

Thermogravimetric analysis of wood plastic compounds

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Introduction

At the request of society and consumers, there is a growing incentive to use sustainable alternatives in construction, including environmentally friendly materials.

Fiber-reinforced composites have less built-in energy than bricks, steel, aluminum or wood plywood, and that is smaller as more natural the polymer resin and fibers are, like biocomposites, made from renewable resources.

Among the various current applications of biocomposites, there has been significant growth in the field of construction, both in non-structural and semi-structural components, namely in energy- garden and pool furniture, flooring, walls, doors and windows, efficient roofs and passive construction, exterior wall coverings, insulation, special acoustic application, pavements, decorative elements, as well as in the construction of pedestrian bridges and roads, docks, sidewalks and paving slabs¹.

Natural fiber biocomposites, such as wood-plastic composites (WPC), are widely used in outdoor applications such as substitutes for solid wood and wood products.

Commercial WPCs are produced in solid or hollow profiles from PE, PP and PVC polymers. WPC will offer reduced embodied energy due to the inclusion of biobased polymers (PLA, lignin), recycled HDPE, recycle PVC and wood.

In the GELCLAD european project, the eco-external facade cladding layer for protective and aesthetic proposes is structured by an engineered wood polymer composite (ecoWPC) like skin layer which will be made of bio-resins/recycled compounds, such as lignin based ones developed by TECNARO (Arboform), mixed with wood and cheap lightweight natural fillers².

In this work, wood plastic compounds of different composition were investigated by thermogravimetric analysis (TGA). This measurement provides information relevant about thermal stability in WPC's

and allows evaluating the role of different additives present on the formulation.

Methods

The WPC test pieces of known composition (**Table 1**), produced by NAVODNIK in the scope of the project GELCLAD, were measured using TGA either in nitrogen or in oxygen atmosphere.

TGA measurements were performed using a Setaram TGA 92 and alumina (1300 μ l) crucibles. The measurements were done under nitrogen and/or oxygen atmosphere, using a gas flow of 50 ml/min for both carrier gases. The heating rate was 10°C/min in a range of temperatures from 25°C to 850°C.

Table 1 Composition of WPC test samples used in this work

Sample	Polymer	Wood fibre (wt. %)	CaCO ₃ (wt%)	ATH (wt%)
WPC 1	PVC	30	20	-
WPC 2	PVC	30	-	-
WPC 3	PVC	50	-	20
WPC 4	PVC	50	-	-
WPC 5	PVC	70	-	-
WPC 6	PVC/PLA (100:20)	40	-	20
WPC 7	PLA	30	-	-
WPC 8	PLA	50	-	-

Results and discussion

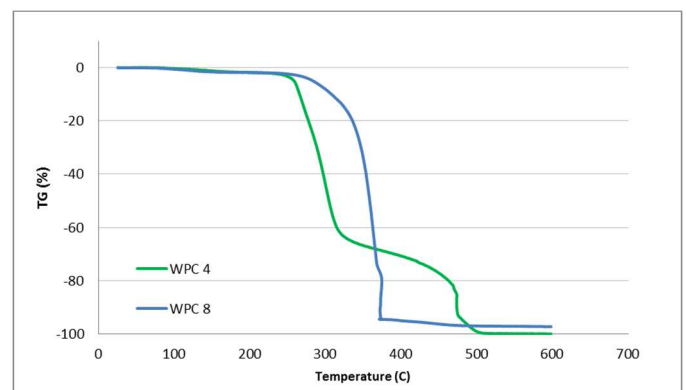


Figure 1: Thermograms of WPC's based on PVC and PLA with 50% wood fibres in oxidative environment (O₂)

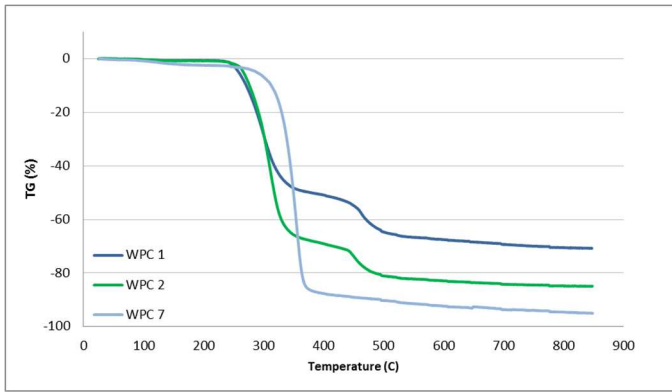


Figure 2: Thermograms of WPC's based on PVC and PLA with 30% wood fibres in inert environment (N₂)

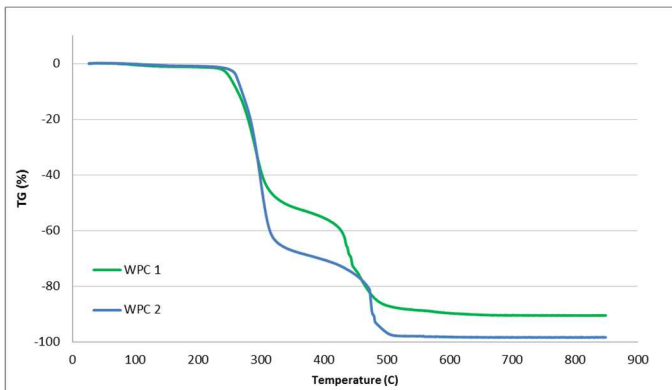


Figure 3: Thermograms of WPC's containing 30% wood and PVC polymer with and without CaCO₃ filler in O₂

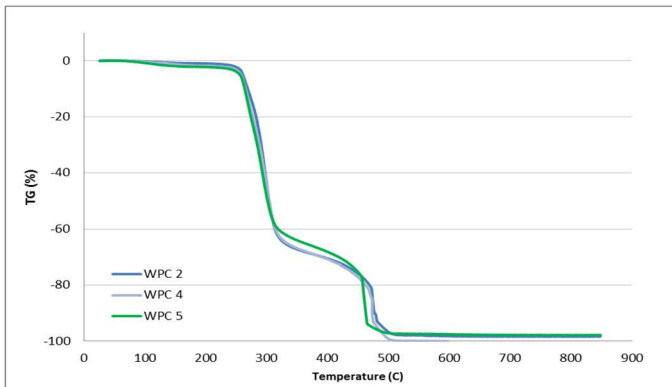


Figure 4: Thermograms of WPC's containing different ratios of PVC and wood fiber in O₂

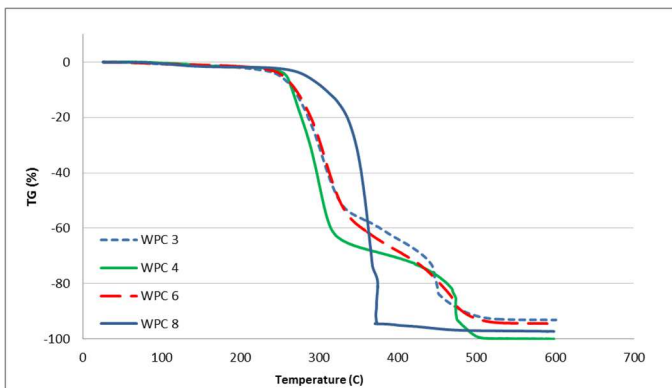


Figure 5: Thermograms of WPC's with ATH (dashed lines) and without ATH (continuous lines) in O₂

Conclusions

As expected, in =₂ carrier gas, the mass loss is higher in both polymers than in inert carrier gas N₂, due to thermo-oxidation of carbon (figures 1 and 2). PLA shows higher thermal resistance than PVC until near 375°C, in both environments, but shows a continuous degradation after 260°C, instead of PVC that shows a baseline near 350°C, retarding posterior weight loss.

PLA lost 90% of its mass until 375°C, although PVC lost equivalent weight only at 475°C, which emphasizes the role of chlorine atoms of PVC molecules at high temperature (figures 1 and 2).

Figure 3 shows that CaCO₃ filler increase the thermo-oxidative resistance of WPC. The maximum decomposition rate of the composite was decreased. The improvement of the thermal decomposition temperature of composite was due to the poor thermal conductivity of this compound. The increase of residual mass is obviously due to not burned inorganic Ca.

Figure 4 shows that the increase of wood content has not a significant effect in thermal stability of WPC. This conclusion is valid for both polymers (PVC and PLA).

Regarding FR effects of Alumina Trihydrate (ATH) in WPC (figure 5), it is shown that the fire retardancy effect of ATH is seen until very near in the beginning of thermal decomposition. This feature confirms the high retardancy efficiency of ATH (which is opposite to thermal stability), showing that ATH becomes chemically active and functional from the beginning of thermal decomposition of plastic matrix, shifting up the ignition point and releasing water.

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[2] Deliverable D2.3 - Gelclad natural materials and additives. February 2017