The application of plasma treated polyethylene and glass fibers in composites and sandwiches prepare via rotational molding.

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Introduction

Preparation of multilayer skin-foam and skin-foam-skin sandwich, as well as composites products via rotational molding have dragged the attention of researchers to improve the mechanical and thermal properties of the final rotomolded products.

In rotational molding there is no pressure to ensure the mechanical adhesion, therefore chemical or physical treatment of the matrix and/or the filler is required. Plasma treatment has been established as a fast, clean, and effective method for the surface treatment of polymers and different types of fillers for adhesion improvement. The present work investigates the potential application of plasma-treated polyethylene and plasma-treated glass fibers to produce PE-PU sandwiches and glass fiber composites via the rotational molding technique.

Thesis goals

- To determine the effect of using plasma treated polyethylene on the adhesion between the Polyethylene and polyurethane foam in sandwiches structures.
- To determine the effect of using plasma treated polyethylene and plasma treated glass fibers on the properties of composites prepared via rotational molding.
- To demonstrate the possibility of the application of the developed materials in the selected industrial applications.

Experiments

Different samples were prepared and tested to achieve the objectives:

- PE/PU Sandwiches with PE plates containing different percentages of untreated, and plasma treated polyethylene without fibers.
- Composites from untreated and plasma treated polyphenylene with untreated and plasma treated glass fibers.
- Lids of insulated containers (Figure 1) were produced from plasma treated polyethylene and from plasma treated composites with different wall thickness, filled with polyurethane and compared to the original lids produced from pure untreated polyethylene in Olivo cold logistic company.

Figure 1: Lid Prepared in Olivo company

Results

De-bonding force (Figure 2) and PU residue on PE plates (Figure 3) increased significantly as a results of including different percentage of plasma treated polyethylene in PE plates, which indicated a great improvement in the adhesion between PE and PU as a result of the plasma treatment of polyethylene powder.

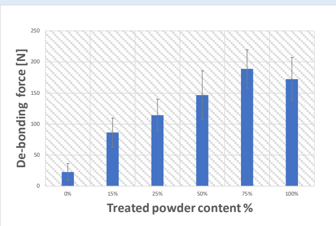

Figure 2: Effect of plasma treatment on de-bonding force .

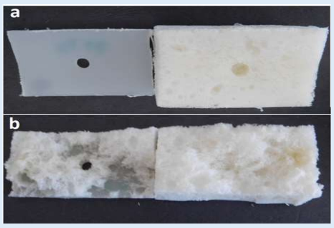

Figure 3 Effect of plasma treatment on PE residue a)UT.PE, b)PT.PE.

Tensile strength (Figure 5), tensile modulus (Figure 6) and flexural modulus (Figure 7) of the composites prepared using a mixture of 10 min treated powder and 40 min treated glass fibers increased with increasing fiber contend comparing with pure polyethylene. Treatment of the powder and the fibers significantly improved adhesion between the matrix and the fibers in the composites (Figure 8).

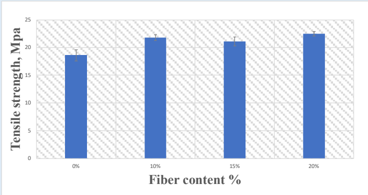

Figure 4: The effect of fiber content on the tensile strength of the treated composites.

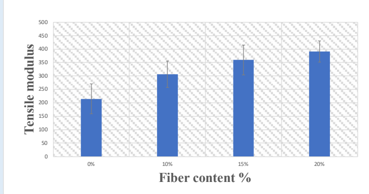

Figure 5: The effect of fiber content on the tensile modulus of the treated composites.

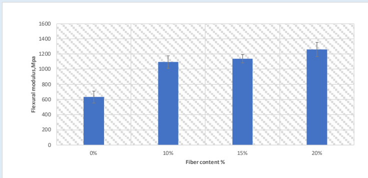

Figure 6: The effect of fiber content on the flexural modulus of the treated composites.

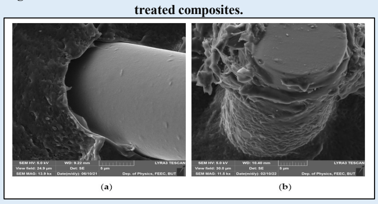

Figure 7: SEM images of adhesion between PE and glass fibers :a) untreated PE and untreated fiber, b) 10 min plasma treated PE and 40 min plasma treated glass fibers

Falling weight test was used to evaluate our industrial sandwiches samples. Samples with 4 mm and 3.5 mm wall thicknesses that containing 10 wt% of glass fibers showed identical deformation behavior to the behavior of unfilled samples with 5mm wall thickness, even at the highest impact energy no break or separation was noticed (Figure 8)

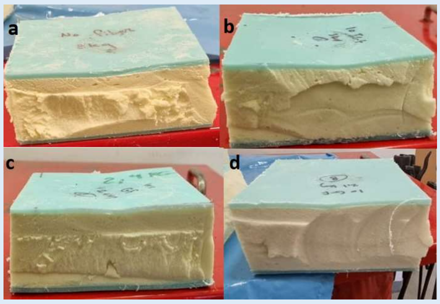

Figure 8: The deformation of the samples after falling weight: a) Samples prepared using treated powder, b) samples contain 10% of glass fibers with wall thickness 5 mm, c) Samples contain 10 of glass fibers with wall thickness 4 mm, d) Samples contain 10% of glass fibers with wall thickness 3,5 mm.

In figure 9 is presented Kayak prepared from plasma treated polyethylene with 10% of plasma treated powder. The kayak made from the composites was 17%. lighter than the original kayak made by Zelezny kayaks & canoes company.

Figure 9: Kayak made from treated composites

Conclusions

- Plasma treatment of polyethylene powder proved to be a successful method to improve the adhesion between the polyethylene and the polyurethane foam.
- Plasma treatment proved to be successful in improving the adhesion between the polyethylene and the glass fibers, and the mechanical properties of their composites.
- Plasma treated polyethylene and its glass fibers composites with different walls thickness proved to be successful replacement of untreated polyethylene in industrial insulation containers, without affecting their ability to absorb shocks.