Durable bio-based polymer composites reinforced with natural waste fillers with antibacterial properties

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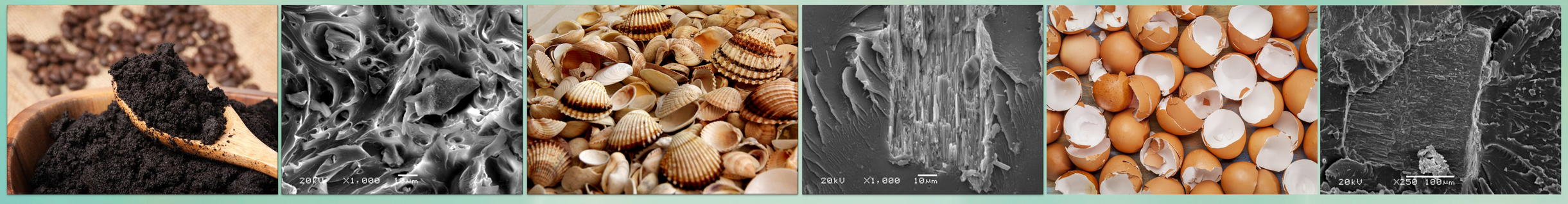
Alarming information on environmental pollution prompted the scientific community and industry to search for sustainable solutions aimed at reducing the negative impact of manufactured products on the environment. Therefore, the project aimed to create a functional, ecological polymer composite based on bio-based PET reinforced with natural waste particles (coffee grounds, eggs and mollusks shells) with antibacterial properties.

The main goal of the project was to develop a functional hybrid ecological thermoplastic composite with antibacterial properties. The base material was a bio-based matrix – polyethylene terephthalate (bioPET), while waste particles were used as the reinforcing phase: coffee grounds, chicken eggshells, and mollusk shells. Moreover, the composites were modified with antibacterial particles – traditional metals and their oxides: silver, copper oxide and titanium oxide.

Natural particles interact weakly with the hydrophobic polymer matrix; therefore, chemical and thermal treatment was necessary for the production of composites. In the case of composites where most components are natural substances, it is reasonable to use natural modifications that do not disrupt the biological composition of the composite.

Waste fillers derived from food waste (coffee grounds, eggshells, and mollusk shells) were obtained from several restaurants. They were subjected to mechanical processing—grinding in mills with two sieve sizes (50–500 μm) to evaluate the effect of particle size on the mechanical properties of the composites. Then, they underwent various chemical treatments. The modification of coffee grounds was carried out using an aqueous solution of sodium hydroxide and acetone. The concentration of the sodium hydroxide solution was 10%, 15%, and 20%.



On September 28-29, 2022, the Kick Meet 2022 EcoMat meeting was organized in Kraków in collaboration with partners from Ranplast and the University of Riga. The meeting was attended by four representatives from Cracow University of Technology, four from the University of Riga, two from Ranplast, as well as invited guests from CUT and the universities of La Sapienza and Quebec (Prof. Denis Rodrigue, Department of Chemical Engineering, Université Laval). The meeting was a place to present cooperation plans and substantive discussion.

To achieve this goal, secondary objectives were defined, which aimed at creating a universal method of modification of waste particles.
All produced composites were subjected to mechanical testing – tensile, bending, and impact tests, as well as low- and high-cycle fatigue tests. SEM images were also taken to assess the surface structure and the adhesion between the fillers and the polymer matrix. The organic particles were analyzed for size, and their structure was examined using an optical microscope. Some of the composites were also tested for wettability, and the total free surface energy was determined.
As a result of the project, universal chemical modifications of fillers were proposed in order to increase the adhesion of the fiber/matrix, which positively affected the strength properties. Moreover, a universal mathematical model was developed, the task of which was to predict the properties of polymeric materials and the life expectancy of the manufactured materials. The produced materials could be successfully used in many industrial sectors, both for products with a short and long life cycle. The project proposed a universal stand for small electronic equipment. The product was characterized by high mechanical properties as well as antibacterial properties that were so important at the time.

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