Polylactic Acid (PLA) and Wood Composite as a Sustainable Material Alternative in Additive Boat Manufacturing and Its Degradation in Marine Environment

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Abstract: For the sustainable boat production, a new composite material consisting of PLA and wood was introduced in the study. Wood, yellow pine from the forests of the Mediterranean region of Turkey, was in two form in the study: (1) 8% in weight in the composite and (2) solid wood. From the both kind of the material, specimens were produced by additive manufacturing technique in two (parallel and cross) printing directions and after that, the specimens were subjected to accelerated aging processes representing long-term effects of marine environmental agents such as humidity, salt and temperature in four conditions namely: (1) without, (2) one-week, (3) two weeks and (4) four weeks aging. Tensile and compressive testing were performed for all the samples and the results were given comparatively. A scanning electron microscope (SEM) analysis and thermal analysis were also performed to appreciate the bonding performance of the materials and the environmental effects on the composite. According to the results, newly introduced PLA/wood composite material was found usable for the interior design elements whose the complex form and the limited exposure to the marine environment.

1. INTRODUCTION

From the first day that human used water for transportation until today, wood, as the most sustainable alternative, has been the main material used in small marine craft building by maintaining its competitiveness with the help of developed woodworking technologies and additives [1]. Considering today's efforts for the sustainable maritime industry, an alternative composite material consisting of a local wood (yellow pine micro particles) and Polylactic acid (PLA), a thermoplastic, was introduced in the study for the boat structural elements with complex form. These two materials in the composite were biodegradable and can be used in the replacements of petroleum-derived polymers [3].

2. METHODOLOGY

Since the structural elements with complex forms can be produced by additive manufacturing techniques, the fused filament fabrication (FFF) method with 3D printers was used to produced composite samples using the composite filament in an optimum mix-

ture (8% wood in weight [4]). Two printing directions, cross and parallel, were also considered as the parameter of the performance of the introduced composite.

To understand the effects of marine environmental agents such as humidity, salt and temperature, specimens were subjected to accelerated aging in four conditions: (1) without, (2) one week, (3) two weeks, and (4) four weeks in an Ascott type cabin.

Tensile and compressive tests were also performed for all the samples (aged, non-aged). A scanning electron microscope (SEM) analysis and thermal analysis were also performed to appreciate the bonding performance of the materials and the environmental effects on the composite. Additionally thermal analysis was done for the samples.

3. RESULTS AND DISCUSSION

The degradations were seen clearly at a level of 10% in first week, 20% in second week and 30% in one month for PLA/wood composite as PLA is a biodegradable material. Solid wood shows a high resistance in the first two weeks. The degradation is less than 5%, but if the one-month data is analysed a 20% degradation can be seen. Tensile and compression tests showed similar degradation performance.

Newly introduced PLA/wood composite material was found usable for the interior design elements whose the complex form and the limited exposure to the marine environments.

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