The Metamorphosis of BUTTERFLIES

November 2026

BUTTERFLIES Project
Bio-Polymers & Additive Manufacturing

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BUTTERFLIES Project Bio-Polymers & Additive Manufacturing

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BUTTERFLIES Project
Bio-Polymers & Additive Manufacturing

OVERVIEW

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OVERVIEW

BUTTERFLIES Project Bio-Polymers & Additive Manufacturing

Project Name:

Advanced hyBridised manufactUring Technique for nexT genERation oF bio-intelLIgent componEntS *(Acronym: BUTTERFLIES)*

Funding Programme:

HORIZON-CL4-2024-TWIN-TRANSITION-01-TWO-STAGE

Project Duration:

36 months

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OVERVIEW

The **BUTTERFLIES** project addresses the growing need for **sustainable** and **digital transformation** in **advanced manufacturing**.

It targets the widespread **adoption of biopolymers in additive manufacturing** (AM), using **chitin** and **chitosan**, natural, biodegradable materials, to reduce dependency on fossil-based inputs.

By leveraging these materials within **Binder Jetting** (BJT) and **Two-Photon Polymerisation** (2PP) technologies, **the project promotes greener production methods**.

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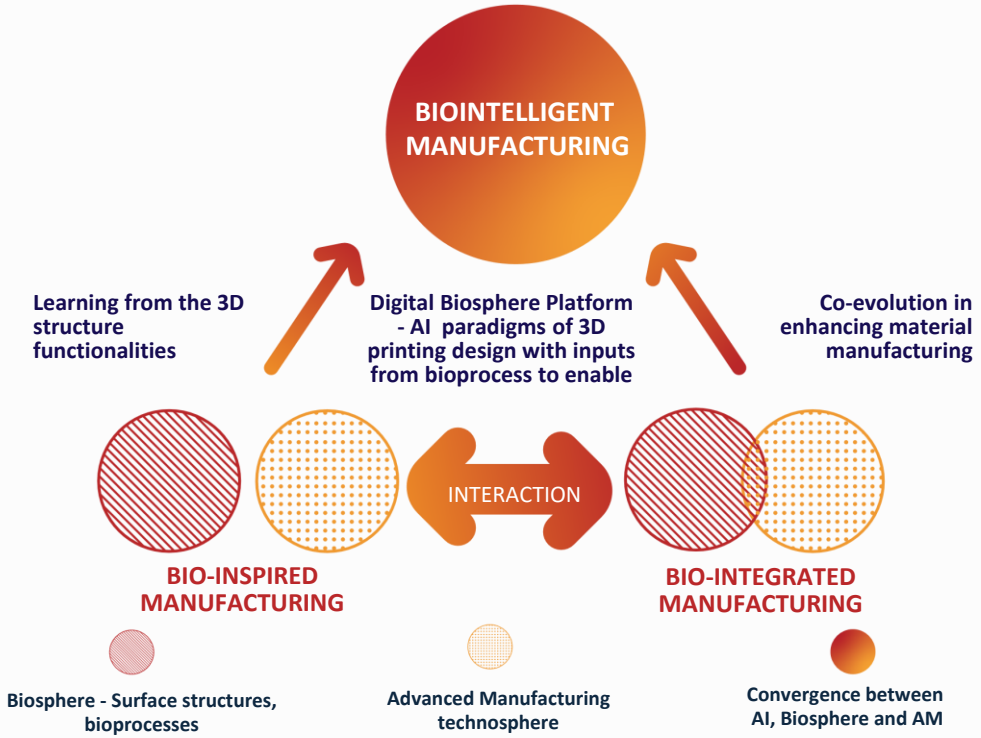
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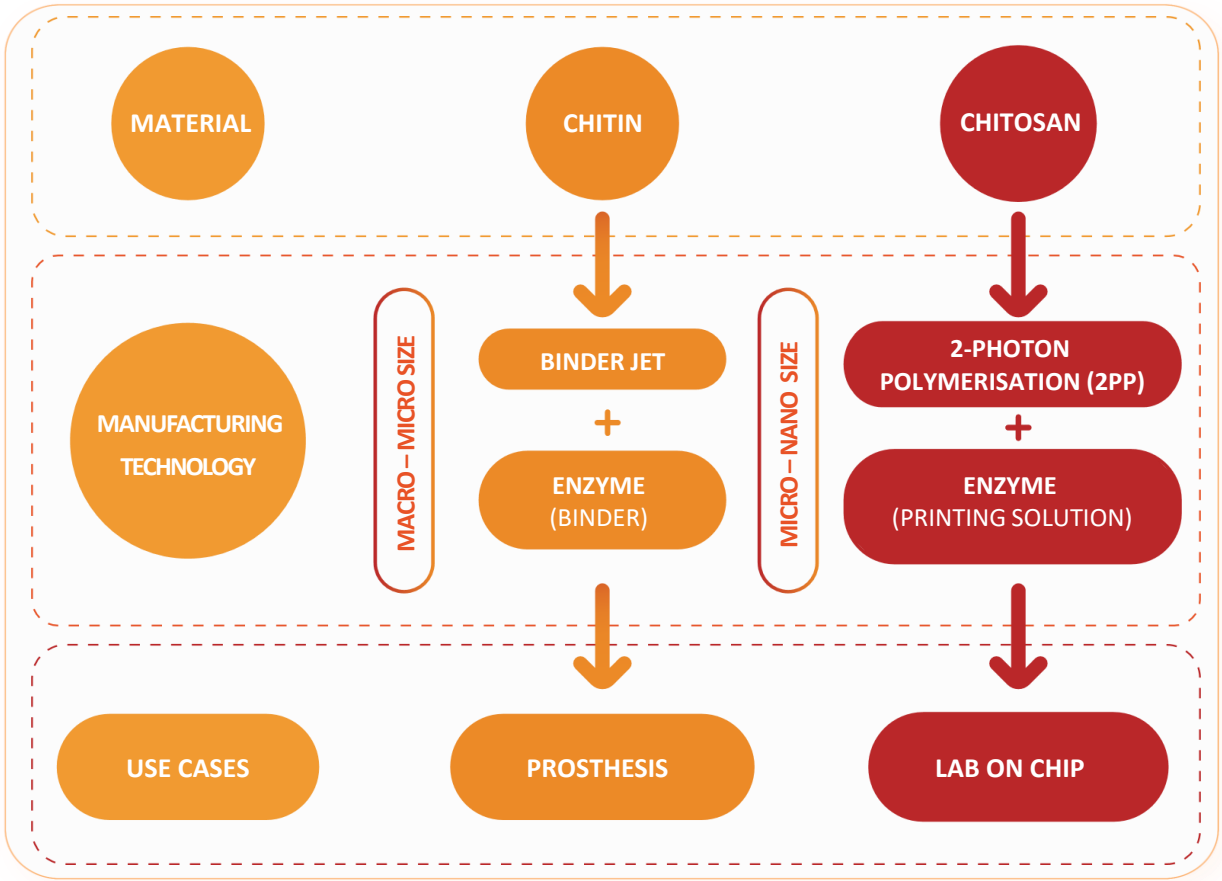
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CONCEPT AND APPROACH

Relationship between bio-inspiration, bio-integration and bio-intelligence in BUTTERFLIES





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CONSORTIUM MEMBERS

RTO

- mtc – where progress happens
- Fraunhofer
- tecnalia – MEMBER OF BASQUE RESEARCH & TECHNOLOGY ALLIANCE
- Empa – Materials Science and Technology
- EWF

Technology Providers

- Vital 3D Technologies
- valuedata
- CONCR3DE – YOUR 3D POWDERHOUSE
- 3drivers – QUADRANTE
- iconiq – INNOVATION
- A&A

End Users

- MAUSA
- EXPERIMENTICA – Scientific Excellence in Ocular Models℠

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PROJECT STRUCTURE AND MANAGEMENT

WP8 & 9: Exploitation, dissemination and training

Phase 1: Requirements and Specifications

WP1: Industrial requirements capture and specifications

Phase 2: Technology Developments

WP2: Development of chitin binder

WP3: Binder jet development for chitin printing

WP4: 2 photon polymerisation development for chitosan printing

WP5: Digital Biosphere Platform development

Phase 3: Industrial Demonstration and Validation

WP6: Lifecycle and lifecost assessment

WP7: Industrial demonstration

WP10 & 11: Project Management

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PROJECT'S OBJECTIVES



Development of Novel Bio-Based Materials

- **ChNC crosslinkers for use in BJT.**
- **Syntesis of photo-curable chitosan-based polymers for high-resolution 2PP**

Advanced Manufacturing Process Design

- **Optimisation of AM parameters and binder interactions for printing with biomaterials.**
- **Development of laser-based and beam-shaping methods for precision printing.**

Digital Integration and Smart Process Control

- **Use of AI and Machine Learning to automate parameter selection and quality control.**
- **Creation of a "Digital Biosphere Platform" to simulate, guide, and monitor processes.**

Equipment Innovation

- **Design and prototyping of modified AM machines compatible with bio-based materials.**
- **Development of new scanning systems for 2PP to increase throughput.**

Scalability and Demonstration

- **Validation of use-cases in biomedical and healthcare sectors, e.g., organoid scaffolds.**
- **Techno-economic and environmental impact assessments to prove viability.**

Capacity Building and Knowledge Transfer

- **Develop guidelines, training materials, and open datasets to support replication and upskilling.**

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IMPACT

Scientific and Technological Impact



BUTTERFLIES introduces **novel biopolymer formulations and printing processes**, thereby **pushing the boundaries** of what **AM** can achieve in terms of **resolution**, **sustainability**, and **material intelligence**.

The project will demonstrate functional parts with **bio-based materials**, including **scaffolds** for **biomedical applications** with **embedded biological functionality**.

Environmental Impact



By **replacing petroleum-based binders** and **polymers** with **chitin** and **chitosan**, the project will directly **reduce carbon emissions** and **chemical waste** associated with **conventional AM**.

It **promotes circular economy** principles, sourcing **raw materials** from **renewable** or **waste-derived streams** and facilitating their **end-of-life biodegradation**.

Economic and Industrial Impact



The project supports **new value chains** in **biomaterials** and **advanced manufacturing**, particularly in **high-value sectors** like **health tech** and **regenerative medicine**.

It also opens up **future industrial applications** in **automotive**, **aerospace**, and **packaging**.

Social and Policy Impact



BUTTERFLIES promotes **gender balance**, **inclusivity**, and **skills development** across the consortium.

It supports **EU policies** on **digital** and **green transitions**, aligning with **Horizon Europe** and **industry strategies** by encouraging **responsible innovation**, **standardisation**, and **sustainability-focused entrepreneurship**.

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END USER CASE STUDY

MAUSA

Use case component:

- **Prostheses, orthoses, implants**

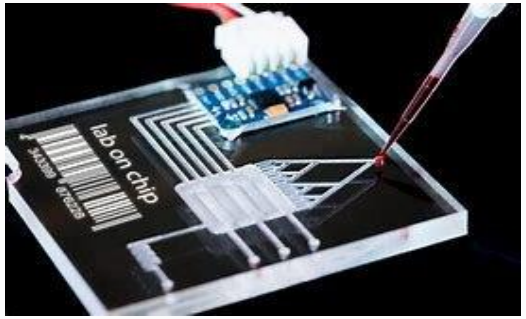




EXPERIMENTICA
Scientific Excellence in Ocular Models℠

Use case component:

- **Technology platform for drug efficacy testing in Ex-Vivo model**



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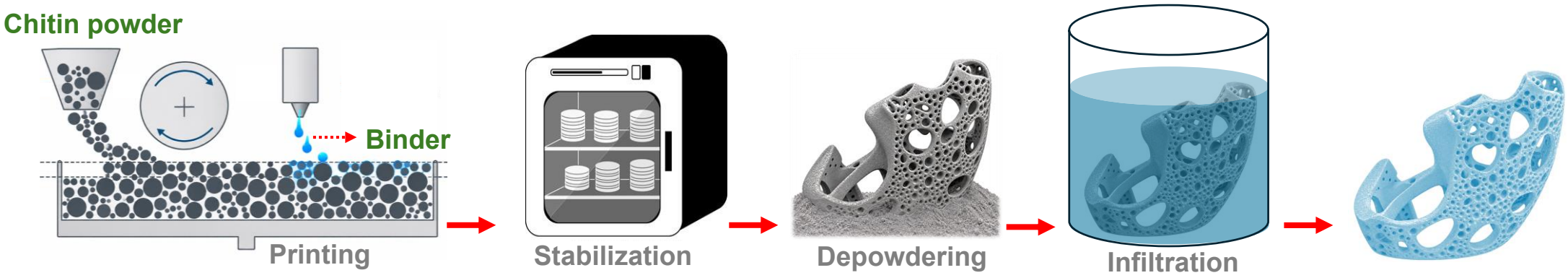
BINDER DEVELOPMENT

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Role of Binder



Printing (structure formation):

- Bonding particles to form a cohesive green part with sufficient strength and stability for subsequent processing.

Infiltration (structure consolidation):

- Further improvement in interparticle bonding and densification to enhance mechanical properties.

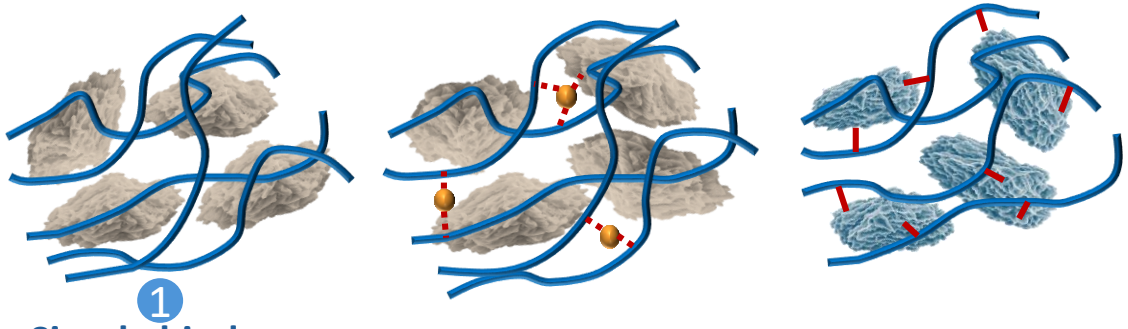
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Binding Mechanism

Non reactive binder



1

Simple binder
- Film formation
- Cohesion
- Adhesion

2

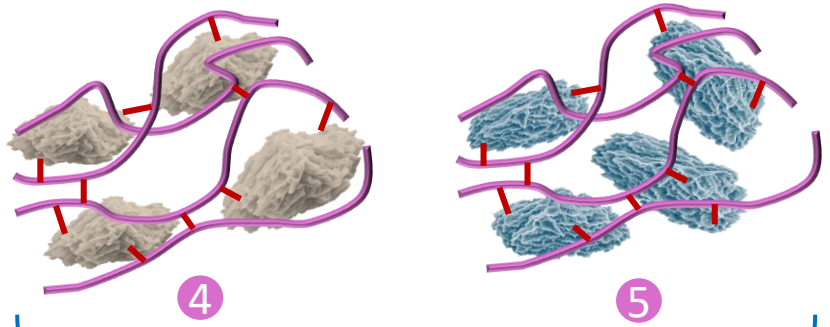
Addtives in powder
- Ionic interaction
- Covalent interaction

3

Functionalized powder
- Binder-powder interaction
- Covalent bond formation

- **Binder contains simple biopolymer**
- **Long term stability and easy to optimize on BJT**

Reactive binder



4 5

- Contains functionalized biopolymer
- Binder can form covalent bond with powder and among themselves
- Can promote mechanical properties

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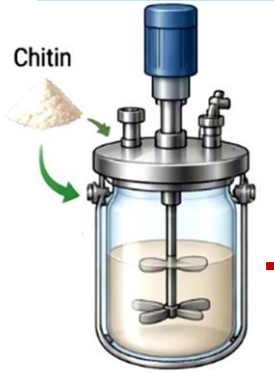
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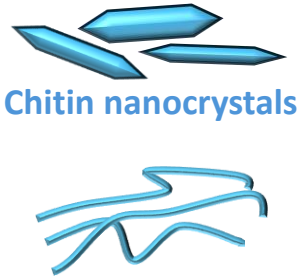
Binder Component Preparation and Selection

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1. Binder component preparation and selection



Optimization



Chitin nanocrystals

Chitosan

Analysis
- Size, stability
- Film formation
- Rheology

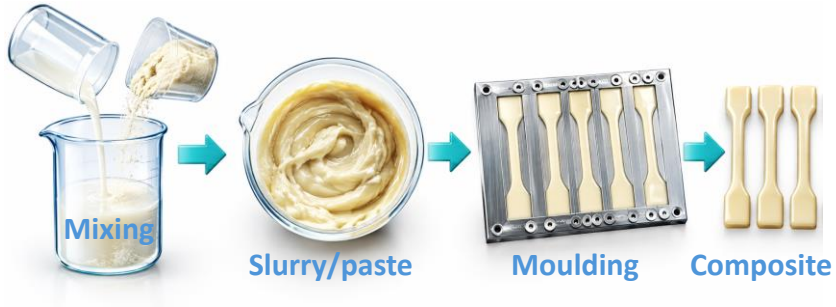
Analysis
- Molecular weight
- Film formation
- Rheology



- Film formation
- Mechanical properties
- Stability

3. Binder performance assessment

Chitin powder-binder composite preparation



2. Powder sourcing



Powder selection
- Particle size (~50 µm)
- Availibility
- Price





Chitin composite

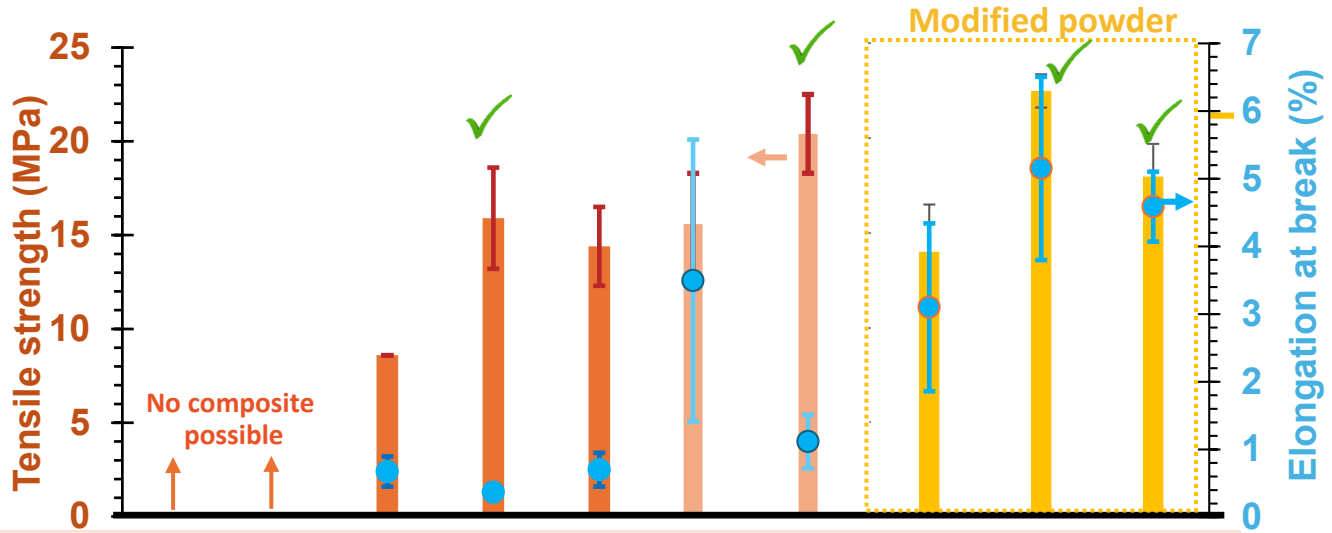
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Non-reactive Binder Selection for BJT

Mechanical properties of chitin composites using different non reactive binder composition



Chitosan %	5	5	5	5	5	0	5	1	2.5	5
Additive1 %		2.5	5	10	10	10	10			
ChNC %					2	5				
Additive2 %						1	2			

- Binder-powder composition with promising mechanical properties were selected for BJT trials.

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BINDERJET DEVELOPMENT

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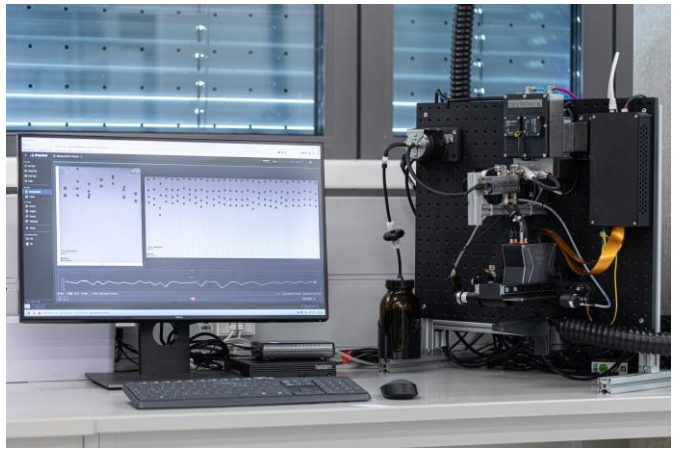
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BINDER JET: PROCESS QUALIFICATION

Binder jettability

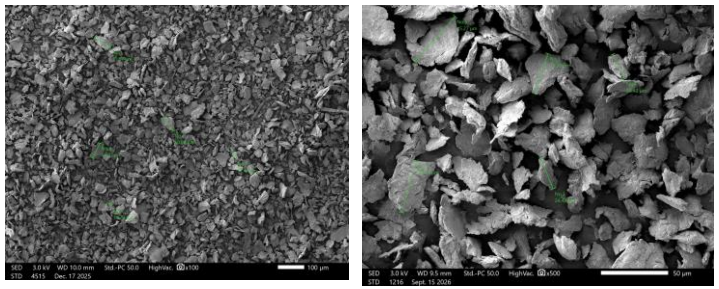
- Rheology screening of chitin-based binders (WP2): shear rates up to 50,000 1/s and frequencies up to 10 kHz
- Drop-watching test rig with an industrial high viscosity piezo printhead (Xaar Aquinox)
- Waveform development to define the printing process window



Drop-watching test rig at Fraunhofer IPA

Chitin powder

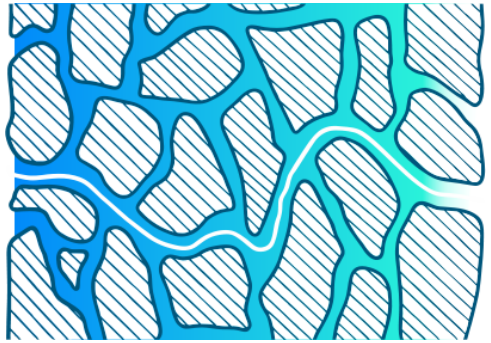
- Particle shape and size (SEM, laser diffraction), flowability, packing density and spreadability
- Chitin particles are flake-like and irregular, unlike spherical PA12, so they flow poorly
- Result drives the recoater design



SEM, x100: chitin powder (left) vs. PA12 (right)

Powder–binder interaction

- Infiltration kinetics (Washburn tests) and dynamic contact angle on the powder bed
- Drop impact: droplet velocity tuned to avoid powder splashing
- Single-layer drying tests and green part strength



Binder infiltration into the powder bed (schematic)

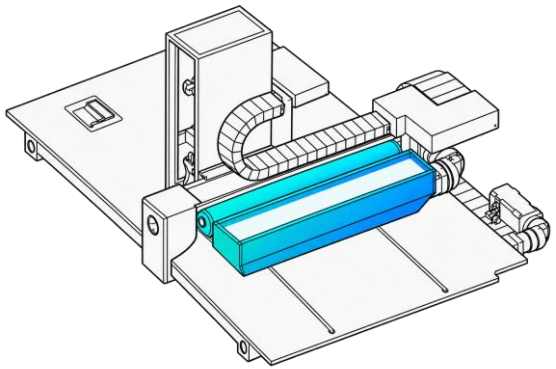
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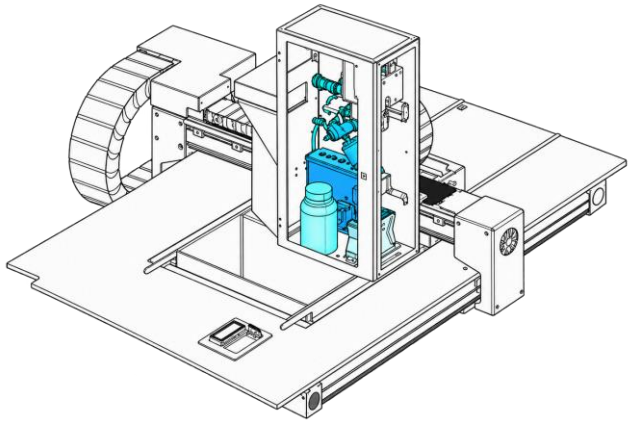
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BINDER JET: LAB TEST RIG

Test rig design



Top-feed recoater for poorly flowing bio-based powders



Print module with recirculating binder supply, inline drop-watching and service station

Progress and lessons learned

- Recoater moved from bottom feed to top feed to handle chitin powder; design completed in October 2026
- Print module and binder supply set up and qualified with drop-watching

What we learned about bio-based binders

- Viscosity changes after long circulation in the fluid system
- Printhead and binder heat up during jetting; solved by adapting the drive waveform
- Brass fittings corrode and the binder gels with copper ions; wetted parts must be stainless steel

Next steps

- Assembly and commissioning of the recoater
- First coupon printing with chitin powder and chitin-based binder
- Process data feed the AI-based Digital Biosphere Platform and the LCA

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LCA LCC ANALYSIS

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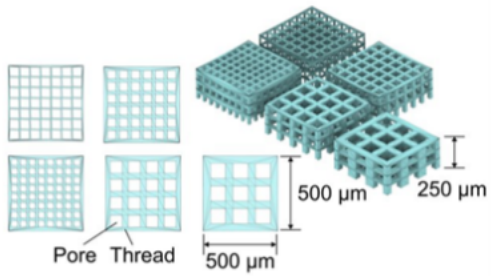
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LCA Framework (conventional vs new CS)

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CS1 - Organoid scaffolds



Conventional Route

TBD - Matrigel-based organoid culture or synthetic hydrogel scaffold

Innovative Route

Chitosan bio-polymer Two-photon polymerization

CS2 - Orthotic device



Conventional Route

PA12 - Multi Jet Fusion

Innovative Route

Chitin based Binder Jetting

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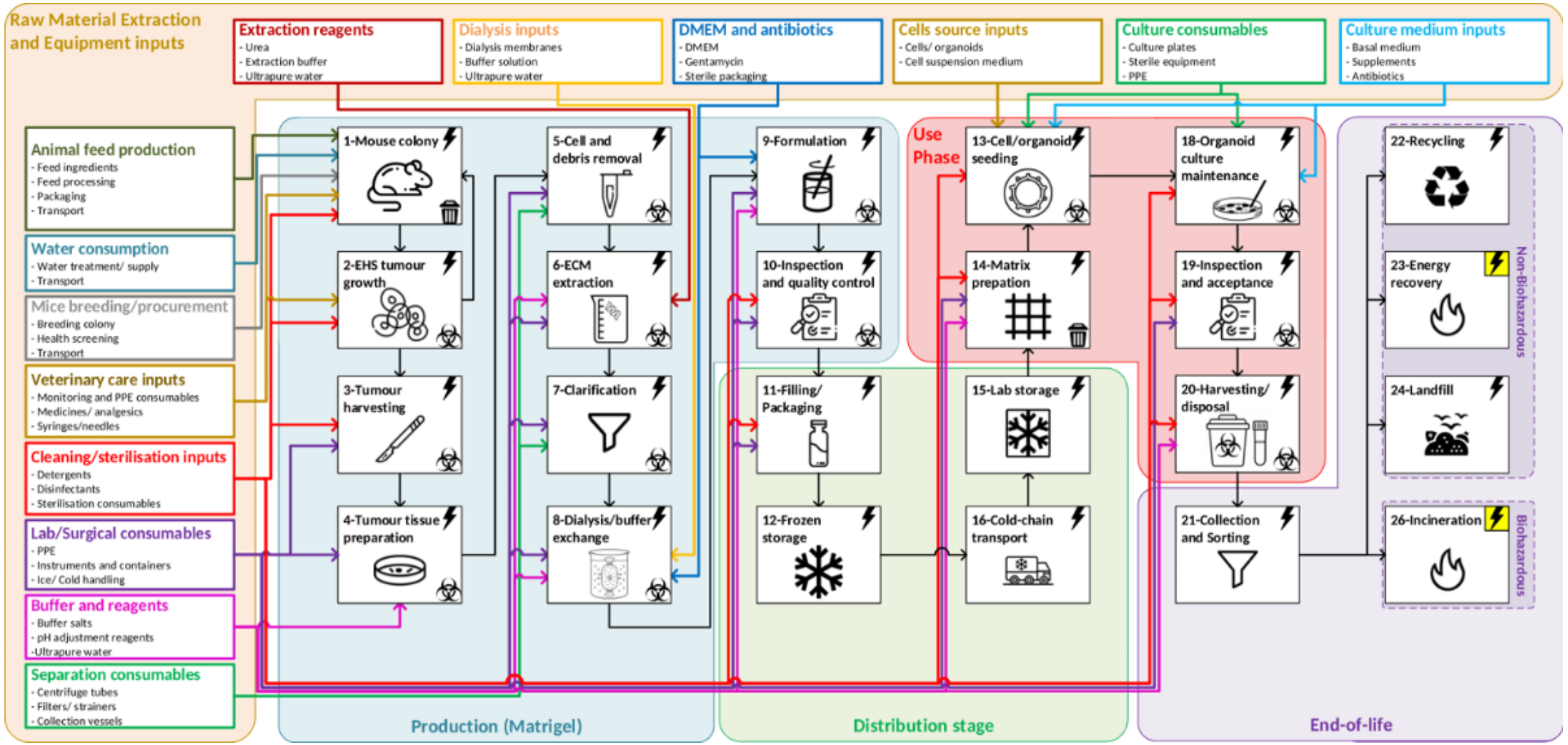
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CS1 organoid scaffold: towards LCI

Example - Flowchart of matrigel organoid culture system



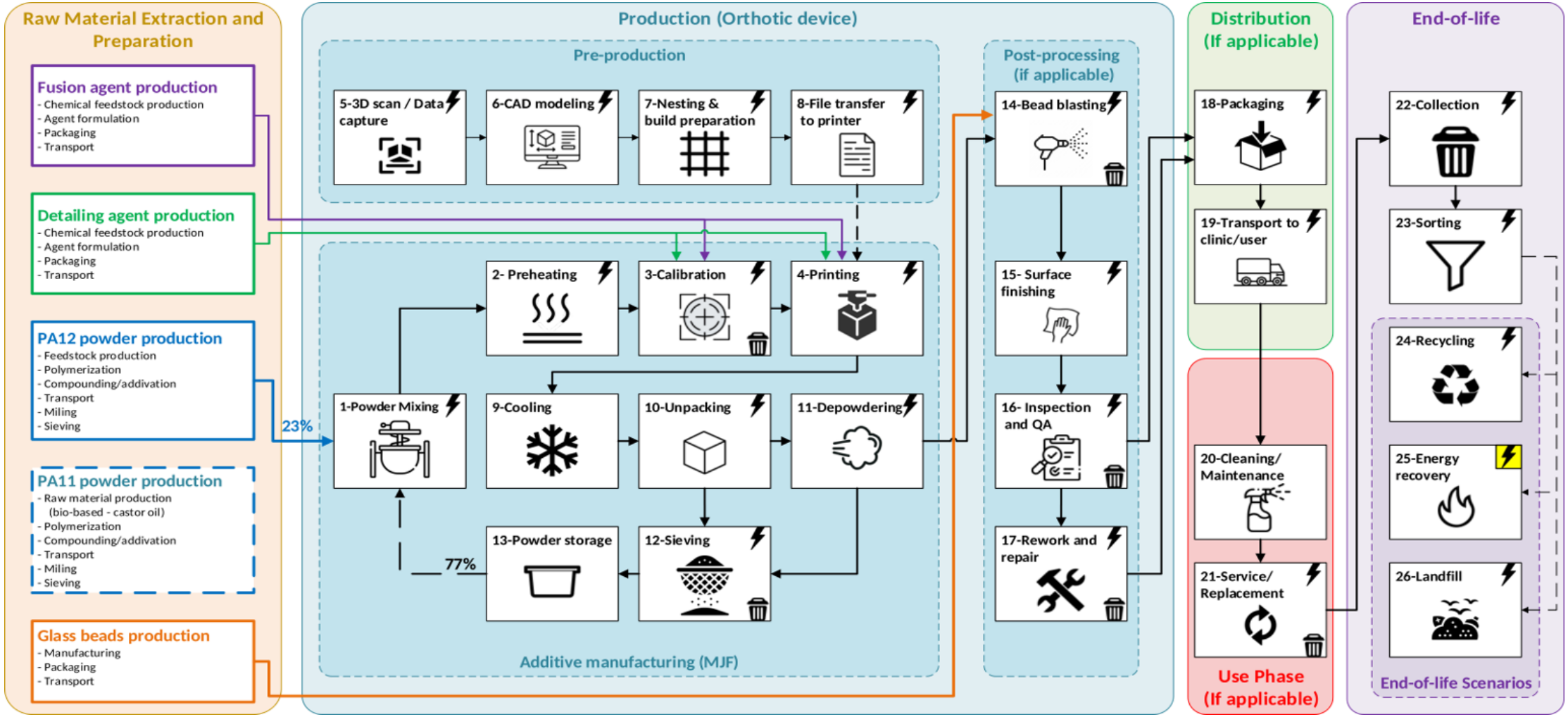
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CS2 orthotic device: towards LCI

Example - Flowchart of PA12 MJF orthotic system



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Next Steps

- Complete models of CS1 and CS2: Matrigel and chitosan 2PP organoid culture in CS1, and PA12 MJF and chitin/chitosan BJT orthotics in CS2;

- Both the the BJT route has quantified upstream chitin and chitosan proxies, but project-specific data on insect-derived feedstock, binder, printing, recovery, yield and post-processing are still under study;

- Furher stage of life cycle are under consideration: rework, service life, distribution and end-of-life treatment;

- Transition of LCI data, adopted for LCA, also towards LCC models, in order to deliver also economic indicators.

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ANY QUESTIONS?

Thank you!



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