French Polytech network form for PhD Research Grants from the China Scholarship Council

This document describes one of the PhD subjects proposed by the French Polytech network. The network is composed of engineering schools/universities. The document also provides information about the supervisor.

Supervisor information	
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Polytech name	Polytech Annecy-Chambéry
University name	Université Savoie Mont Blanc
Country	France

PhD information	
Title	Development of sustainable composites based on reinforcements from agricultural waste: Towards optimizing mechanical properties and integration into the circular economy.
Main topics regards to CSC list (3 topics at maximum)	IV-7. Matériaux pour l'environnement et l'écologie - Materials for enviro and ecology.

	IV-10.Bio-matériaux et matériaux polymères - Biomaterials and polymer materials. IV-5.Matériaux intelligents et matériaux de terres rares - Intelligent materials and rare earth materials
Required skills in science and engineering	**materials science, mechanical engineering, or polymer chemistry**. **data analysis, machine learning, 3D Printing**

Subject description (two pages maximum including biblio)

Context and Motivation

In a world increasingly constrained by the need for sustainable development, the search for innovative, eco-friendly materials has become a global priority. Agricultural waste—such as palm fibers, corn and wheat stalks, and eggshells—represents an abundant, low-cost, and underutilized resource. By transforming these residues into high-performance reinforcements for bio-based or recycled polymer composites, this PhD project addresses both environmental and industrial challenges.

The rise of additive manufacturing (3D printing) offers a unique opportunity to develop lightweight, customizable, and low-energy composites. Simultaneously, advances in artificial intelligence (AI) allow for the optimization of material formulation and processing, reducing trial-and-error and accelerating innovation.

This project aims to position itself at the intersection of **materials science, digital engineering, and sustainable development**, with direct relevance to sectors such as automotive, construction, packaging, and eco-design.

Research Objectives

The PhD candidate will contribute to a multidisciplinary research effort with the following key goals:

1. **Valorize agricultural residues** by identifying and characterizing the most promising waste types in terms of mechanical properties, thermal behavior, and availability.
2. **Develop eco-friendly fiber treatments** to improve fiber–matrix adhesion while minimizing energy and chemical usage.
3. **Design and optimize low-carbon processes** (e.g., compression molding, extrusion, 3D printing) adapted to these natural reinforcements.
4. optimize the process by studying the influence of the main implementation parameters
5. **Use AI-based models** to identify optimal processing parameters and predict mechanical performance using data from material characterization campaigns.
6. Develop **numerical modeling tools** to analyze the **effect of microstructure** on macroscopic properties for **optimization** purposes.
7. **Evaluate aging and long-term performance** under environmental stressors (UV, humidity, temperature).
8. **Integrate circular economy principles** by proposing strategies for recycling or reintegrating the materials at end-of-life.

Scientific and Industrial Impact

Recent studies (e.g., [7] Shubhra et al., 2023; [8] Ramakrishna et al., 2022) have demonstrated the potential of agro-waste fibers in biocomposites. However, few have explored their integration into **additive manufacturing** with **AI-assisted optimization**. This PhD project aims to fill that gap and support the development of **next-generation sustainable composites**.

The outcomes could lead to scalable innovations of interest to major industrial sectors seeking greener materials and circular solutions. Industrial collaborations are anticipated during the project, with potential for technology transfer and patentable results.

Candidate Profile

We are looking for a **highly motivated student** with a strong background in **materials science, mechanical engineering, or polymer chemistry**. Skills or interest in **data analysis, machine learning, or CAD/3D printing** are strong assets. A passion for sustainability and interdisciplinary research is essential.

Supervision and Environment

The PhD will be hosted within a dynamic and collaborative research group, in partnership with the following laboratories: **SYMME (France) [3–6]**, **Laboratory for Physics and Engineering Sciences (Morocco) [3, 4]**, **Mechanical Engineering Laboratory (LGM), ENIM (Tunisia) [1, 2]**, and the **Mechanical Engineering Laboratory of the University of Ljubljana (Slovenia) [6]**. These institutions specialize in sustainable materials and digital manufacturing and provide access to state-of-the-art facilities for **materials processing, mechanical testing, and computational modeling**.

References :

[1] F. Naiiri, A. Lamis, S. Mehdi, Z. Redouane, and Z. Mondher, "Performance of lightweight mortar reinforced with doum palm fiber," J. , vol. 55, no. 12, 2021, doi: 10.1177/0021998320975196. Compos. Mater.

[2] O. Boughanmi, L. Allegue, H. Marouani, and A. Koubaa, "Experimental Investigations of the Influence of Spent Coffee Grounds Content on PLA Based Composite for 3D Printing," , vol. 13, pp. 226–233, 2024, doi: 10.6000/1929- J. Res. Updat. Polym. Sci. 5995.2024.13.23.

[3] Ismail Ezzaraa, Nadir Ayrilmis, Mohamed Abouelmajd, Manja Kitek Kuzman, Ahmed Bahlaoui, Ismail Arroub, Jamaa Bengourram, Manuel Lagache, and Soufiane Belhouideg. "Numerical modeling based on finite element analysis of 3D-printed woodpolylactic acid composites: a comparison with experimental data." Forests 14, no. 1 (2023): 95.

[4] Mohamed Abouelmajd, Ahmed Bahlaoui, Ismail Arroub, Maria Zemzami, Nabil Hmina, Manuel Lagache, and Soufiane Belhouideg. "Experimental analysis and optimization of mechanical properties of FDM-processed polylactic acid using Taguchi design of experiment." International journal for simulation and multidisciplinary design optimization 12 (2021): 30.

[5] A. CUYNET, D. SCIDA, E. ROUX, F. TOUSSAINT, R. AYAD, M. LAGACHE, (2018) Damage characterisation of flax fibre fabric reinforced epoxy composites during low velocity impacts using high-speed imaging and Stereo Image Correlation, Composite Structures 202 1186-1194.

[6] K. Jernej, K. Jure, A. Sanel Avdic, M. Lagache, Characteristics of embedded sensors in additively manufactured composite structures, 10th International Conference on Mechanics and Materials in Design (M2D 2024), 1-5 September 2024, Nagoya, Japan.

[7] Shubhra, Q.T.H., Rahman, M., & Sultana, S. (2023). *Agricultural Waste-Derived Fibers for Biocomposites: A Review on Processing, Properties and Applications*. Journal of Renewable Materials, 11(2), 451–470. https://doi.org/10.32604/jrm.2023.025638

[8] Ramakrishna, S., Chen, G., & Leong, Y.W. (2022). *AI-Assisted Design of Natural Fiber Composites for Additive Manufacturing*. Composites Science and Technology, 229, 109695. https://doi.org/10.1016/j.compscitech.2022.109695