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Preparation of green composite from Local natural fiber in Thailand and Poly (lactic acid)

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Abstract: *Paragrass is a weed of Thailand. It can be applied as reinforcing material for green composites. It was cleaned, soaked in NaOH, washed, dried and ground. The composite sheet was prepared from laminated technique. paragrass were sandwiched between poly(lactic acid) (PLA) sheets then molded by compression in hot press machine at temperature set of 190 degree Celsius. Properties of composite sheet were investigated according to TISI standard No. 876-2532. From the results, Modulus of ruptures, density, water and moisture absorption, thickness swelling and thermal properties were passed the TISI standard.*
Keywords: *Green composite , Paragrass, Poly lactic acid*

I. Introduction

Petroleum synthesized plastic products have been globally used. They are very useful for human life. However, there are many problems from using these plastics too, especially affecting to the environments. They need long time for decomposition and some of them are toxic. Therefore, new synthesized plastics (green product), environmental friendly products are needed. Biological plastic has been studied [1]. One of the most interesting biopolymer is poly(lactic acid), PLA. This polymer comes from plant and it can be easily decomposed biologically. Now a day, many products such as nappy, plastic bag, cap and dish, etc. were produced using PLA [2]. However, PLA has not been wide applied because of its high cost and fragile property. In order to improve its property and reduce production cost, some natural materials were added into the process. The good points of using the mixture of PLA and natural product is that it can be decomposed naturally. However, the weak point of this idea is that PLA is hydrophobic , but the natural fiber is hydrophilic. This difference affects to the interaction force taking place between PLA molecules and natural fibers (lowering the mechanical strength) [3]. To increase the interaction force, some chemicals such as silane, maleic anhydride was added into the process.

The aim of this research work is to study the optimum ratio of PLA and fiber (from Paragrass) for the preparation of green composite, and to study the mechanical and physical properties of the obtained green composite.

II. Apparatus and Method

2.1 Fiber preparation

The paragrass were dried under sun light. The dried fibers were ground and sieved with size of 5-20 mm. Fibers were treated with 1 M of sodium hydroxide (NaOH) for 24 hours, washed with water until pH 7 and dried.

2.2 Fiber improvement

The Silane solution was prepared at 0.5% concentration in acetone. The Silane grade A was obtained from Connellbrothers Co,Ltd. The paragrass was boiled in silane solution at 65^oC for 2 hrs. It was subsequently incubated at 85 ^oC for 12 hrs. The final fiber product should be < 5% moisture.

2.3 Preparation of composite material

The PLA bead was incubated at 80^oC for 24 hrs. Then, it was compressed to be a plate form (300x300x1 mm.) by using the hot press hydraulic machine. The hot press hydraulic machine model MP 101 from CBN C.,Ltd. was used in this work. Twenty tons pressing power, 190^oC, 10 minutes and cooling time for 5 minutes were used in this work.

The composite sheet was prepared by laminated technique. Paragrass were sandwiched between poly lactic acid sheets then molded by compression in hot press machine at 190 ± 5 ^oC, 20±5 bar for 20 min. The metal mold with size of 300x300x8 mm. was used in this step. The ratios of PLA/The paragrass (10/90, 20/80, 30/70, 40/60 % w/w) were studied. Five replications for each ratio were prepared. The preparation of composite from PLA and paragrass by laminated technique is shown in Fig. 1.

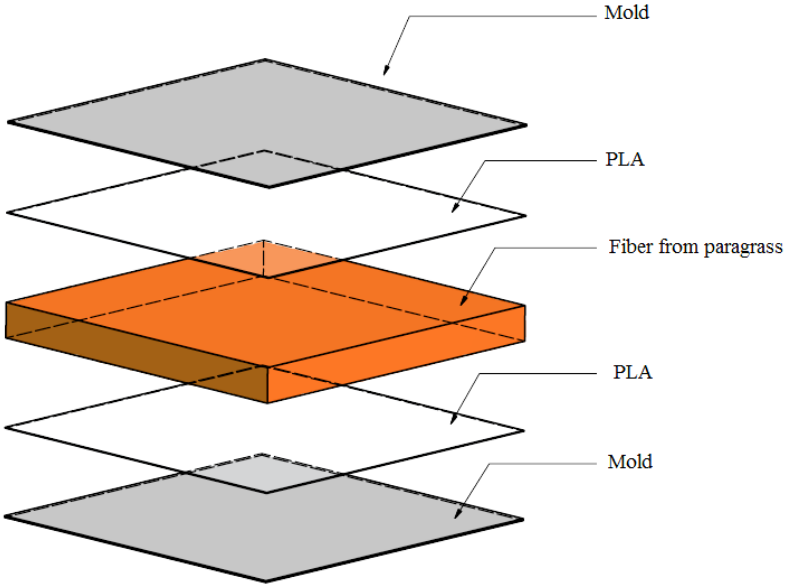


Fig. 1 Preparation of composite from PLA and paragrass fiber by laminated technique

2.4 Testing of composite sheet

Properties of composite sheet were investigated according to the TISI standard No. 876-2532. Modulus of rupture, density, water and moisture absorption, thickness swelling were evaluated. Morphology was studied by using a scanning electron microscope (SEM). Thermal property was measured by hot disk thermal constant analyzer model BP 221 from Kinetics Engineering Solutions Co.,Ltd.

III. Results and Discussion

3.1 Morphological analysis

The color of composite was brown. Its surface was smooth. The paragrass fibers were inserted throughout the composite material. The composite can be cut easily and smoothly. The picture of the composite prepared from PLA and paragrass fiber is shown in Fig. 2.

Fig. 2 Picture of the composite prepared from PLA and paragrass fiber.

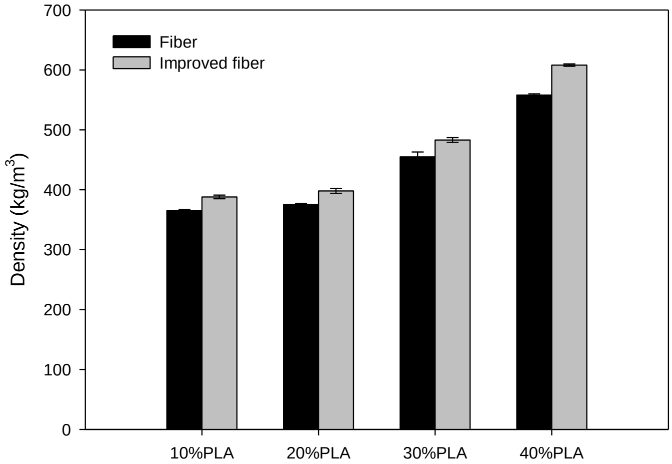


Fig. 3 The density of composite prepared from PLA/fiber and PLA/improved fiber

3.2 Density

The density of the composite prepared from PLA and paragrass fiber increased as increasing % PLA content. PLA is the reinforcement agent, reduces the vacancy sites occurred in the composite material. Therefore, the density of composite was relatively increased [4]. From Fig 3, the densities were found in the range of 360-600 kg/m^3. This density do agree very well to the TISI standard No. 876-2532 (500 kg/m^3). The interesting formulas (PLA/fiber) which posed the good densities were (40/60; 608 kg/m^3).

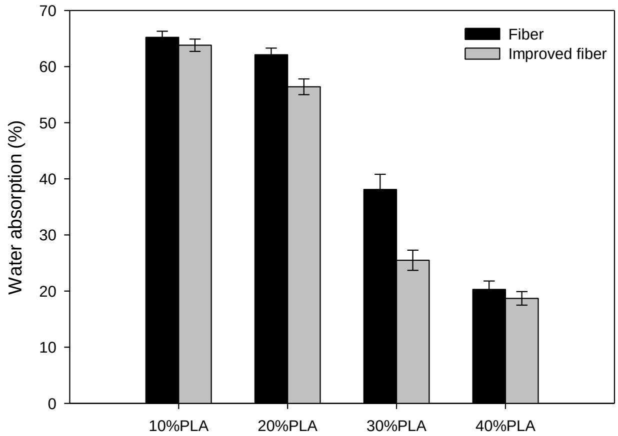


Fig. 4 The water absorption of composite prepared from PLA/fiber and PLA/improved fiber

3.3 Water absorption and thickness swelling

Water absorption and thickness swelling seemed to be decreased as the PLA content increased. As known that the PLA content affects to the density of the composite [5]. Therefore, increasing PLA content, From Fig 4and Fig 5, the water absorption would be decreased. For the composite prepared from PLA and improved fiber. It was found that improved fiber showed strongly affect to water absorption and thickness swelling properties. The content of improved fiber was increased, then the density increased, and water absorption and thickness swelling decreased significantly. It was due to the improved fiber played strong effects on the increment of interaction force taken place between PLA and improved fiber. Thus, water molecule could move or pass through the composite sheet with difficulty [6].

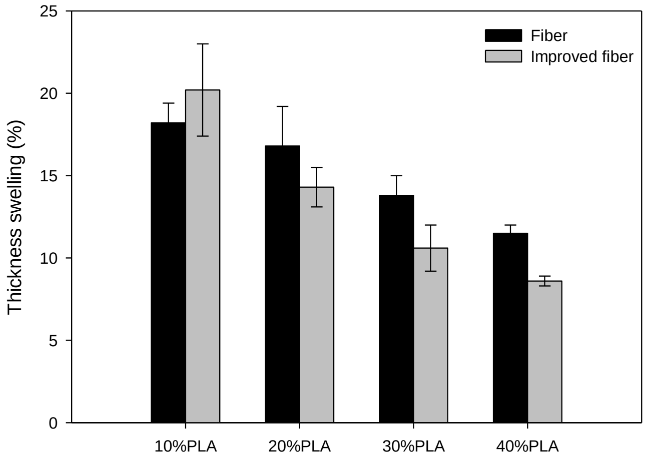


Fig.5 The thickness swelling of composite prepared from PLA/fiber and PLA/improved fiber

3.4 Modulus of rupture

From Fig 6, the modulus of rupture seemed to be increased as the PLA content were varied ranging from 10-30 % w/w. It was due to the main function of the fiber content in this process is the reinforcement agent. The fiber content increased the interaction force occurred in the composite material. Oppositely, at % PLA more than 40%, the modulus of rupture tended to be decreased. As widely known that the PLA properties are rigid but brittle, broken easily. Therefore, increment % PLA content in the composite formula, the natural fiber content was decreased, then the reinforcement function also decreased. The prepared composite with %PLA more than 40% w/w were, therefore, broken easily [7]. For the system included the improved fiber (using silane solution), it was clearly found that the modulus of ruptures of the prepared composites were high, and higher than those obtained from the not improved fiber experiments. It was due to the interaction force between the improved fiber and PLA was significantly higher than that obtained from not improved fiber and PLA [8]. This result agreed very well with the morphological results as shown in Fig. 7. The morphological study of composite prepared from PLA/fiber. The interesting result was obtained from 30% PLA/improved fiber system which posed the modulus of rupture at 14.1 MPa. This value passed the TISI standard NO. 876-2532 (13.8 MPa).

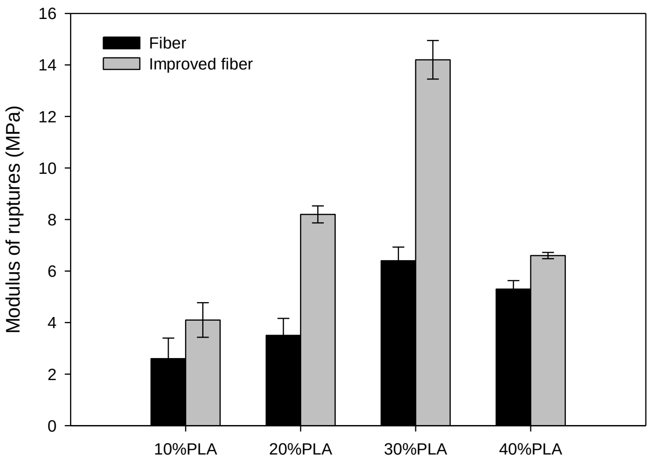
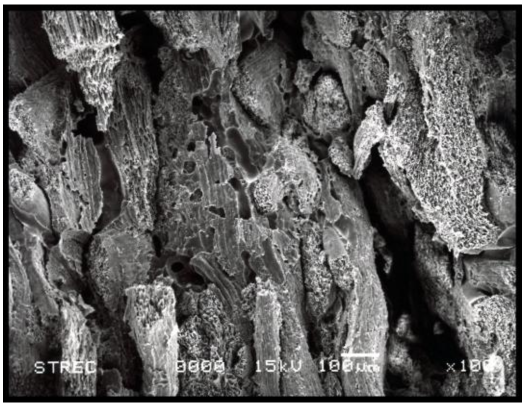


Fig.6 The thickness swelling of composite prepared from PLA/fiber and PLA/improved fiber



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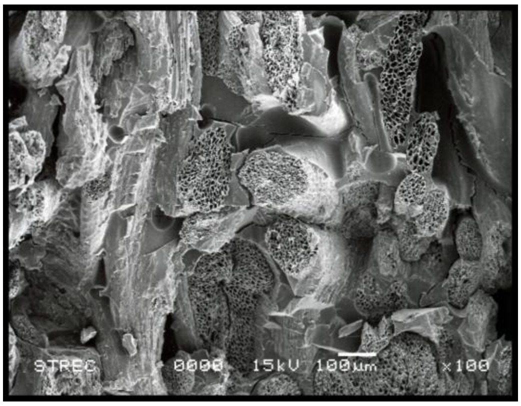

b

Fig. 7 Morphological study of composite prepared from PLA/fiber
(a) Paragrass fiber/PLA composites
(b) Silane treated Paragrass fiber/PLA composites

3.5 Thermal conductivity

From the results shown in Fig 8, the thermal conductivity of the composite seemed to be increased with increasing PLA content. It was due to the rigidity of the composite increased depending on the increment of %PLA content. Therefore, the thermal conductivity was increased [9].

Oppositely, the thermal conductivity decreased with decreasing PLA content. More vacant sites were found in the composite material. Oxygen contained in the vacant sites was the insulator. This result was very interesting, if this composite (low content of PLA) would be applied to be the wall. The wall with low thermal conductivity, it is showing the insulator ability. This knowledge would be applied for reducing electricity used in the house or building.

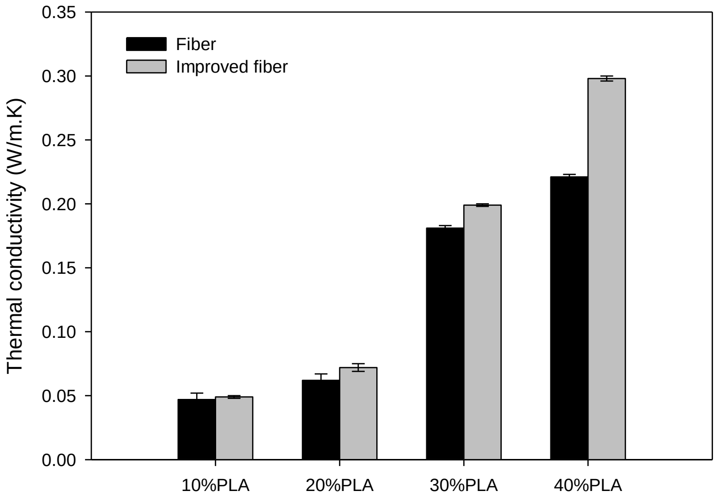

Fig.8 The Thermal conductivity of composite prepared from PLA/fiber and PLA/improved fiber

IV. Conclusion

The green product, composite prepared by PLA/ paragrass fiber was successfully studied. According to the result obtained from the 30%PLA/improved fiber, the modulus of rupture, density, water and moisture absorption, thickness swelling and thermal property were passed the TISI standard. Therefore, it would be possible to be used in the real applications (nappy, plastic bag, cap, dish, wall, building, etc.)

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