Camille THIBAUT

Ph.D. thesis (2016-2019)
LGP2 (D. Chaussy; A. Denneulin; D. Beneventi)
3SR (S. Rolland du Roscoat; L. Orgeas)

Development of innovative bio-based and functional materials for the production of 3D smart objects by 3D printing

Développement de matériaux bio-sourcés et fonctionnels pour l'impression 3D par extrusion

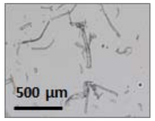
Context

+ Additive manufacturing (3D printing)

images : 3D hubs

- Complex and lightweight designs
- Short manufacturing lead time
- Free design modification
- Compatible with a broad range of materials (metal, plastics, ceramic, gel, food…)

+ Cellulose as a bio-based material



- Abundancy & availability
- Low cost
- Biodegradability
- Good mechanical properties
- Numerous derivatives with interesting properties (carboxymethyl cellulose, cellulose acetate, nanocellulose…)

= Additive manufacturing of cellulose

- Binder jetting with cellulose powder
- Sheet lamination with paper sheet
- Material extrusion with cellulose suspension or pastes

chronology

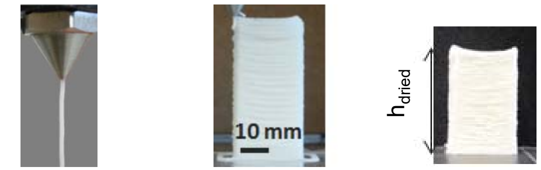
Funded by AGIR (Alpes Grenoble Innovation Recherche)

Methods

• Formulation

Inert + functional material

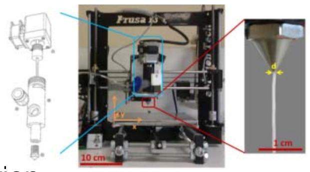
Extrusion | Printing | Drying



Homogeneous flow through small nozzle | Maintaining of filament and 3D solid shape after printing | Maintaining of the 3D solid shape after air drying

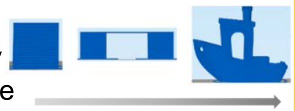
• 3D printer : process

Software settings (layer height, extrusion width, printing speed..)



Device customization (dispensing, nozzle design, tank…)

3D simple geometry to more complex one



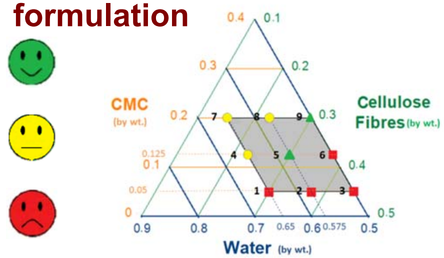
• Characterization

Dimensional reliability and structure
Mechanical properties of the printed parts
Durability (aging, recycling)

Publication :
Thibaut C. et Al, Carbohydrate polymers (2019),
DOI : 10.1016/j.carbpol.2019.01.076

Results

• Selection of a compatible formulation



Dry content: 35 to 50 wt%

• Characterization of this formulation

Rheology

Thinning behavior n = 0.2
Yield stress 6.0 ± 0.4 kPa

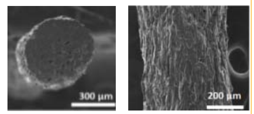
Strain after air-drying

Longitudinal 3.5 ± 0.5%
Transversal 32 ± 1%

Mechanical properties

Young's modulus 5.4 ± 0.5 GPa

Microstructure (SEM)

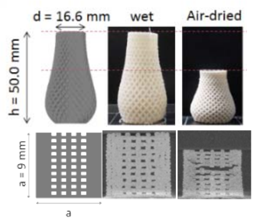


Cross-section | Surface

• 3D model printability

Accurate printing of models

Shrinkage upon Drying and dimension reliability



FunPrint