4D PRINTED BIOBASED POLYSTER/CELLULOSE COMPOSITE MATERIAL

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Introduction

3D printing or additive manufacturing using smart materials has led to the emergence of the 4D printing, gaining a large amount of interest in the scientific community. 4D printing targets the creation of dynamic parts with new functionalities within an object, such as the ability to change shape over time. This change is obtained by using smart or stimuli responsive polymers that react to external factors such temperature, humidity or light for example.
In this study, a bio-based composite material with heat-triggered shape memory ability was successfully developed for 3D printing. A polyester matrix based on citric acid, sebacic acid and glycerol, reinforced with cellulose nanocrystals and cellulose micro-powder, was thermally cured.

Results

The purpose of the study was to quantify the effect of curing duration on the material's shape memory behaviour so two thermo-mechanical approaches were used: (1) displacement in 3-point bending and (2) angular recovery from a beam bent at 90° in a single cantilever setup. It was found that the glass transition temperature was highly dependent on the curing duration, with an increase from -26°C after 6 hours to 13°C after 72 hours of curing. Slower recovery rates and low levels of shape recovery were observed when the sample were cured less than 24h (22-70%). However, as the curing time was extended to 48 and 72 hours, faster recovery rates and higher recovery percentage were reached (90-100%). Results demonstrated that once a sufficient curing threshold was achieved, additional curing time could be used to tune the material glass-transition temperature and create heat-triggered 3D printed products.

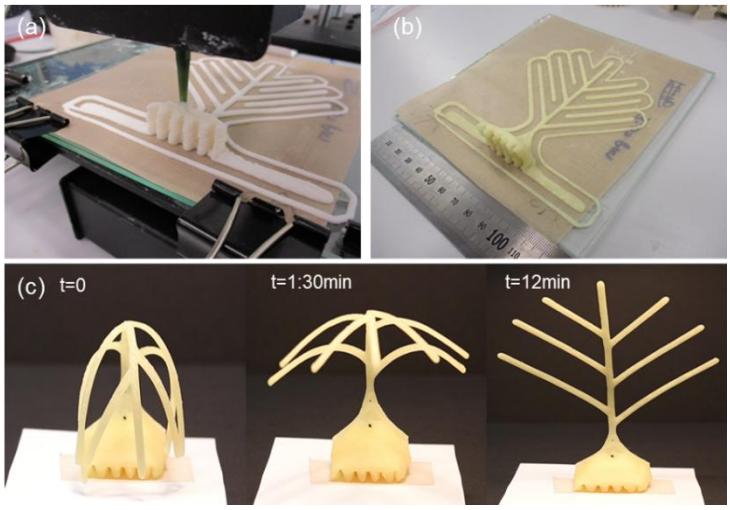

Figure 1 (a) Paste printing of basic tree-like design, (b) after 48 hours curing at 104°C, (c) Heat driven shape recovery effect on the tree-like design [1]

Reference

1. Barbier M, Le Guen MJ, McDonald-Wharry J, et al.: Quantifying the Shape Memory Performance of a Three-Dimensional-Printed Biobased Polyester/Cellulose Composite Material. 3D Print Addit Manuf. 2021.