Impact of recycling on the mechanical properties, surface roughness and antibacterial efficiency of copper-loaded PLA for 3D Printing Applications

Clémentine Helfenstein-Didier*[1], Virginie Dumas[1], Youssef Jouili[1], Pierre-Philippe Elst[2], and Maria Doubenskaia[1]

[1]Ecole Centrale de Lyon, CNRS, ENTPE, LTDS, UMR5513, ENISE – Ecole Centrale de Lyon, CNRS, ENTPE, LTDS, UMR5513, ENISE – France

[2]Ecole Centrale de Lyon, ENISE – Ecole Centrale de Lyon, France – France

Abstract

In recent years, the rapidly growing field of 3D printing has revolutionized the traditional manufacturing industry. The appeal of this technology lies in its ability to intricately design and optimize complex geometric models, as well as in its remarkable design flexibility, recyclability, and minimal material waste. One current challenge for 3D printing technology is the development of antimicrobial surfaces that can come into contact with food and humans to control bacterial colonization and prevent disease spread.
To achieve antimicrobial 3D-printed surfaces, the use of Poly-Lactic Acid (PLA). polymers loaded with copper (Cu) nanoparticles has increased over recent years in 3D printing applications. These advancements introduce new properties to the composites, opening up possibilities for future applications in developing medical devices, food processing equipment, and other surfaces requiring antimicrobial characteristics.

However, both standard PLA and copper nanoparticle-loaded PLA (PLA-Cu) undergo changes in their properties during recycling. While previous studies have shown the potential to recycle failed 3D-printed objects into reusable PLA filaments, there is limited research on the recycling of PLA-Cu.

In this context, our preliminary study explores the impact of recycling on the mechanical, topographical, and antibacterial properties of PLA and PLA-Cu used in 3D printing.

Mechanical tests show that PLA-Cu, before recycling, has better mechanical resistance than standard PLA, owing to a higher elasticity modulus. However, after recycling, the ductility of recycled PLA-Cu (rPLA-Cu) significantly decreases, in contrast to recycled PLA (rPLA), which remains relatively stable. Surface roughness of printed parts also increases significantly after recycling, particularly for rPLA-Cu, which also exhibits porosity due to a decrease in print quality.
Recycling also reduces the antibacterial efficacy (against *E. coli*) of PLA-Cu, possibly by altering the size and distribution of copper particles, which are crucial factors for antibacterial activity. In conclusion, the study shows that recycling PLA-Cu leads to significant performance losses, suggesting the need for additional nanoparticles or adjustments to extrusion parameters to limit these degradations and enhance the durability of the recycled material.

*Speaker