt% (sample A), b). coir fiber 8.50 wt%/paint filler 91.40 wt% (sample B), c). coir fiber 13.60 wt%/paint filler 86.30 wt% (sample C), and d) pure paint without the presence of coir fiber (sample N). While the addition of thinner as a paint diluent was not more than 0.10 wt% of the total weight.

Performance tests of the four types of composite materials as anti-weathering coating materials consist of scratch tests, bending tests, peel adhesion tests and flame resistance/fire-retardant tests. The test material is mahogany which is widely used as a board for making fishing boats, except for the bending test which uses zinc which is sold in hardware stores. The coating was done manually using ACE 1706530 brush made from 25.4 mm polyester at room temperature 27ºC, humidity 77% and pressure 1.01 MPa to obtain a layer thickness between 0.50 to 0.75 mm.

2.4 Scratch resistance test against high-pressure waterjet

The scratch with a length of 50 mm was carefully made on each sample by pressing once using a cutter knife (Kenko, type L500, thickness 0.5 mm) until it penetrated the wood base material. The resulting scratches were then sprayed with concentrated water at a temperature of 25ºC with a pressure of 1.5 bar at a distance of 500 mm for 60 seconds using a water pressure gun (Den-Sin, type C-110E). This scratch test was carried out three times for all samples and the result were taken from the one who had the most severe peeling.

2.5 Peel adhesion test

Before the adhesion test was carried out, the surface of the sample was cleaned with acetone then rinsed with distilled water and dried in the hot sun for 4 hours. The adhesion test was carried out using outdoor mounting tape (TACTIK PTA530318-10217448 from Meridian International Co., Ltd - China) with a dimension 21.0 x 50.0 mm which was stuck to each sample for 5 days. Withdrawing the tape is done in one stroke so that the basic wood material was exposed. The resistance of the test piece is measured by mapping the peeling surface area on transparent/scale tracing paper.

2.6 Flame resistance and fire-retardant measurement

The samples were placed in the middle of a gas burner (Rinai RI-522C stove) diameter of 100 mm, tuned on the highest flame position with a pressure of 4.5 bar, and suspended at a height of 50 mm from the burner surface. All samples received the same treatment where observations were made by recording the time it started to burn in the first minute then the time when the fire started to spread in the next minute.

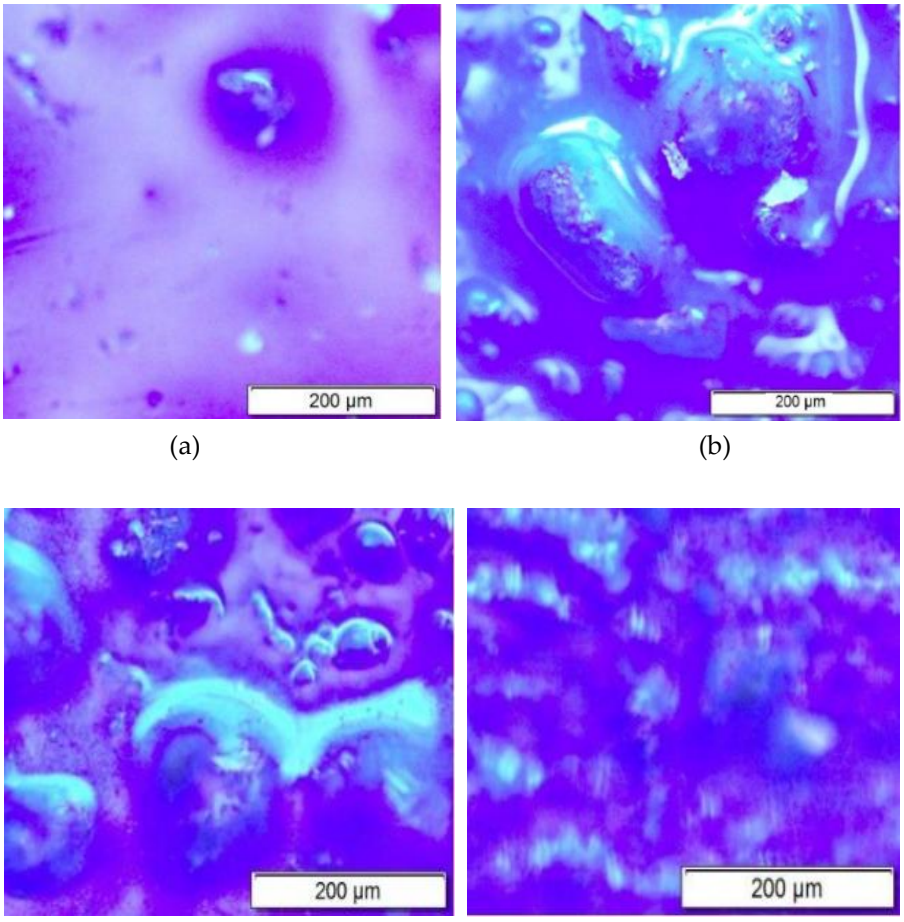
The gas used is natural 19 kg of natural gas supplied from the State Gas Company (PGN) which was purchased from a local store.

2.7 Bending test

The bending test for the four samples was done by applying a composite layer on the base material of zinc metal, not from wood like the other sample for practical reasons in looking at the ductility performance of the coating layer/composite itself. The bending process is carried out using a mandrel with a radius of 1 mm to form a U-shape letter then straightened and re-bend, this process is repeated five times. This test were done in 3 positions for each sample and the results were taken from the worst cracks.

3. Result

The mixing between coconut coir fiber as reinforcement and alkyd-based paint as a matrix is shown in Figure 1. The fiber grains are seen blending with the paint which acts as a binder. As the fiber weight fraction increases, the density of the composite becomes higher as seen from the density of the fibers in the order starting from the lowest density, namely sample A, then B and C. Sample N is a pure base paint/ coating without an addition of fiber which is used as a reference.



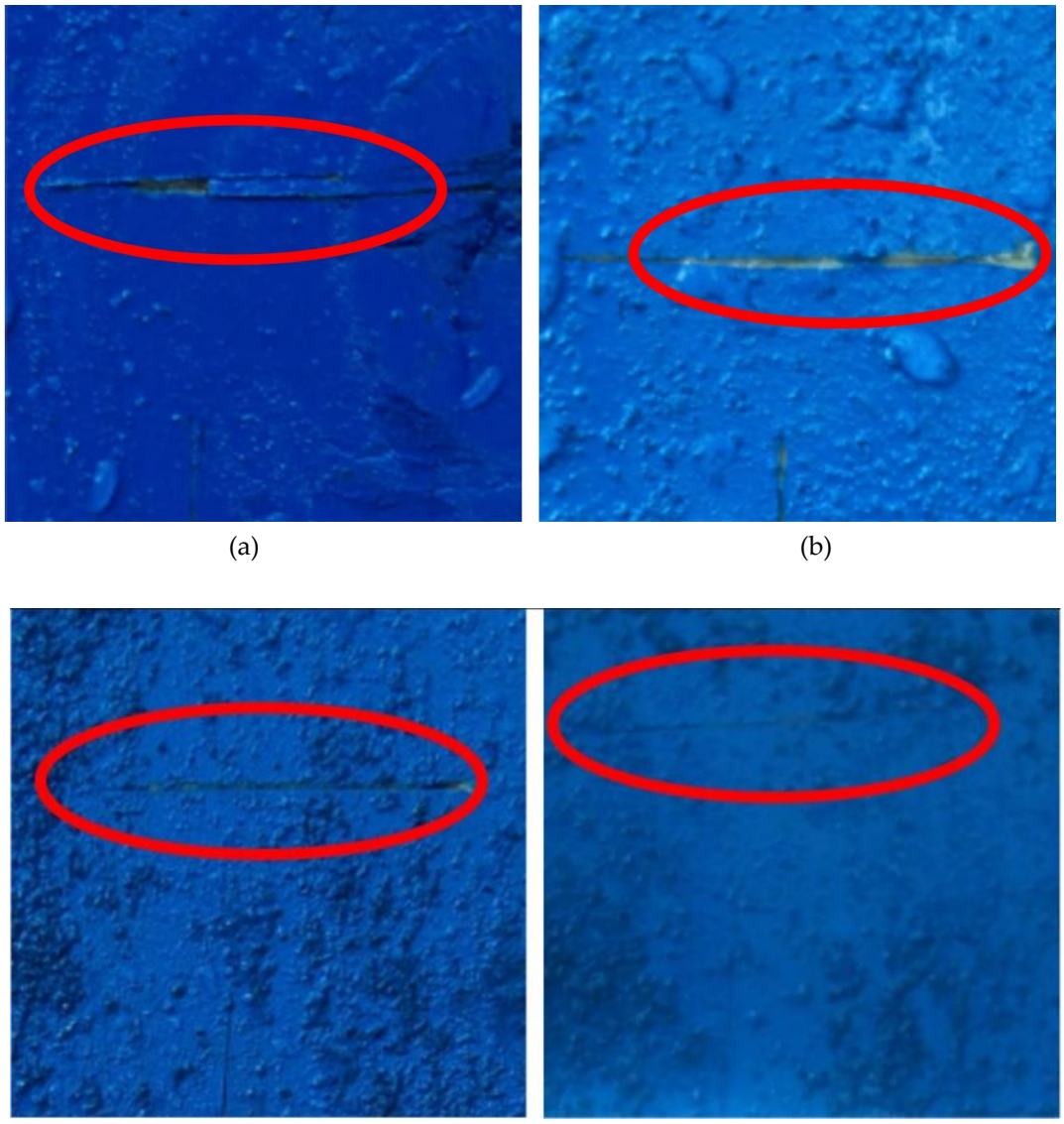
(a) (b)

(c) (d)

Figure 1. Image taken from OLYMPUS BX5M microscope: (a) sample N, (b) sample A, (c) sample B, and (d) sample C

The results of the scratch test and resistance to pressurized waterjet spray are presented in Figure 2. Soaking in a hot alkaline solution is able to make a rough surface of the fiber and reduce hydrogen bonding which ultimately reduces its hydrophilic properties [16] [19]. Thus, this alkaline treatment improves the

interface adhesion between the fiber and matrix paint which improves the mechanical properties of the composite as a coating. The addition of the fiber weight fraction increases the test resistance, this is due to the role of coir fiber which has a tensile strength between 131 MPa – 220 MPa [15] which is able to withstand high pressure water compared to the sample without the addition of fiber.

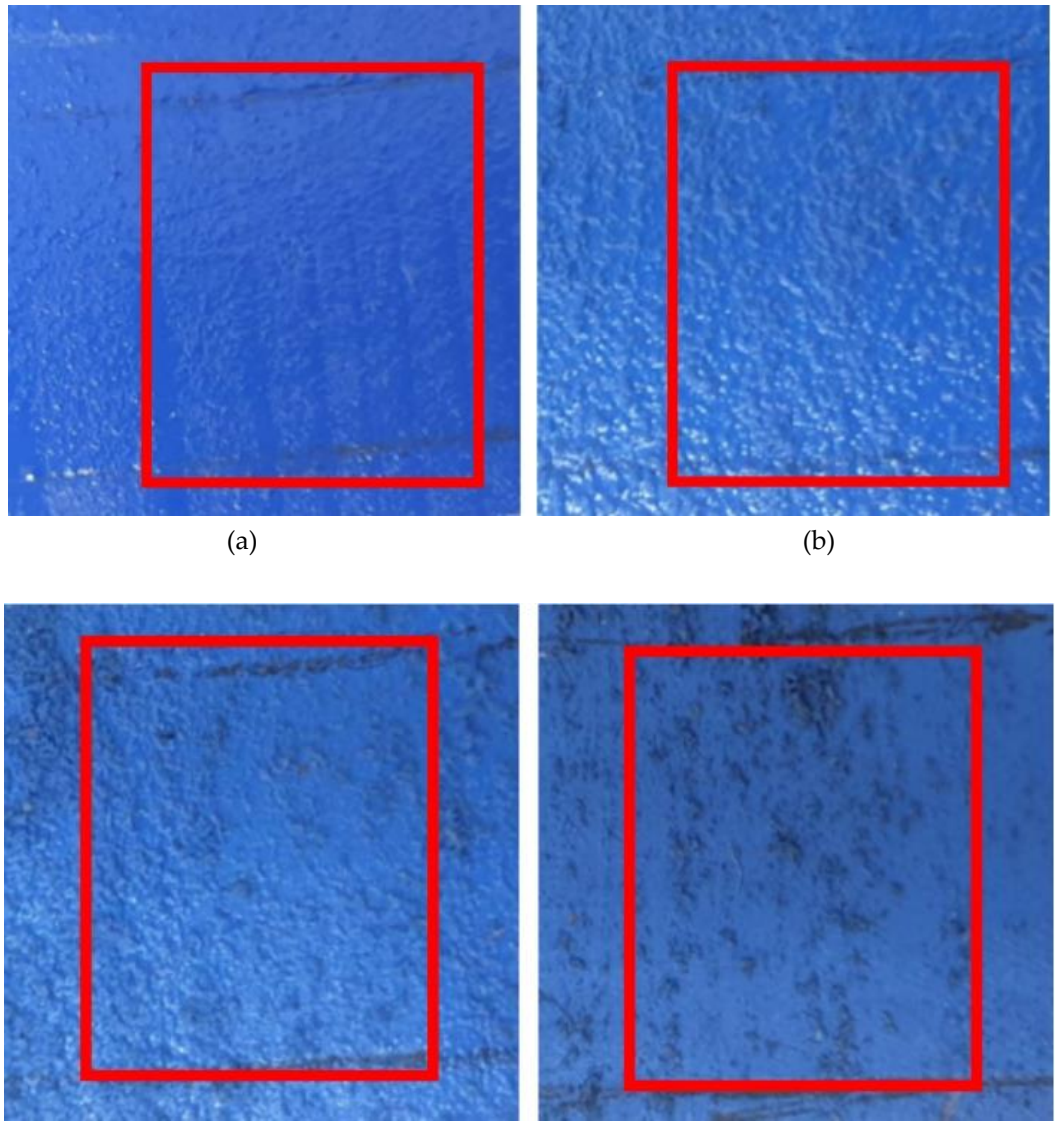


(a) (b)

(c) (d)

Figure 2. Scratch test of (a) sample N, (b) sample A, (c) sample B, and (d) sample C

The adhesive characteristic depicted in Figure 3 is based on peel adhesion results, All the samples showed similar behavior in which no peeling was detected during the test which proved a good adherent between coating and wood as a based material.



(a) (b)

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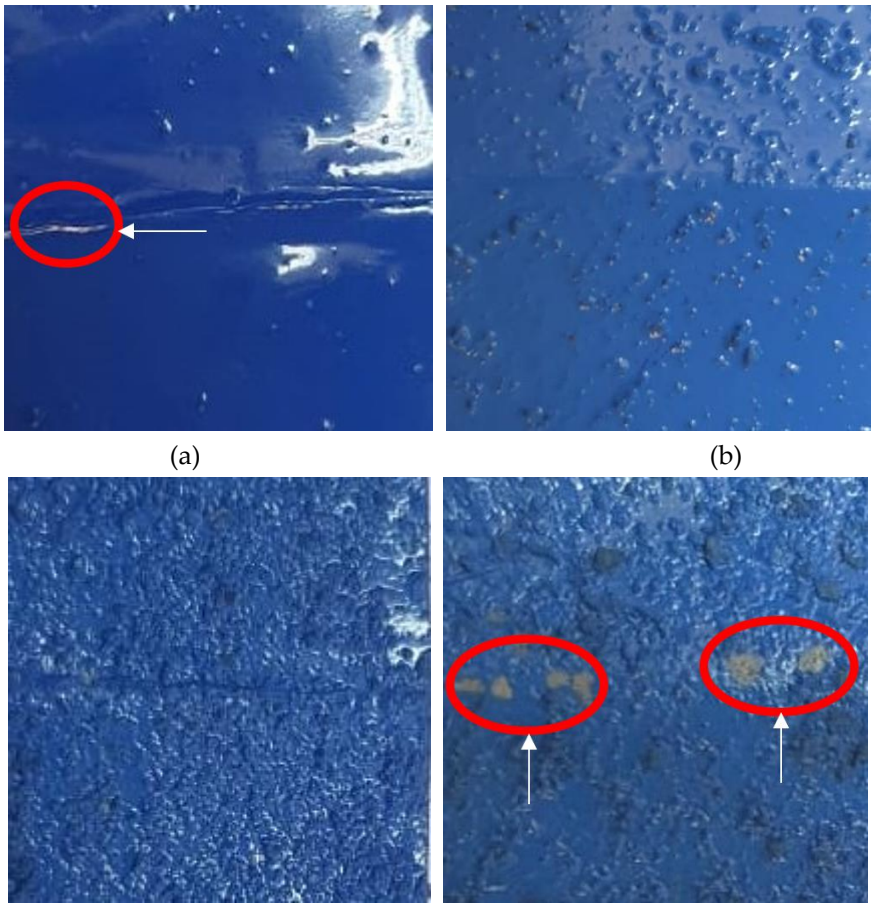
Figure 3. Peel test of (a) sample N, (b) sample A, (c) sample B, and (d) sample C

In addition to the scratch and peel test, a flexural/bending test was performed to examine the internal bonding of the composite coating itself. As illustrated in Figure 4, the addition of coir fiber shows high characteristics compared to the sample without fiber. This is due to the high ductility of coconut coir fiber with a value of around 15% - 40%. Although the amount of fiber does not have much effect on ductility, performance is slightly better on sample A, but the tendency of increasing the fraction weight will deteriorate the bending's performance. In that case, the result indicated a substantial plastic behavior in which incompatibility aggregation of the coating composite occurred.

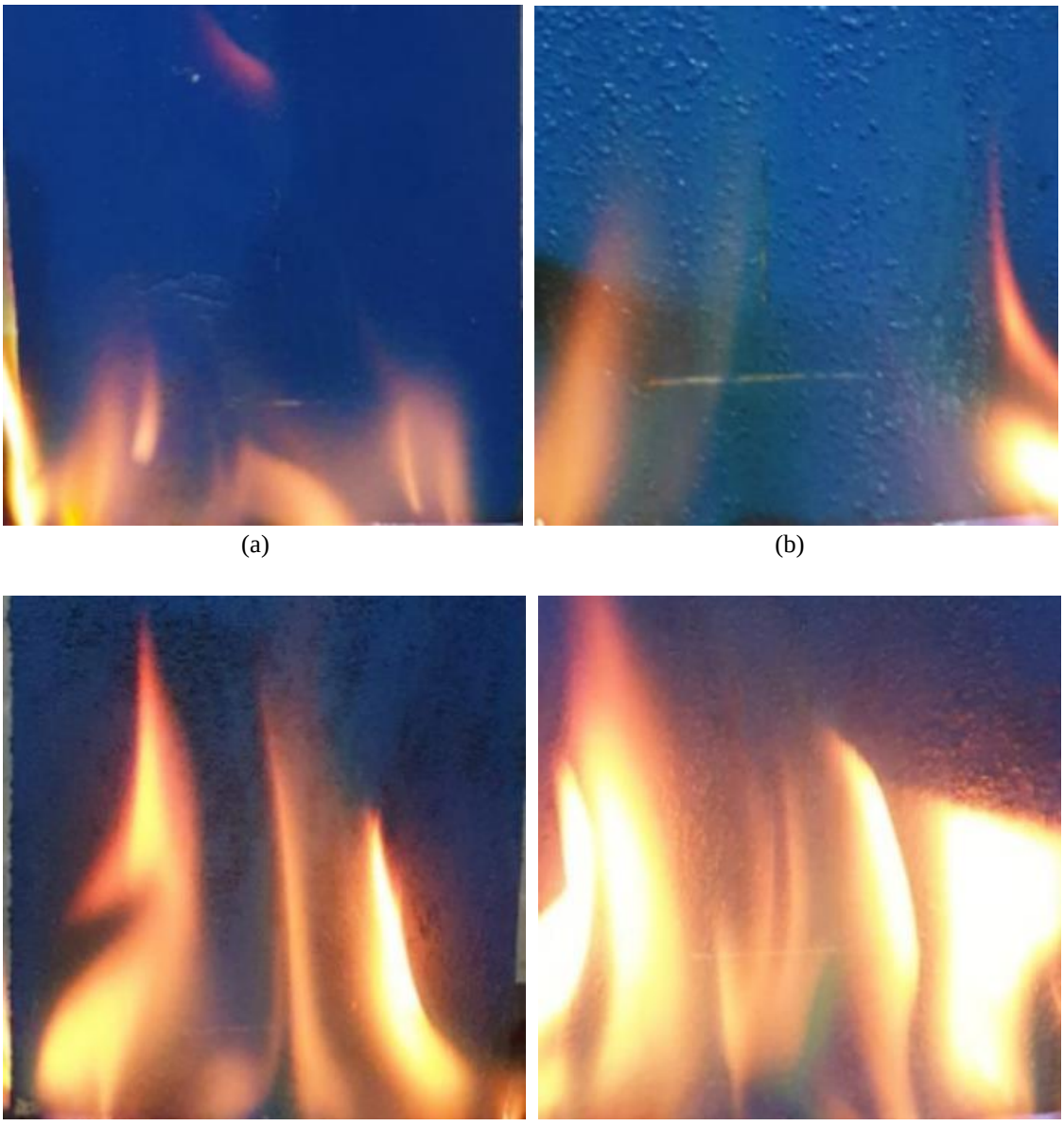


(a) (b)

(c) (d)

Figure 4. Bending test of (a) sample N, (b) sample A, (c) sample B, and (d) sample C

The flame resistance and fire retardant test concluded that samples A, B, and C have good stability or resistance to fire for the first minutes before the fire spreads to the sample's body compared to sample N. However as depicted in Figure 5, the speed of the fire spreading after the first minutes showed that the sample N experienced a slowdown compared to other samples that had fiber, except the sample A retained a best stability. This result was due to the presence of fiber which had reached the melting point will increase the speed of the fire spread and the reaction of hydrophobic alkyd paint. The good fire retardant of sample A may be explained by the possible optimum macro-entanglement between coir fiber and alkyd-based paint as a matrix.



(a) (b)

(c) (d)

Figure 5. Fire retardant test after the first minute of burning: (a) sample N, (b) sample A, (c) sample B, and (d) sample C

4. Application

Prior to coating, the wood structure must be cleaned of all kinds of dirt, especially oil and grease impurities using sandpaper (grinder), scrap tools, or descaling materials. The coating process can be applied in several ways, for example by using a brush, spraying with simple equipment, or using a compressor. The drying process is carried out by exposing them to the hot sun for 2 days. Please note that during the coating and drying process, the boat is not allowed to come into contact with water, for example from pouring rain.

5. Conclusion

Sample C showed good performance on scratches, and peeling (by spraying with high-pressure water), this is because the fibers that have undergone alkaline treatment can blend with alkyd paints which are hydrophobic/water-repellent. The existence of fibers that have relatively high tensile strength [A] can withstand pressure so coatings with fibers have better-peeling resistance than those without fibers. The results of the bending test confirmed the role of coir fiber which has high ductility [B] so the specimens with fiber showed good bending results.

However, the addition of fiber with a large weight fraction will decrease the bending properties because the interface bonding between the fiber and the matrix paint is not perfect due to the large fiber size and the modification of the fiber properties to approach the hydrophobic of the paint does not perfectly occur. Thus, sample A has the most optimal bending characteristics. Sample A showed the best performance as a fire retardant because coconut coir still had water-absorbing/hydrophilic properties, although it was not too different from samples B and C. This fire-retardant performance was seen when compared to a coating without fiber (sample N). Of all the performance criteria, sample A obtained from fraction weight 3.40 wt% performed the best for anti-weathering coating composite for traditional fishermen's boats

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