

**Additive Manufacturing (AM) & Energetic Technical Textile (ETT)
with nitrocellulose formulations**

9th International Nitrocellulose Symposium 2023

Sébastien CUVELIER – Clara DEBIESSE

- **Little History & ways to new formulations / new applications**
- **Additive Manufacturing (AM) development**
- **Energetic Technical Textile (EET)**
- **Conclusion**



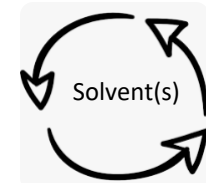
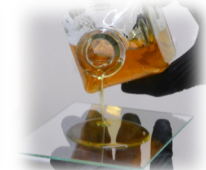
How could we make artificial silk fibre ?

How could we make homogeneous propellant ?

Common point



Nitrocellulose fibres



Nitrocellulose Jellies



Choice of NC type & others ingredients
Get the most of NC Morphology change and viscosity

1884

January	February	March	April
Mon 7 14 21 28	Mon 4 11 18 25	Mon 3 10 17 24 31	Mon 7 14 21 28
Tue 1 8 15 22 29	Tue 5 12 19 26	Tue 4 11 18 25	Tue 1 8 15 22 29
Wed 2 9 16 23 30	Wed 6 13 20 27	Wed 5 12 19 26	Wed 2 9 16 23 30
Thu 3 10 17 24 31	Thu 7 14 21 28	Thu 6 13 20 27	Thu 3 10 17 24 31
Fri 4 11 18 25	Fri 1 8 15 22 29	Fri 7 14 21 28	Fri 4 11 18 25
Sat 5 12 19 26	Sat 2 9 16 23 30	Sat 1 8 15 22 29	Sat 5 12 19 26
Sun 6 13 20 27	Sun 3 10 17 24 31	Sun 2 9 16 23 30	Sun 6 13 20 27
May	June	July	August
Mon 5 12 19 26	Mon 2 9 16 23 30	Mon 7 14 21 28	Mon 4 11 18 25
Tue 6 13 20 27	Tue 3 10 17 24 31	Tue 1 8 15 22 29	Tue 5 12 19 26
Wed 7 14 21 28	Wed 4 11 18 25	Wed 3 10 17 24 31	Wed 6 13 20 27
Thu 1 8 15 22 29	Thu 5 12 19 26	Thu 2 9 16 23 30	Thu 7 14 21 28
Fri 2 9 16 23 30	Fri 6 13 20 27	Fri 4 11 18 25	Fri 1 8 15 22 29
Sat 3 10 17 24 31	Sat 7 14 21 28	Sat 5 12 19 26	Sat 2 9 16 23 30
Sun 4 11 18 25	Sun 1 8 15 22 29	Sun 6 13 20 27	Sun 3 10 17 24 31
September	October	November	December
Mon 1 8 15 22 29	Mon 6 13 20 27	Mon 3 10 17 24	Mon 1 8 15 22 29
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Hilaire de Chardonnet
(1839-1924)



Paul Vieille
(1854-1934)

1884

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Industrial applications
"Mother-in-law" silk



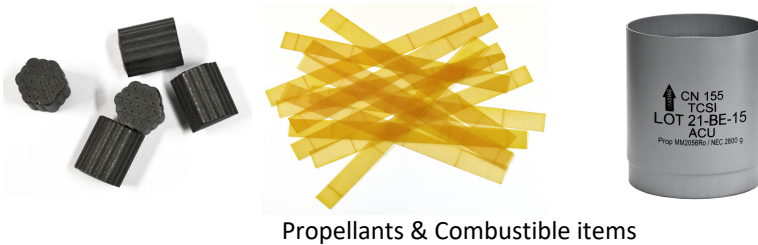
Military applications
"Single base" propellant (smokeless)



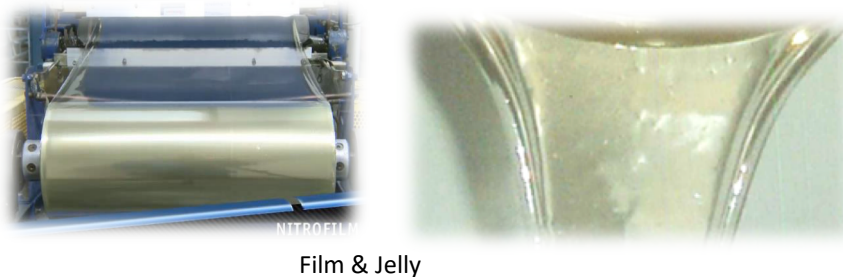
Our NITROCELLULOSE BASE Products



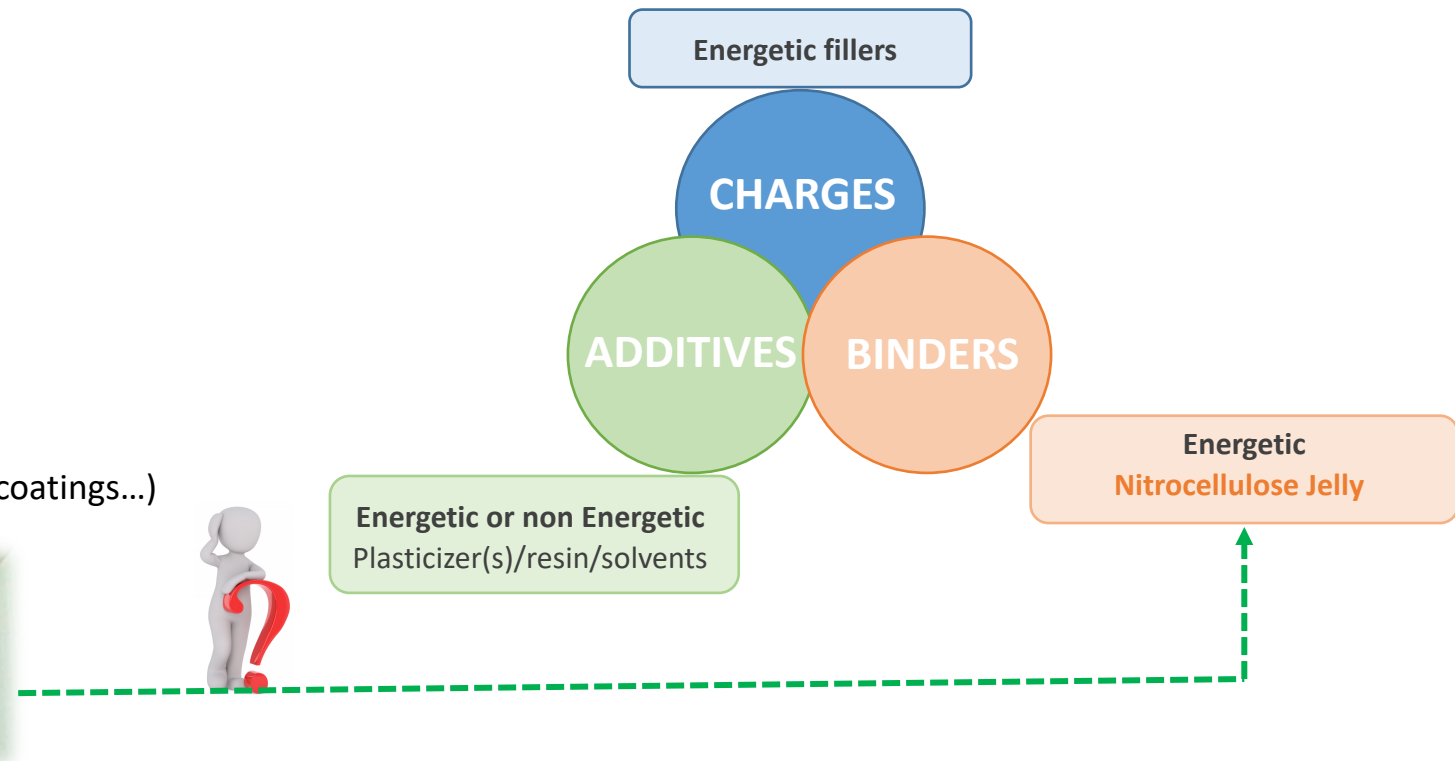
Our main NC applications for Eurenco products

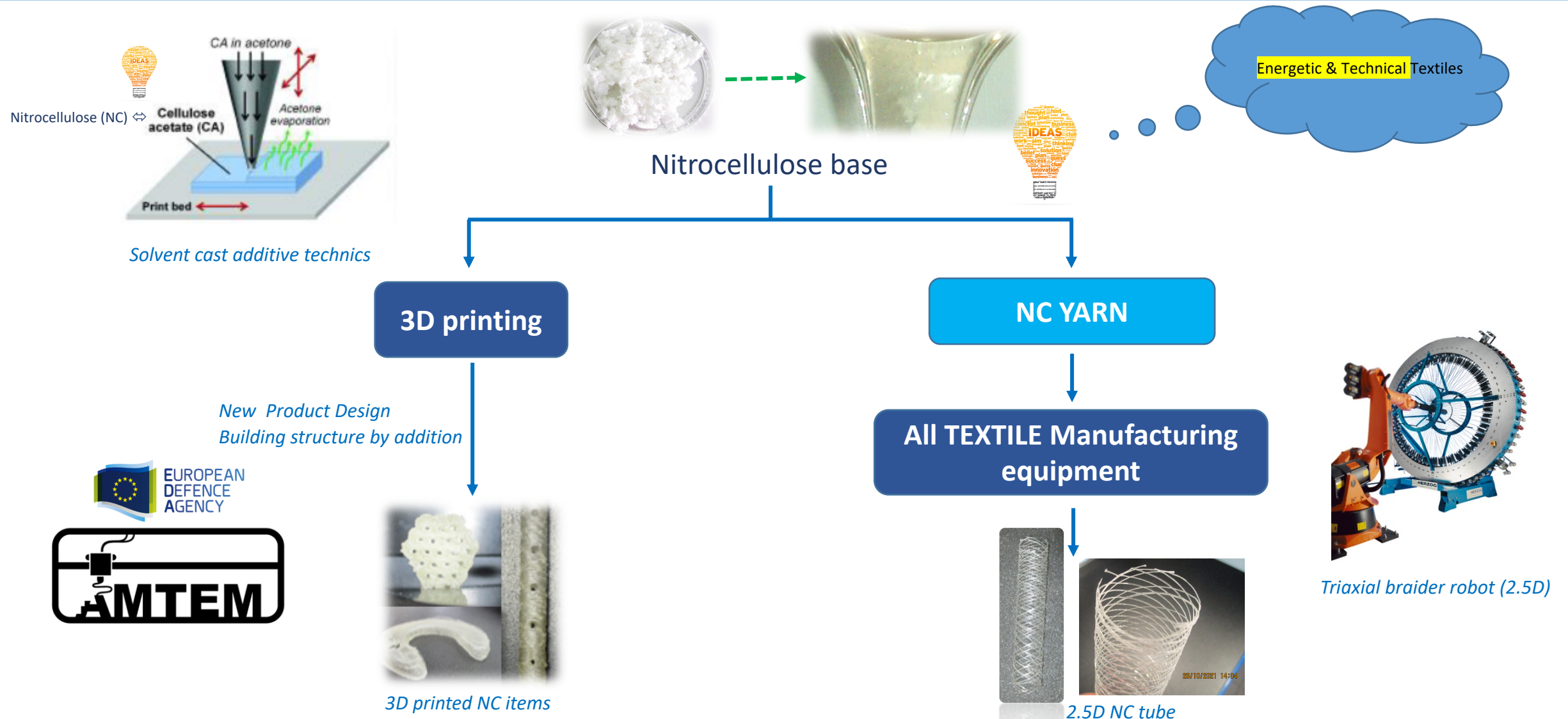


But also, NC applications for Eurenco products (film, glues, coatings...)

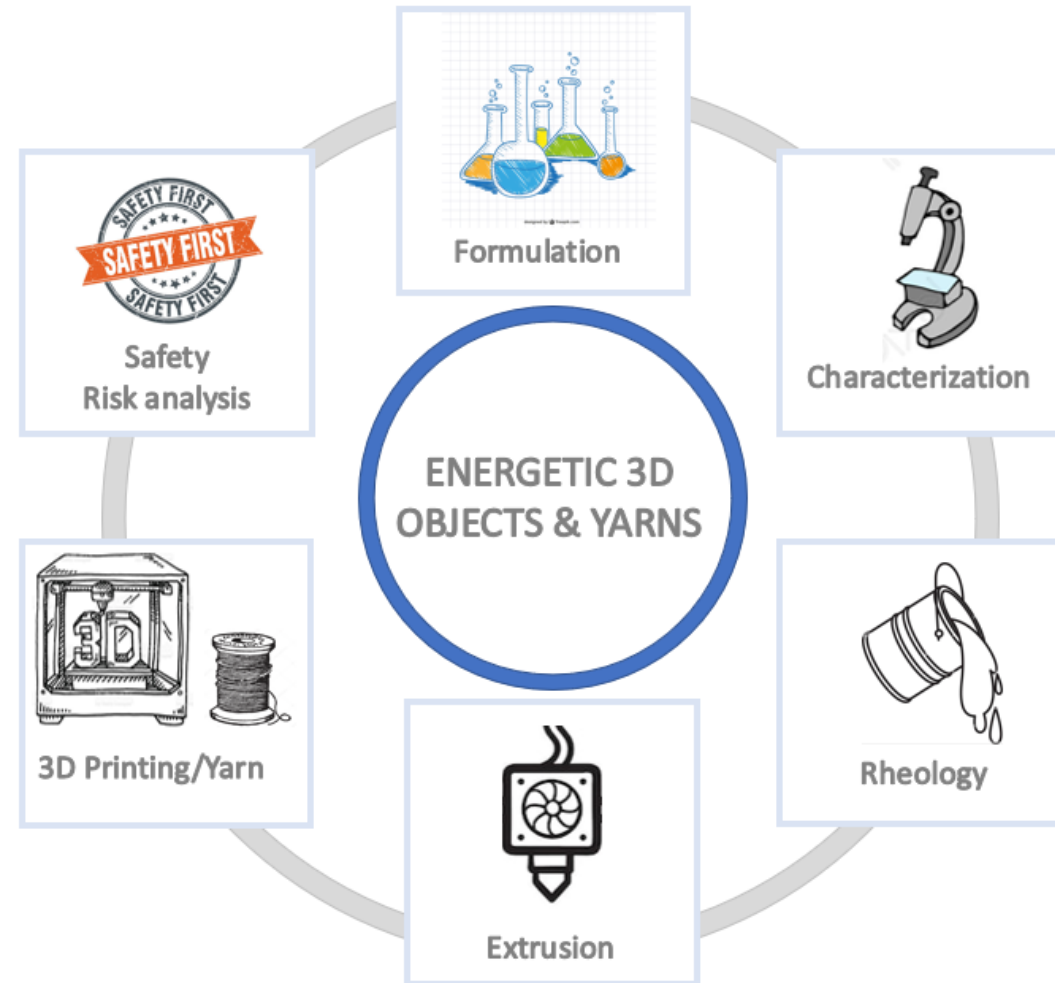


NEW GREEN FORMULATIONS

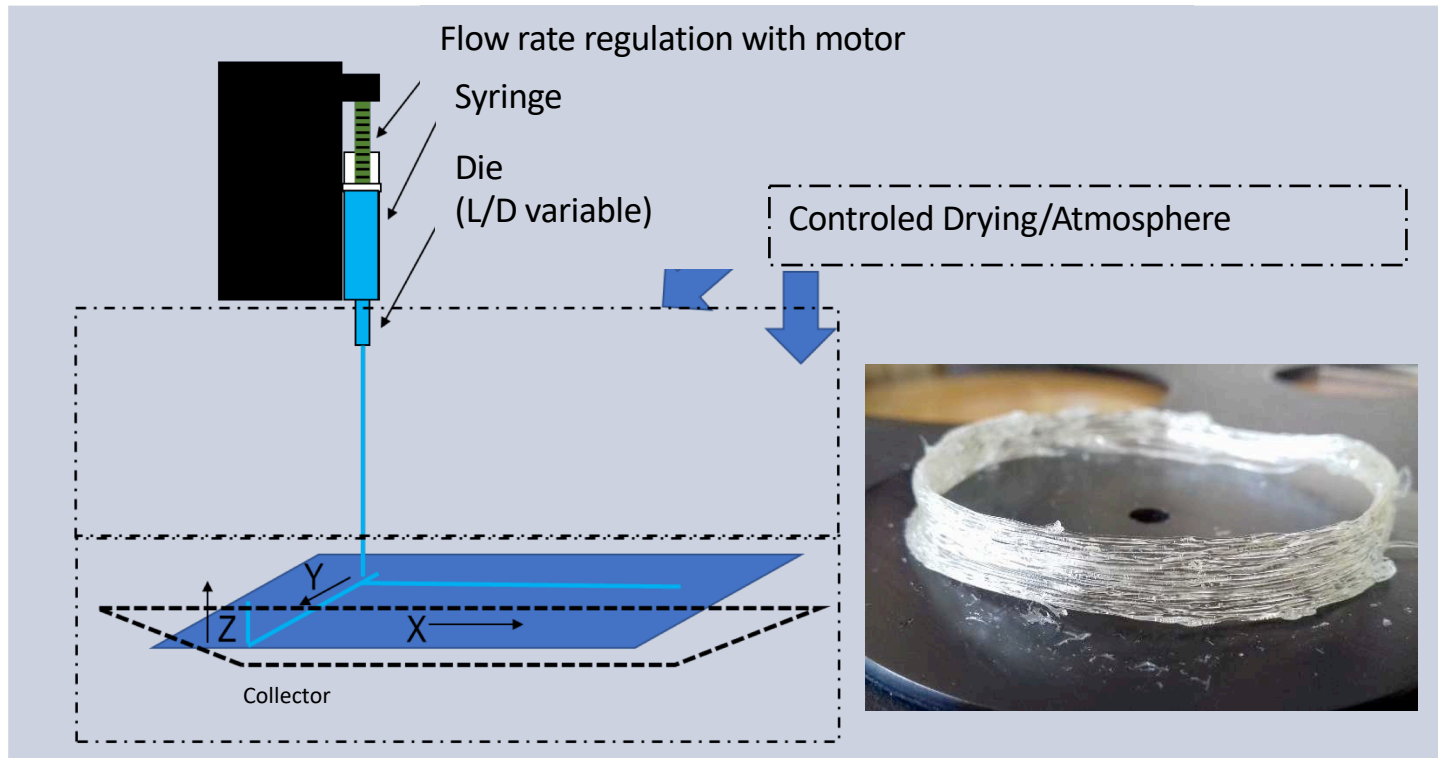




**SKILLS needed for solvent
cast Add. Man. Tech and NC
base yarn production**



First device



KEY PARAMETERS:

1. FORMULATION

- Viscosity of Jelly
- Bubble removing

2. EXTRUSION/ PRINTING

- Extraction velocity
- Size of die

3. CONDITIONING

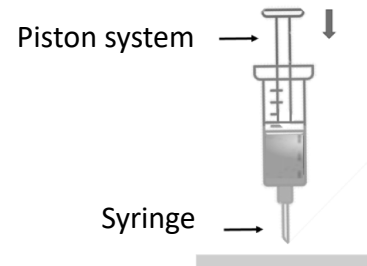
- Temperature
- Drying conditions

Good adhesion between layers



Selection of 3D printing method

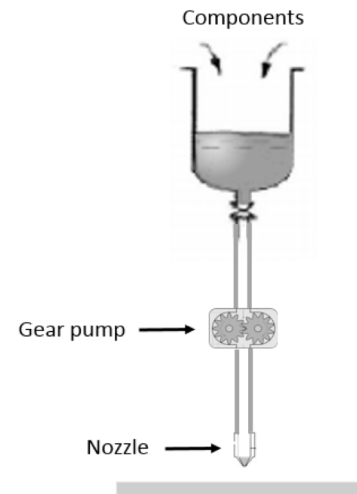
First prototype (batch : 50 ml)



Easy using
In adequation with collodion properties

Syringe = overpressure
No device evolution possibilities = need
Small quantity

Current process (continuous 250 ml)

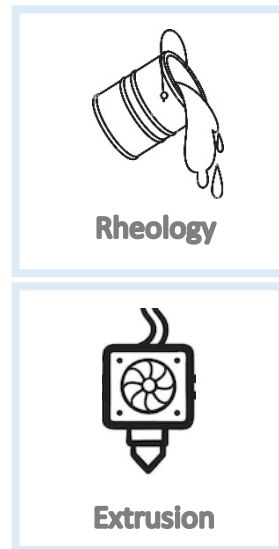
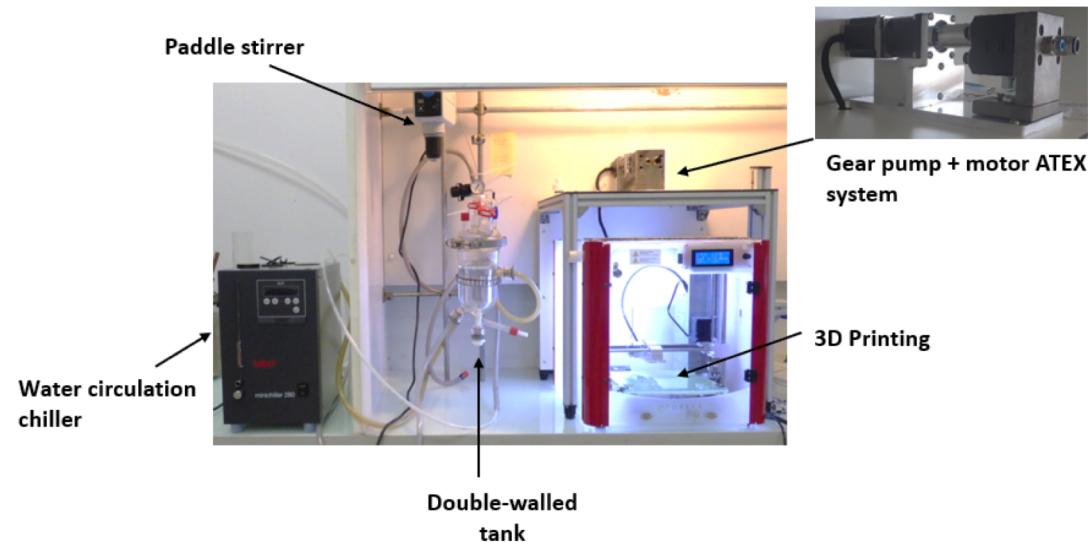
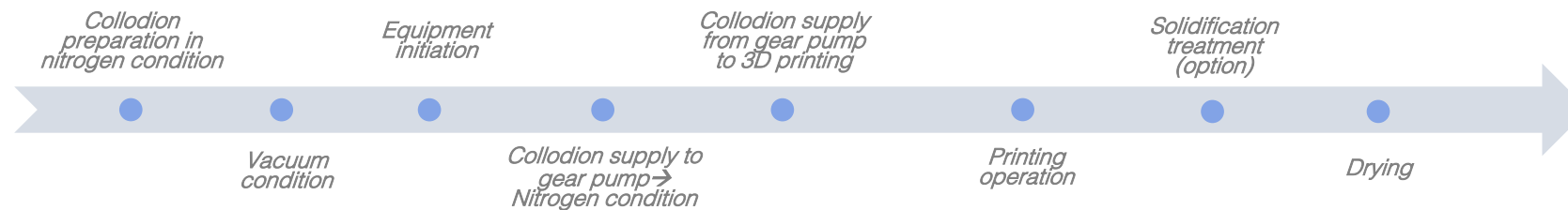


Precise flow with gear pump
Precise deposit with nozzle
Possibility to use several tanks for several deposit in futur

Non existent equipment

Device configuration

Patent number WO 2022/129771 A1



Parameters & optimizations



**3D Printing based-collodion
Thin structures**



Air inclusions
Shrinkage and distortion



Deposit optimization
Structure stabilization
Drying step



Parameters & optimizations



3D Printing
parameters

Resolution control
Dimensional stability

Porosity

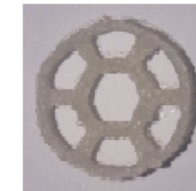
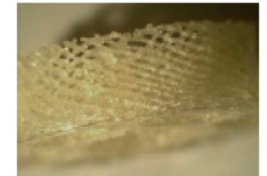
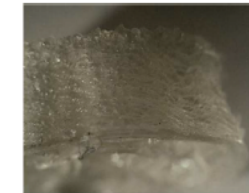
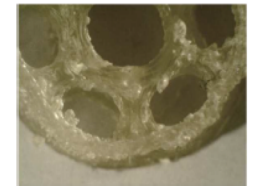
Solidification
treatment

Continuous deposit
No sagging
Better cohesion layer

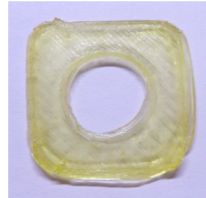
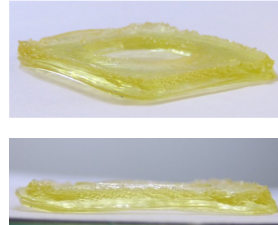
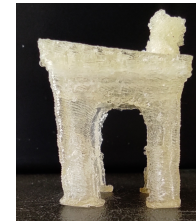
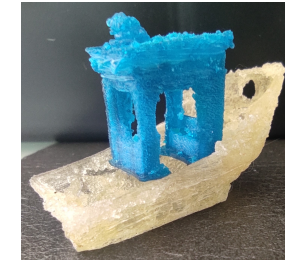
Decrease resolution

Air flow

Faster solvent evaporation
Fixed complex structure
Better dimensional stability control



Realization & Proofs Of Concept (POC)



First results

No inclusion
air structure

No distortion 3D
printing

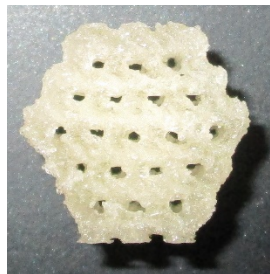
First geometries

3D Benchy and new
designs

EURENCO design



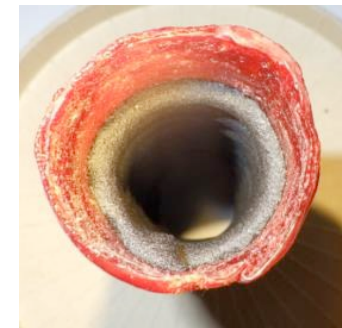
Cup



*19 perf. « Rosette »
Propellant*



*½ horseshoe
container*



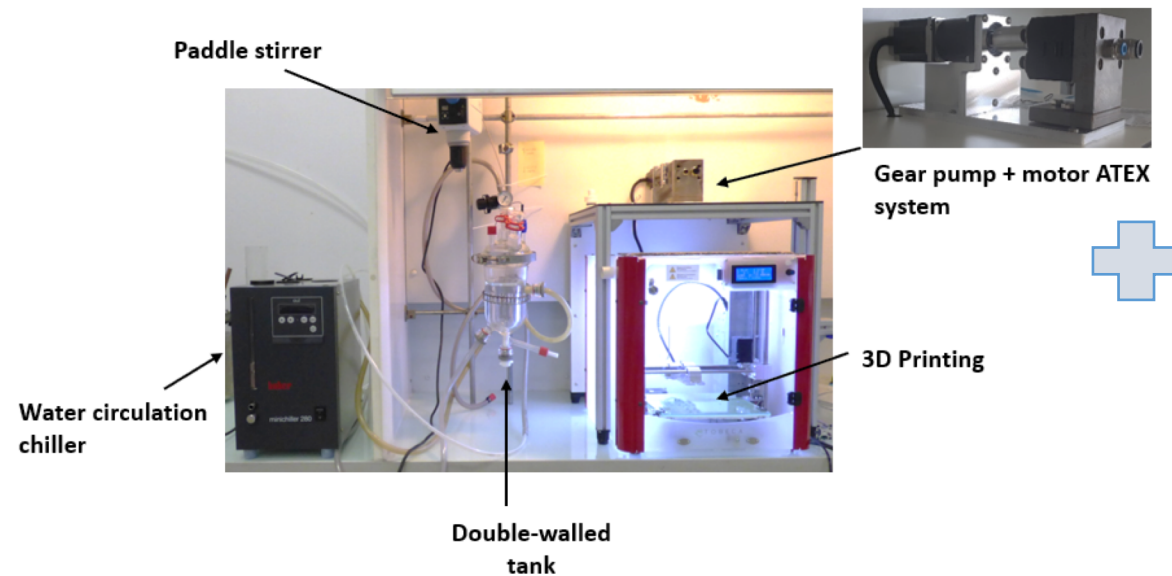
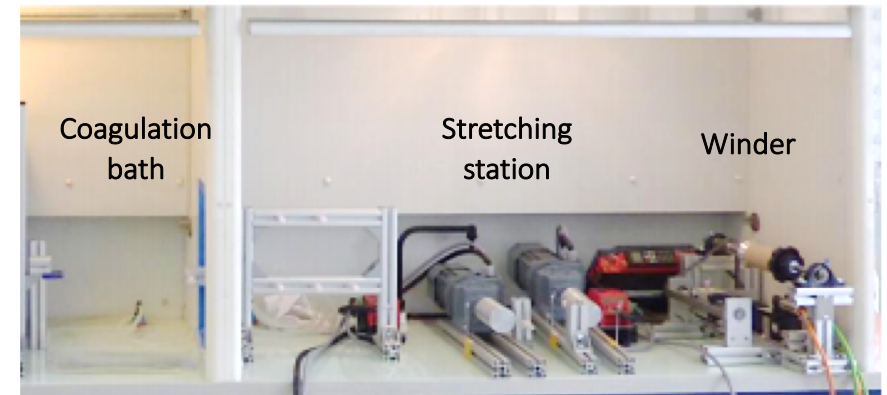
*155mm igniter tube
with black powder*



*Perforated igniter
tube*

Device

3D Printing module combined with Yarn module



Parameters & optimizations for yarns production



Formulation

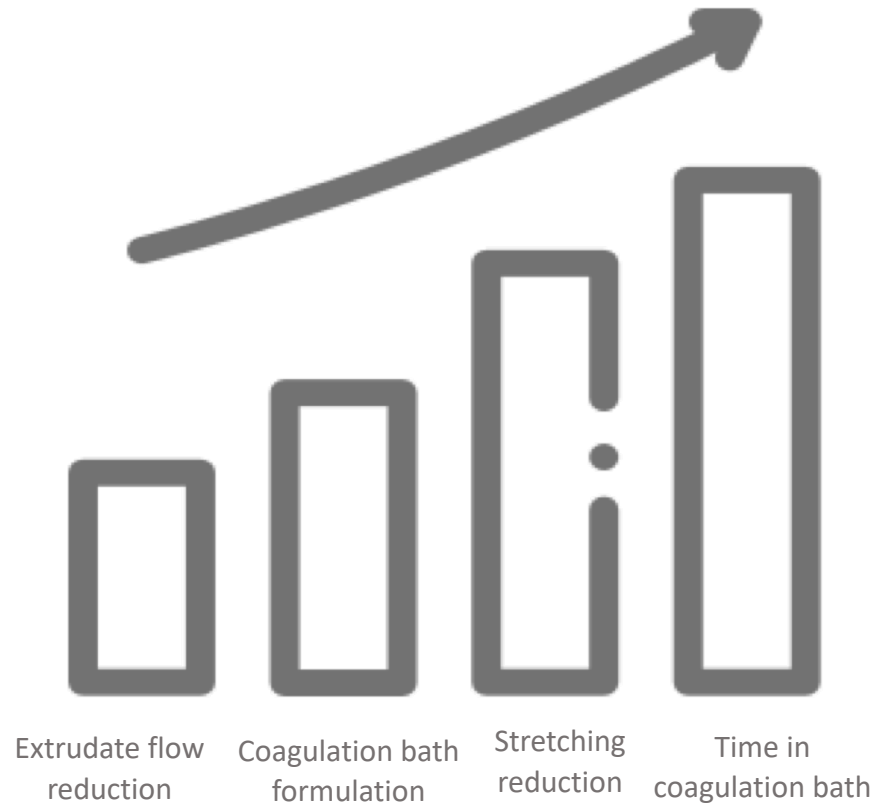


Rheology

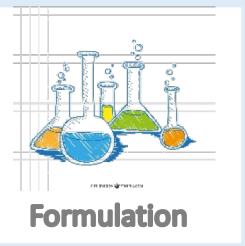


Extrusion

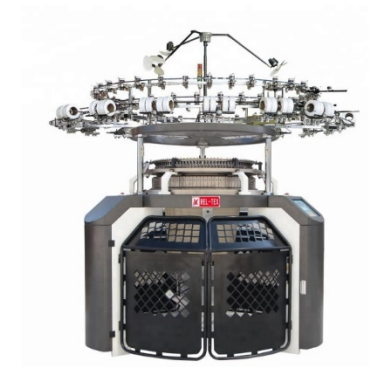
Mechanical properties evolution



Nitrocellulosic yarn compatible
with the most selective
process : The knitting process



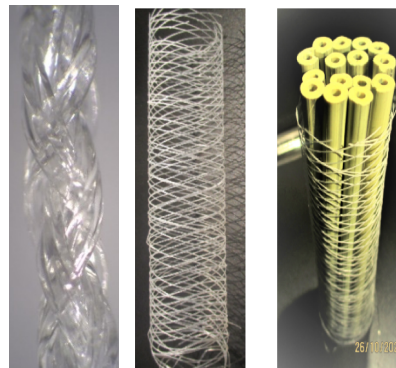
Hand made Proofs Of Concept (POC)



FIRST YARNS

BRAIDING

KNITTING

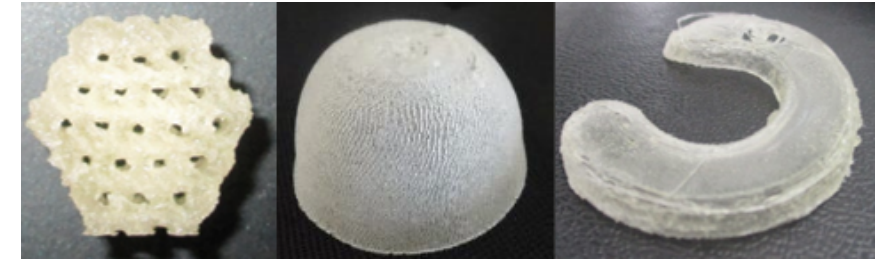


fixed structure



soft structure

3D solvent cast = Agile technology for rapid prototyping



Energetic Technical Textiles = New yarns for pyrotechnical effects

