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Ph.D. thesis (2018-2021)  
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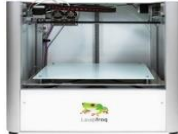
# Multi-material 3D printing of a structural bio-based and functional object from the lignocellulosic biomass

Impression 3D multi-matériaux d'un objet fonctionnel à base de la biomasse lignocellulosique

## Context

**Three-dimensional (3D) printing** is a revolutionary manufacturing technology:

- low material loss;
- complexity of the object ≠ its cost.
- easy cost-effective product customization;
- one machine → infinity of objects.



**Cellulose**, the most abundant bio-based material, is used for 3D printing. However many challenges remain:



Many researches has been conducted to **3D print composites** yet:

- the thermoplastic used have poor thermal and mechanical performances;
- photo-cured resins are costly.
- the material is petro-sourced.



**Bio-based thermosetting** resin with cellulose → Bio-based and cost-effective material with good performances.



1 Håkansson et al., « Solidification of 3D Printed Nanofibril Hydrogels into Functional 3D Cellulose Structures ».

Funded by



## Objectives

### Main target

**A 3D-printed bio-based and functional object.**

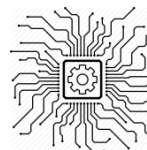
### Formulate and print a structural ink

- Formulate a printable bio-based ink;
- reach the Hot-melt extruded filaments printing conditions;
- minimize the shrinkage upon drying and curing;
- print a structural object with good mechanical and thermal performances;
- print a water and chemical resistant sustainable object.



### Give an added value to the printed object

- Formulate a printable functional ink;
- print the ink with a full compatibility with the structural ink;
- print the two inks simultaneously with a two head 3D-printer.



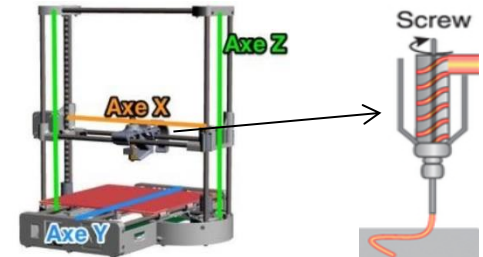
## Methods

### Ink formulation

Resin and cellulose with additives mixed in a planetary mixer.



### 3D-Printing by extrusion



### Material and ink characterization

