PROPERTIES AND PERFORMANCE OF NATURAL FIBRE REINFORCED ORGANOSHEETS MADE USING BIO-BASED THERMOPLASTIC MATRICES

S. Pichler [1], G. Wuzella [1] A.R. Mahendran[1*] and H. Lammer [1]

[1] Kompetenzzentrum Holz GmbH, Altenberger Straße 69, A-4040 Linz, Austria

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ABSTRACT

Currently, lightweight components make use of continuous natural fiber reinforced composites that incorporate thermoplastic reinforcements due to their advantageous features such as recyclability, reduced weight, and environmental friendliness. The organosheets, which are made of thermoplastic prepreg or semipreg material, are stacked and pressed to form sheets. For this study, organosheets were manufactured by combining woven flax fabrics with a bio-based matrix resin derived from PLA/Bio-TPU thermoplastics. Flame retardants were added to both the matrix and reinforcement, and the impact of these flame retardants on the processing parameters was investigated. The hygroscopic nature of the flame retardant posed challenges during processing, leading to an investigation using Dynamic Vapor Sorption. To create thicker parts, the organosheets were layered with recycled PU foam serving as the core material. Flammability tests were performed on the compression molded part, revealing that a minimum of 10% flame retardant loading is required to meet federal aviation regulations. Natural fiber reinforced composites made using organosheets hold promise for applications in automotive or aircraft interiors.

1 INTRODUCTION

The use of natural fibers like flax, hemp, and kenaf in automotive and aircraft interior components, particularly in less load-bearing parts, is making progress now. Organosheets [1][2][3], also known as organoblech, are currently being used in the composite industry. These sheets are primarily made from polyolefin and polyester thermoplastic matrices derived from fossil resources, combined with glass/carbon fiber woven fabric or layered unidirectional tape. The goal is to replace conventional matrix resins with renewable bio-based matrices to reduce CO_2 emissions, facilitate an eco-friendly manufacturing process, and enhance recyclability.

As a novel approach in this study, bio-based extruded cast films with a high content of renewable carbon were manufactured by blending polylactic acid (PLA) with bio-based thermoplastic polyurethane (TPU). The hydrophilicity of the organosheets can cause significant processing difficulties. Therefore, extensive characterization was carried out using a Dynamic Vapor Sorption (DVS) instrument. Additionally, the effect of flame retardant on moisture absorption behavior was investigated.

The organosheets were loaded with flame retardant, and flammability tests were conducted to determine the flame time, drip flame time, and burn length of the bio-based organosheets.

2 MATERIALS AND METHODS

2.1 MATERIALS

Company Lubrizol supplied bio-based thermoplastic polyurethane and PLA granules were purchased from Naturworks (4043D). The flax reinforcement (diagonal twill construction having grammage of 170 g/m2) twill weave were procured from Leinenweberei Vieböck, Austria. For the sandwich laminates, the recycled PET foams were used as lightweight core material.

2.2 METHODS

The PLA/TPU (80:20) were compounded with 10% flame retardant and then extruded in to thin films of ca. 250 µm thickness. Similarly, the flax fabrics were loaded with 13% of flame retardant. The organosheets were manufactured in a compression molding machine at the temperature of around 160-180°C at 10 bar pressure. The construction of the organosheets is illustrated in Figure 1.

The moisture absorption behavior of the organosheets at various relative humidity was measured using DVS instrument for four different organosheets (1-4) and the vertical Bunsen burner test was carried out for the sandwiched organosheets (A-D) as per FAR 25.853 norms.

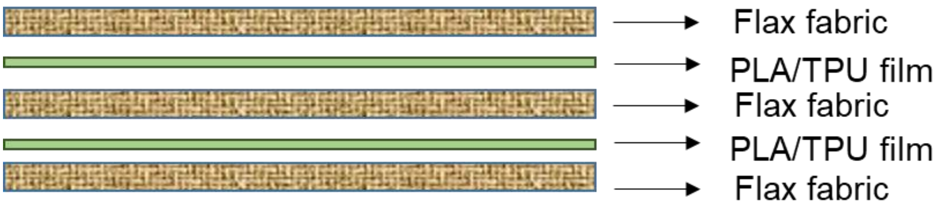

Figure 1a. Organosheet construction for the DVS measurement

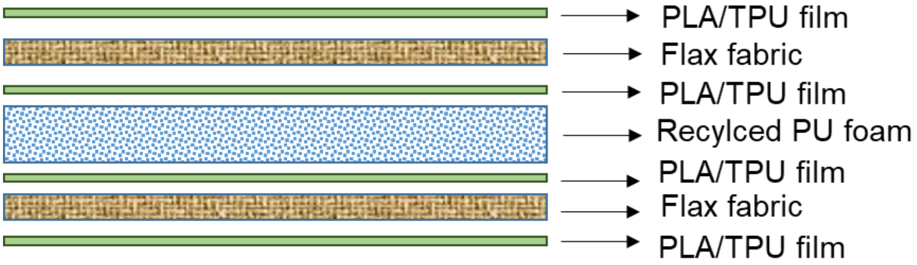

Figure 1b. Laminates with recycled PU foam core for flame retardancy test

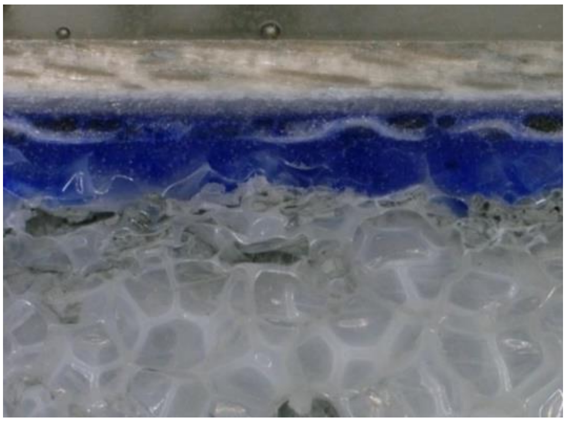

Figure 1c. Microscopic image of the cross-section showing different layers

3 RESULTS AND DISCUSSION

3.1 MOISTURE ABSORPTION

The relative humidity was increased from 0% to 95% in 20% steps and back to 0%. The organosheets containing flax fabrics loaded with flame retardant (1 and 3) showed higher moisture absorption and even up to 15% was observed (Fig.2).

However, the organosheets without the flame retardant showed low moisture absorption behavior. With the help of DVS measurement, it was found that hydrophilicity of the flame retardant caused an increase in equilibrium moisture. The reason is that flame retardant contains phosphate salts, which are highly hygroscopic, and it absorbs moisture under humid conditions and drastically affect the mechanical properties. To verify the above phenomenon individual components in the organosheets were analyzed separately and it confirms that flax fabrics with flame retardant achieved high equilibrium moisture than other individual components.

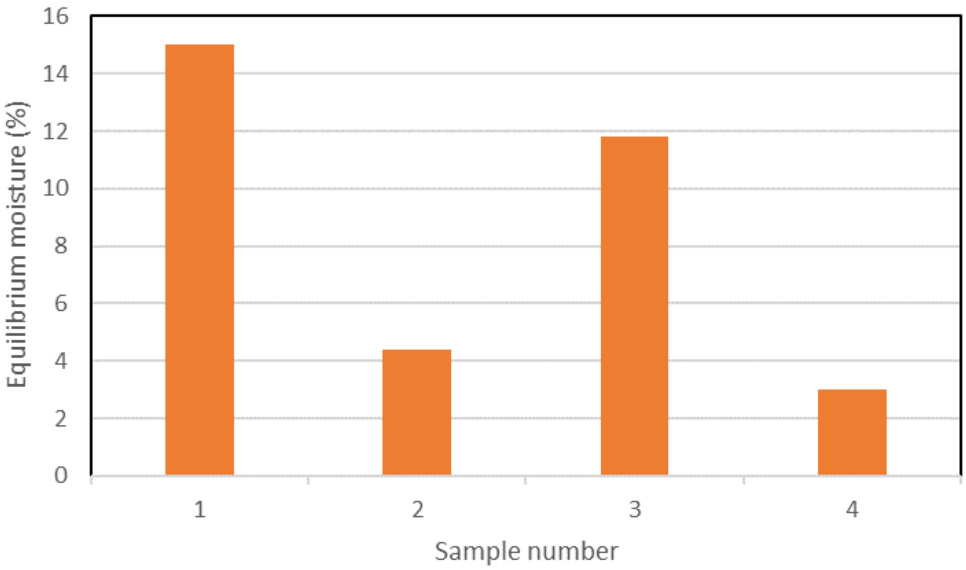

Figure 2. Change in moisture absorption measured using DVS instrument for different organosheet samples

3.1 FLAME RETARDANCY OF NATURAL FIBER REINFORCED ORGANOSHEETS

The resistance to flame for the sandwich organosheets was distinguished from the ignition time, flame time, drip time and burn length measured using vertical Bunsen burner test. The samples A, B are 8mm thick-sandwiched organosheets having flax fabrics with and without flame retardant.

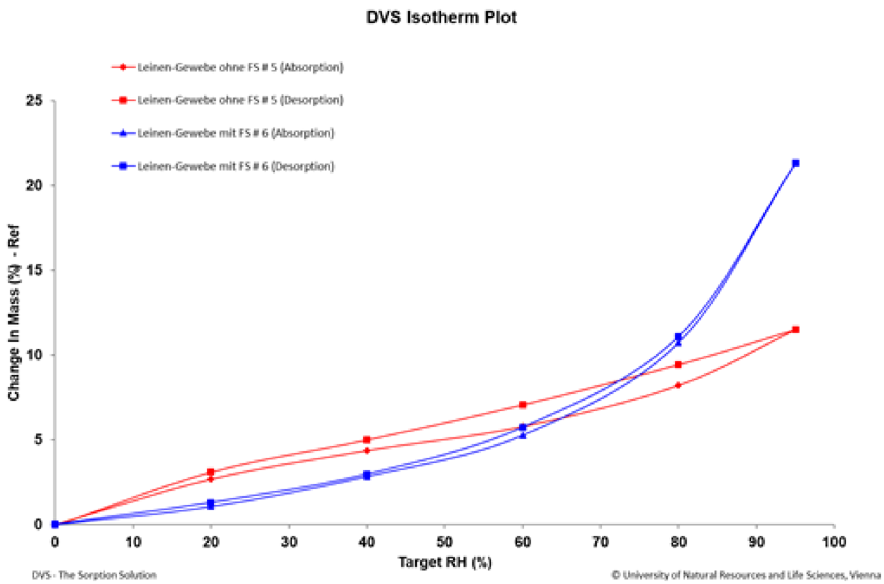

Figure 3. Absorption isotherms of flax fabric without (red) and with loaded flame retardant (blue)

The ignition time of 12 seconds (blue in Table 1) has showed convincing results and passed the test (as per FAR norm). Similarly, samples C, D are 23mm thick organosheets with and without flame retardant and it also passed the 12s ignition time test. The 60 s ignition time test results (orange) for the samples B and D exhibited long flame time 35 and 19s (see Table 1) and it is more than the accepted limit. The result of the investigation shows that if the part gets thicker one need to load all the components with at least 10% flame retardant aiming to improve the flame retardancy and to pass the norm test.

Table 1. Ignition time, flame time, burn length for the sandwiched organosheets measured using vertical Bunsen burner test

Sample name	Flame time(s)	Ignition	Burn length (mm)
Sample A	0	12	10
Sample B	0	12	10
Sample C	5	12	10
Sample D	5	12	10
Sample A	0	60	60
Sample B	35	60	30
Sample C	12	60	130
Sample D	19	60	140

4. CONCLUSION AND OUTLOOK

The organosheets from natural fiber reinforced composites are uncommon but in this investigation we invented a novel technique to produce highly renewable carbon based organosheets for interior applications. The flame retardants are necessary for the organosheets but it may cause moisture absorption as observed from the DVS measurement. To meet the demand for the resistance against flame one need to load the each component in the organosheets with at least 10% flame retardant. The future work is to check different flame retardant for the organosheets and to evaluate the moisture absorption behavior and resistance against flame.

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