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Evaluation of Mussel Shells Powder as Filler Reinforcement for Biocomposites

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Introduction

The use of bio-polyester thermoplastics combined with natural fillers, either organic or inorganic, for the production of bio-composites is nowadays already a reality in many sectors, ranging from agriculture and packaging to manufacturing construction components and other high value applications, in agreement with the circular economy approach.
In this scenario the reuse of wastes from the food industry, due to low cost and large availability, represent a viable route to obtain the circularity of resources and valorization of biomass without food availability competition.

Experimental

A thermoplastic blend of PLA toughened with PBAT (Ecoflex® C1200 from BASF, PLA/PBAT ratio 3:1 w/w) and nucleated with 2% w/w of talc was added by hot melt extrusion with increasing amounts (from 5% to 20 % w/w) of mussel shell powder, according to the following table:

Table 1. Composition of the prepared samples

Sample Name	PLA (wt%)	PBAT (wt%)	Talc (wt%)	Shells (wt%)
base	73.5	24.5	2	0
base + 5	69.5	23.5	2	5
base + 10	65.7	22.3	2	10
base + 15	62.0	21.0	2	15
base + 20	58.3	19.7	2	20

From these compositions both Charpy and "dogbone" shaped specimens were obtained by injection moulding to be sued for tensile and impact behaviour characterization.

Results and Discussion

Thermal Gravimetric Analysis (TGA) showed no volatile degradation of the mussel shell powder under 200 °C, with a minimal mass loss between 200 and 400 °C (5% ca.). Scanning Electron Micrography, micrographs showed irregularly shaped multi-faced particles with a mean aspect ratio of 3 ca (Figure 1, Figure2).

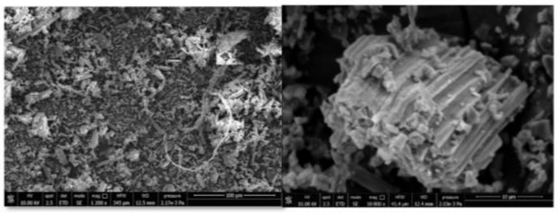

Figure 1. Micrographs at 1200× and 10,000× of shell powder.

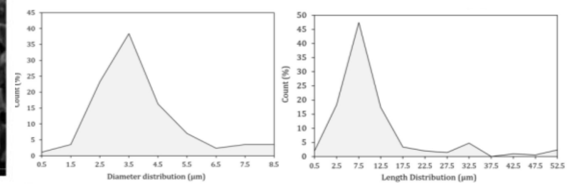

Figure 2. Dimensional analysis of shell powder.

Thermal analysis, with differential scanning calorimetry, revealed that the matrix and all the bio-composites were substantially amorphous after molding at 60 ◦C.
Mechanical properties determined on the corresponding specimens are summarized in table 2.

Table 2. Mechanical properties of tested biocomposites

Name	Elastic Modulus (GPa)	Maximum Strength (MPa)	Elongation at Break (%)	Charpy Impact Strength (kJ/m^2)
base	2.26 ± 0.060	42.0 ± 0.21	312 ± 41.8	8.3 ± 0.62
base + 5	2.28 ± 0.023	40.2 ± 0.98	170 ± 36.8	4.3 ± 0.52
base + 10	2.35 ± 0.047	38.5 ± 0.50	119 ± 24.8	4.8 ± 0.57
base + 15	2.46 ± 0.119	37.2 ± 0.67	49 ± 19.9	5.0 ± 0.44
base + 20	2.62 ± 0.105	35.5 ± 1.65	7 ± 4.1	3.8 ± 1.32

Conclusions

The reuse of a powdered mussel shell waste as reinforcing filler in a typical bio-polyester matrix allowed obtaining a bio-added composite with satisfactory mechanical properties, increasing elastic modulus, without affecting heavily its mechanical and the Charpy impact strength, also with a supposed weak adhesion between the thermoplastic matrix and the powders particles (as typically happen even for natural calcite powder), and despite the different shape, morphology and allotropic composition of the bio-based Calcium Carbonate powder. A viable industrial scale-up of the mussel shell waste powder preparation, for its reuse as biofiller appears possible.

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Biography

Marco Sandroni is ad interim technician at the Department of Civil & industrial Engineering, University of Pisa. Before this role, with a master's degree in Industrial Chemistry, he gained almost 15 years of direct experience in the processing and development of reliable thermoplastic compounds in different big and medium-small companies, in the field of biodegradable/water-soluble polymers, and in the start-up, setup, arrangement and management of extrusion / compounding, dosing, mixing and plasticization/additivation operations applied to almost the wide spectra of thermoplastic materials, both for laboratory research as well for pilot or actual industrial thermoplastics processing plants.