AIT Research

Development of smart 4-D materials utilising novel self assembly polymers

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Introduction

4D printing is a technique that uses a 3D printer to create objects that change their shape overtime. 4D printing involves the use of smart materials that will transform when exposed to an external stimuli. These can include water, heat, light or electric current. 4D printing technology is still in the early phase of research and development. 4D printing is currently being developed by industry leader and research facilities such that of MIT's Self Assembly Lab, Stratasys and Autodesk. Overall, 4D printing is making the object 'programmable' while executing their 'genetic code' whenever you want to have it triggered.

Figure 1: In simple words we can say that in 4D printing a virtual fourth dimension is added which is 'time' (Futurehugs, 2019).

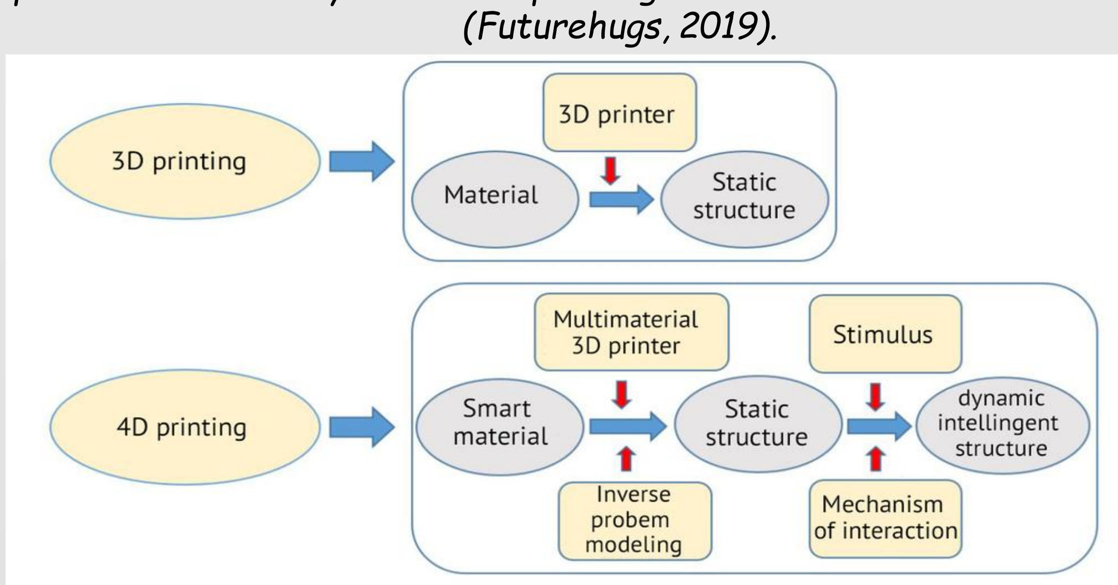

Figure 2: Difference between 3D printing and 4D printing (Papageorgiou, 2017).

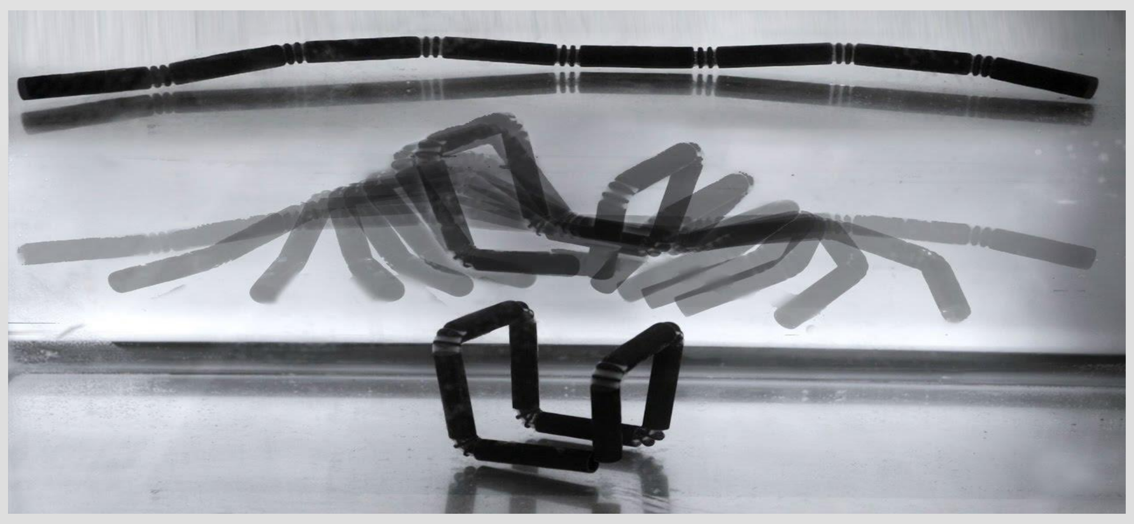

Figure 3: A 4D printed object that has the ability to adjust to its new surroundings (Zinti Nkomo, 2018).

Aim of project

To develop novel 3D printable resin with the aim of speeding up the transition of the 3D printed object at room temperature using smart materials. To date, research enables the 4D printed object to self-assembly at physiological temperature.

Methodology

WORKPLAN 1 :

Formulation development; The selection of photoinitiators, monomers and crosslinkers for the development of a novel 3D printable formulation. Conducting 3D printing trials on different formulations researched with the aim of uncovering our own novel resin.

Self-assembly of 3D printed object at room temperature; To reduce the lower critical solution temperature (LCST) by the incorporation of hydrophobic & hydrophilic monomers.

WORKPLAN 2:

Advanced resin preparation; To vary the concentration of the crosslinker component (DEGDA) in the resin to examine whether the crosslinker concentration effects the mechanical properties of the 3D printed object. Two different aspects will be examined, 3D printing Vs. UV curing of the novel formulation to investigate the characteristic difference between both.

Characterisation methods used throughout; UV-VIS, DSC, FTIR, DMA, Tensile testing, Cloud Point analysis & Swelling studies.

Results to date

To date, PNVCL was synthesised by photopolymerisation. A variety of hydrogels were made incorporating hydrophobic & hydrophilic monomers at concentrations ranging between 10wt% to 50wt%. Below in Figure 4 is an image of the different concentrations of hydrophobic hydrogels containing VAc. The incorporation of VAc into PNVCL found that the higher the concentration of VAc present, the lower the cloud point temperature. The LCST was lowered down to 21℃.

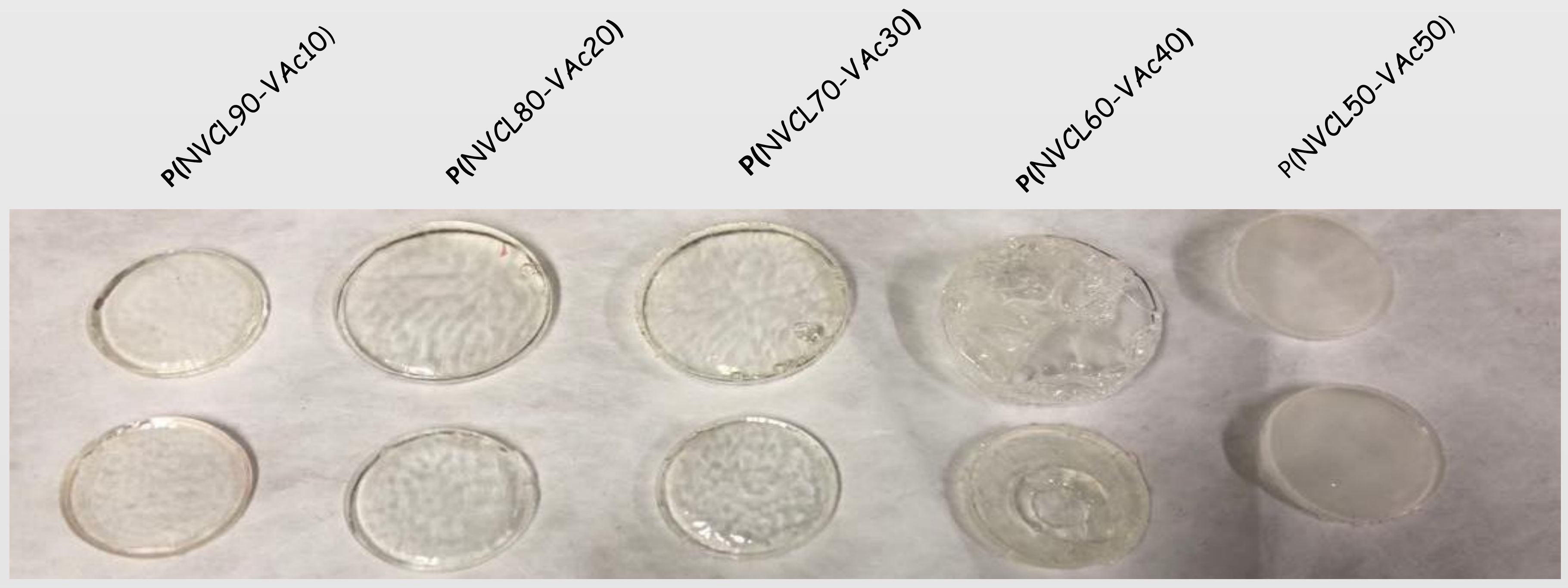

Figure 4: Hydrophobic hydrogels containing varying concentrations of Vinylchloride (VAc) between 10wt% to 50wt%.

Another part of the overall aim was to 3D print with novel formulation. This aim was successfully achieved by using a temperature-sensitive monomer NVCL, DEGDA as a crosslinker and BAPO as the photoinitiator. Figure 5 below demonstrates the difference between a 3D printed flower Vs. a UV cured flower using the same formulation. The UV cured flower was cured using a flower shaped silicone mould. Tensile bars using this formulation was also 3D printed using the Form 2 SLA 3D printer, Figure 6 below.

Figure 5; 3D printed flower Vs. A UV cured flower

Figure 6: 3D printed tensile bars using novel formulation

Future Work

WP1; Advanced resin preparation; to vary the concentration of the crosslinker (DEGDA) in the resin to examine whether the crosslinker concentration effects the mechanical properties of the 3D printed object.
WP2; 3D printing Vs. UV curing of the novel formulation to investigate the characteristic difference between 3D printing and UV curing.
WP3; 3D printing complex 3D designs that could demonstrate a potential for the application of this project.

References

Futurehugs. (2019). *4D PRINTING - self assembling objects - Futurehugs.* [online] Available at: http://futurehugs.com/4d-printing-selfassembling_objects/ [Accessed 17 Apr. 2019].
Papageorgiou, M. (2017). 4D Printing: A technology coming from the future. *Sculpteo.* [online] Available at: https://www.sculpteo.com/blog/2017/10/25/4d-printing-a-technology-coming-from-the-future/ [Accessed 18 Apr. 2019].
Zinti Nkomo, N. (2018). A Review of 4D Printing Technology and Future Trends. *Eleventh South African Conference on Computational and Applied Mechanics,* [online] p.5. Available at: https://www.researchgate.net/publication/328162917_A_Review_of_4D_Printing_Technology_and_Future_Trends [Accessed 12 Apr. 2019].

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