CU 9.1: WOOD BIOEFINERIES

Director of studies: **Emmanuel FREDON**

General CU objectives:

The objective of reducing the dependence of our economy on oil through an increased share of plant-based fuels opens up new prospects for the use of wood.

New recovery processes are based on wood chemistry and biotechnologies supplying biomolecules and biomaterials to many industrial sectors sometimes distant from the timber industry.

In this context, at the end of this CU, students:

• will have an overview of markets, value chains, deposits and applications, aware of the technical, economic and regulatory barriers to be removed.
• will be able to identify development and innovation levers based on academic and technological monitoring.
• will be made aware of the principles and issues of process engineering, reactors, extractions and separation technologies.
• will have sufficient theoretical and practical knowledge to enable them to develop innovative solutions based on the transformation of wood material or its constituents.
• will also be able to select analytical methods, simple or sophisticated, allowing them to evaluate the effectiveness of their process.

Consists of:

- Part 1: Chemical fractionation and bioconversions
- Part 2: Process engineering: reactors, separation and purification
- Part 3: Assessments and techno-economic approach
- Part 4: Laboratory integrator project

Hourly volume

In-person		*Self-directed study*
28.00 H	**Lectures**	**32.00 H**
32.00 H	**Tutorials**	
32.00 H	**Practicals**	

Positioning of the CU in the School reference system:

Units of skills

In accordance with the RNCP sheet

Unit 1
Unit 2
Unit 4

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Part 1: Chemical fractionation and bioconversions	**Coefficient 1**
Session leaders: Emmanuel FREDON (14h), Nicolas BROSSE (6h), Arnaud BESSERER(4h)	
Teaching assistants:	
Prerequisites: CU 5.3 and CU 7.2	
Teaching materials: Course notes – Presentation slides – Reading list – Arche page – Reference book	
Assessment methods: individual	

Learning outcomes	**Description**	**Number of student hours (in-person)**		
		Lectures	**Tutorials**	**Practicals**
Anticipate the phenomena involved when placing wood in a given reaction medium. Select operating conditions for the purpose of pretreatment or targeted fractionation of wood constituents based on the reactivity of the functional groups. Select characterisation tools suitable for lignin and sugar analysis. Choose the most suitable biocatalysts for biomolecule production. Determine and analyse the mass distribution of a polymer.	Application to pre-treatments. Methods for the structural characterisation of lignins and sugars.	5.25	2.00	6.00
	Principle and demonstration of pre-treatment processes: steam explosion.	1.75	2.00	2.00
	Bio-processes and bioconversions in the cascade recovery of wood materials. Selection of biotechnological solutions (enzymes, micro-organisms), case studies.		2.00	
	Bases of macromolecular chemistry: molecular mass distribution and polydispersity.		2.00	
		7.00	**8.00**	**8.00**

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Part 2: Process engineering: reactors, separation and purification	**Coefficient 1**
Session leaders: Nouceiba ADOUANI (10h), Bouchra BELASSAOUI (14h)	
Teaching assistants:	
Prerequisites: CU 5.3, CU 5.4 and CU 6.3	
Teaching materials: Course notes – Presentation slides – Reading lists – Arche page	
Assessment methods: individual and in groups Class assignment– Practical examination	

Learning outcomes	**Description**	**Number of student hours (in-person)**		
		Lectures	**Tutorials**	**Practicals**
Use the basics of process engineering (calculating conversion rates, yields, residence times, kinetics, etc.) Differentiate the types of reactors in order to optimise the operating conditions. Be aware of the principles and techniques of extraction and separation in order to design an integrated sequence of unit operations meeting specifications and performance objectives. Select a separation process appropriate to the mixture to be purified.	Liquid phase reactors: yields, typologies, kinetics, open industrial reactors, applications to "biorefineries" Solid/liquid extraction: balances, transfers, typologies, simulation, applications to biorefineries.	3.50	6.00	
	Separation and purification unit operations, comparative operating principles: liquid/solid separations and bioseparations – Filtration – Centrifugation – Decanting (centrifugal decanter) – Cross-flow filtration – Ion exchange	3.50	2.00	2.00
	Practical session on the press filter.			6.00
		7.00	**8.00**	**8.00**

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Part 3: Assessments and techno-economic approach	**Coefficient 1**
Session leaders: Emmanuel FREDON (4h), Arnaud BESSERER (4h), Pierre GIRODS (8h), Pascal XANTHOPOULOS (6h), Gerard XOLIN (2h)	
Teaching assistants:	
Prerequisites: CU 5.3, CU 5.4, CU 7.2 and CU 7.5	
Teaching materials: Presentation slides - Case studies	
Assessment methods: individual and in groups Excel File - Viva	

Learning outcomes	**Description**	**Number of student hours (in-person)**		
		Lectures	**Tutorials**	**Practicals**
Model and optimise bioprocesses by establishing material and energy balances and simulations. Identify the main value chains and the main industrial players in the wood biorefinery: commodities, specialities, molecules with high added value: define the economic model of a biorefinery and evaluate profitability. Conduct a literature review with the aim of proposing an experimental plan.	The engineering of bioprocesses for biorefineries: issues, methods, simulations of bioprocesses. Case study of the transformation of lignocellulose into fuel ethanol. Material balances in simulator-spreadsheet.	1.75	6.00	
	Research project: identification of innovation levers, bibliographic monitoring and proposals for an experimental plan.	1.75		6.00
	Current markets and stakeholders in wood biorefinery. Innovative ways, economic and regulatory aspects. Case studies: – Related wood deposit – Value chains of wood co-products – Simulation of a consortium of partners for a collaborative project. Economic study, profitability of a biorefinery.	3.50	2.00	2.00
		7.00	**8.00**	**8.00**

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Part 4: Laboratory integrator project	Coefficient 1
Session leaders: Emmanuel FREDON (10h), Arnaud BESSERER (10h), Christophe ROSE, INRAE (4 hours)	
Teaching assistants: Marie-Laure ANTOINE, Christelle PERRIN	
Prerequisites: CU 5.3 and CU 7.2	
Teaching materials: Arche Page– Project	
Assessment methods: in groups Viva– Report– Bibliography	

Learning outcomes	Description	Number of student hours (in-person)		
		Lectures	Tutorials	Practicals
Implement, analyse and optimise an experimental process. Promote the results of the project through oral communication and a written report. Present and defend the project orally.	Practical work involving the processing of wood material. Mini-test campaign, use of advanced analysis methods (INRAE), product analysis.	7.00	8.00	8.00
		7.00	**8.00**	**8.00**

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