Whole spirulina cell-based biomaterials for extrusion 3D printing and more …

Martin Cerff[a], Pia Swatkowski[a], Marvin Braun[a], Vincent Berthé[b]

Introduction :

Fig. Closed loop habitats

Fig. Growing of spirulina

As **space exploration** advances, long-duration missions will rely on closed-loop systems. In this context, materials directly produced from **whole plants** present the advantage to avoid complex extraction processes [1].

Spirulina (a cyanobacterium) presents a valuable resource, serving as both a **food supplement** and a potential **source of oxygen**. Additionally, its ability to grow rapidly in controlled environments and **recycle human organic waste** positions spirulina as a cornerstone of sustainable space habitats, as a material **building block** [2, 3, 4] and even a composite matrix.

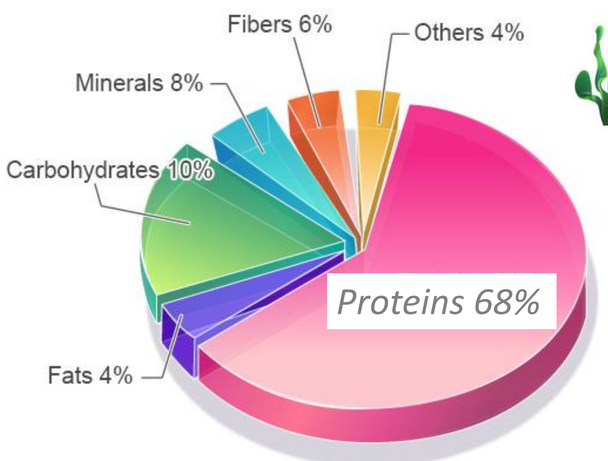


*Fig. Composition of **spirulina** ➔ thermo-mecano plastic **matrix***

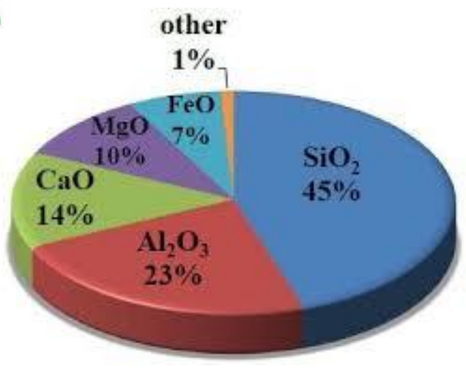
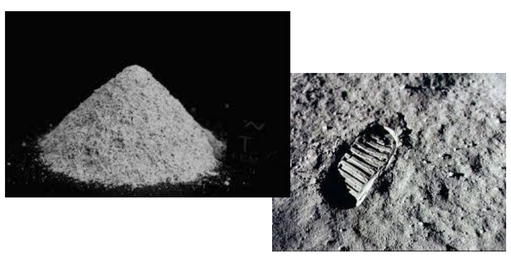


*Fig. Composition of **regolith** powder ➔ **filler***



(1) Ann. Rev. Mater. Res. 2023, 53, 81 - 104.
(2) J. Polym. Sc. 2021, 59, 2878 - 2894.
(3) J. Appl. Polym. Sci. 2013, 130, 3263 - 3275.
(4) Cells. Adv. Funct. Mat. 2023, 33, 2302067.

Objectives :

1) Compouding **full-spirulina with regolith**
2) **3D print** them by Fused Filament Fabrication (FFF)
3) Sinter the composite to produce **ceramic parts**

Compounding:

Raw materials :
Full spirulina / water 5 wt%
Plasticizer : glycerol

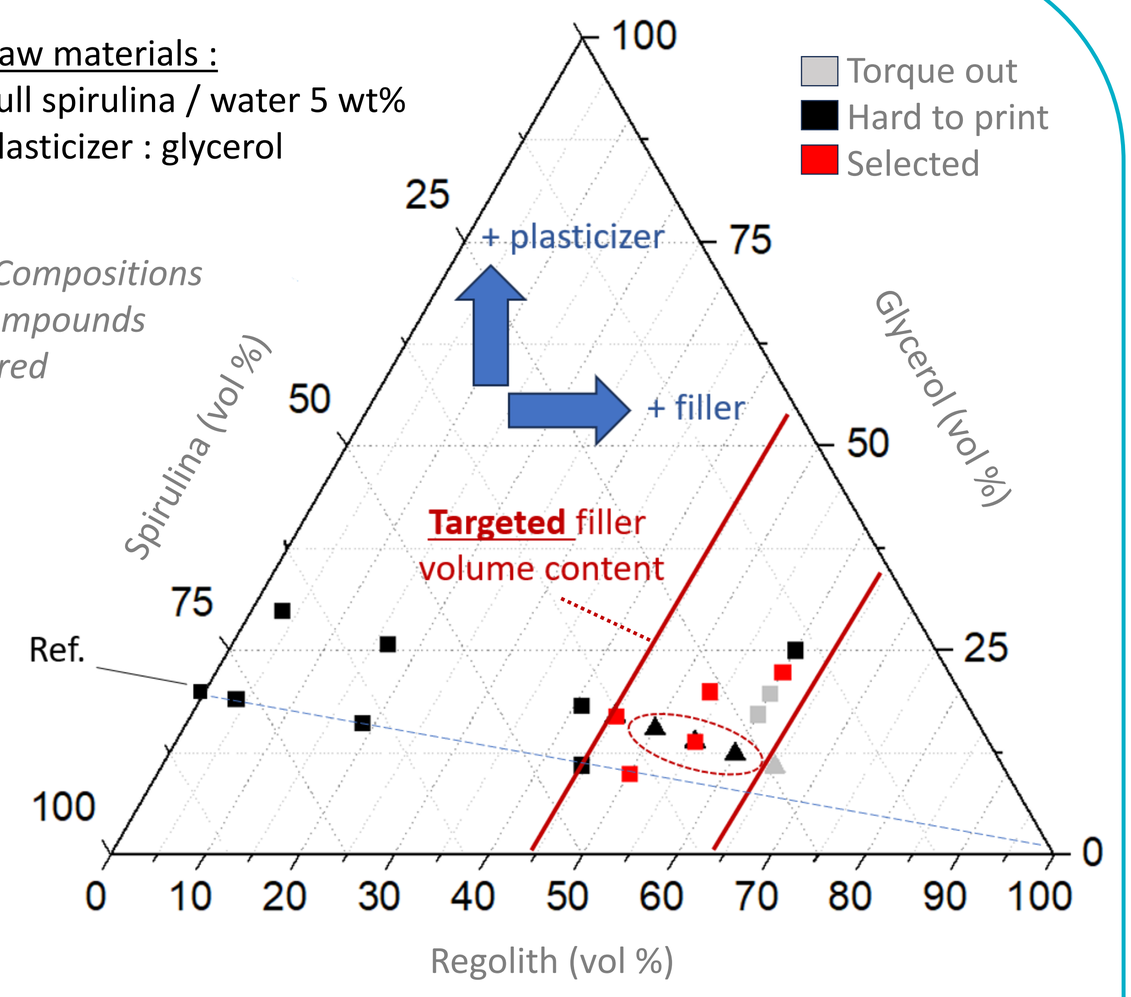


Fig. Compositions of compounds covered

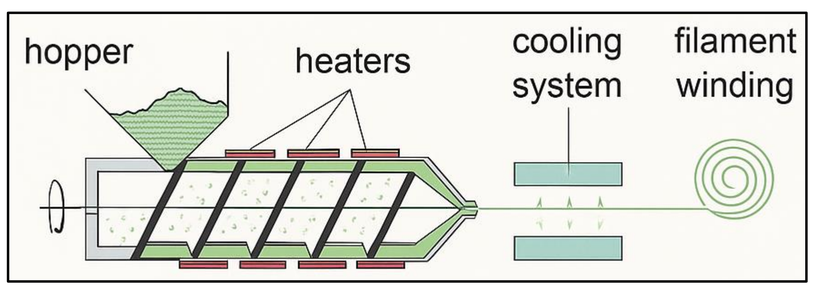


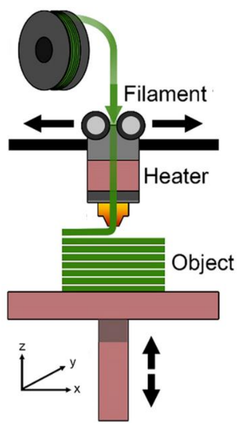
Fig. Extrusion and production of filament

Pre-plasticization :
Dry-blending + 12 h resting

Melt processing conditions :
T : 120 °C
Screw speed : 100 rpm
Residence time: 2 min
Atmosphere : N_2(g)

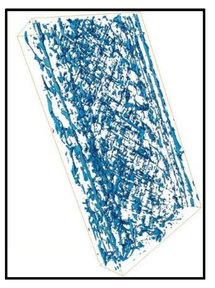
Fig. Filaments (optical microscope)

3D printing :



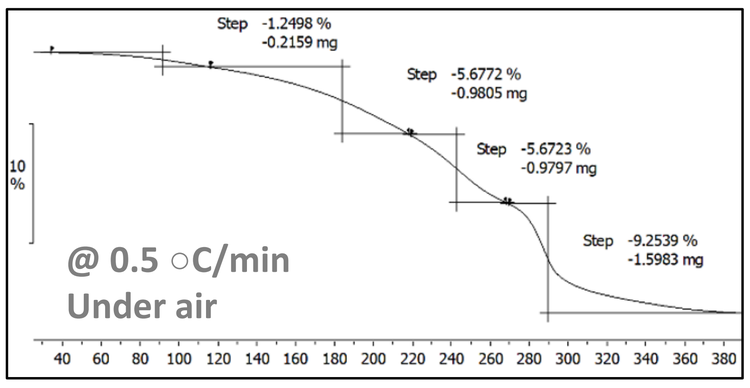
Printing conditions :
Control of the humidity of the compound

Fig. micro-computed tomography



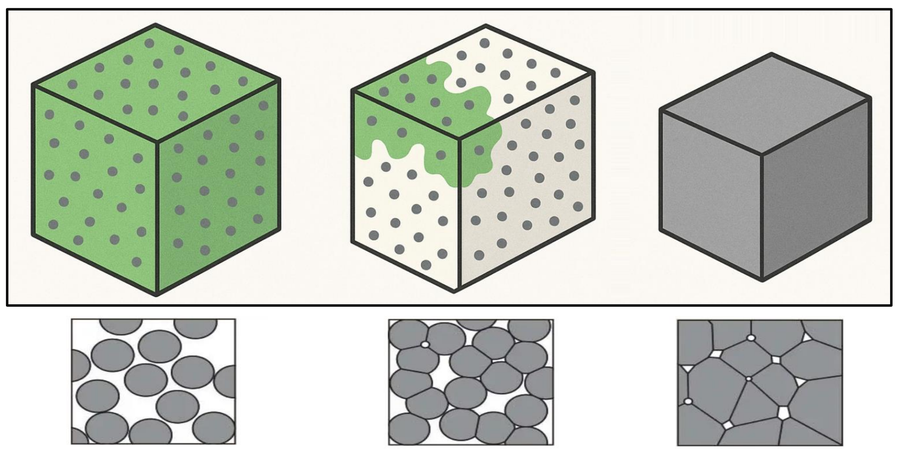
Ceramic part making :

Fig. Thermo-gravimetric analysis (TGA)



Sintering conditions :
Temperature steps, controlled atmosphere, pressure…

Fig. Shaping, Debinding, Sintering (SDS) process



Ceramic parts :

- Thermo-mecano plastic matrix
- Compounding and 3D printing
- SDS process

[a] Blue Horizon S.a.r.l. Betzdorf, Luxembourg

[b] Luxembourg Institute of Science and Technology (LIST), 5, Avenue des Hauts-Fourneaux, L-4362 Esch-sur-Alzette, Luxembourg

Contact :
Dr. Vincent Berthé
vincent.berthe@list.lu