School of Computing, Engineering, and the Built Environment
Edinburgh Napier University

PHD STUDENT PROJECT

Application instructions:
Detailed instructions are available at :
https://www.napier.ac.uk/research-and-innovation/doctoral-college/how-to-apply

Prospective candidates are encouraged to contact the Director of Studies (see details below) to discuss the project and their suitability for it.

Project details

Supervisory Team:

- Director of Study: Dr Carolina Costa Pereira (Email: c.costapereira@napier.ac.uk)
- 2ND SUPERVISOR: Dr Dongyang Sun

Subject Group: Engineering & Mathematics

Research Areas: Engineering (Chemical Engineering, Bioengineering, Energy Technologies, Environmental Engineering, Thermodynamics) and Chemistry (Analytical Chemistry, Synthetic Chemistry)

Project Title: Development of Shape-stabilised PCMs from Agricultural Waste for Clean Energy Applications

Project description:

Agriculture contributes to the world's economic growth by accounting for 4 % of the global gross domestic product (The World Bank, 2023). However, agricultural activities have some negative impacts on the climate, including the use of resources and emissions due to straw burning. Straw burning is common in South Asian countries accounting for close to 80% of the emissions in some of them and causing transboundary air pollution issues even in Europe (UNECE, 2022). Reducing emissions and energy consumption in parallel with increasing energy efficiency and using renewable energy sources and sustainable materials are key actions in the energy challenge.

Phase Change Materials (PCMs) offer a promising solution by providing thermal storage, management, and regulation, as well as waste heat recovery. These materials can bridge the gap between energy demand and production, particularly in solar systems. PCMs have vast potential applications in passive building temperature control, heating and cooling systems, photovoltaic (PV/PVT) systems, and even clean cooking technologies. However, challenges such as long-term stability, low thermal conductivity, leakage and the need for sustainable materials must be overcome to fully realize their benefits. Shape-stabilized PCMs (SS-PCMs) have been studied to maintain shape stability and prevent leakage problems using porous structures such as carbon and silica skeletons, metal frameworks and polymers.

Sustainable Development Goals targets have promoted the interest in bio-based materials and agriculture residues like natural fibres, lignocellulosic or biochar, with natural porous structures that are excellent for preparing SS-PCMs. Utilising waste natural fibres or lignocellulosic materials as PCM supports offers multiple benefits: significant cost reduction, waste valorisation, and reduced carbon emissions compared to incineration (aligning with SDGs 3, 7, 11-13, and 15). However, this research area is still under development and requires further exploration due to the wide variety of bio-based materials.

In this context, the project focuses on the selection and sustainable transformation of agricultural waste into a novel, entirely bio-based composite Shape-Stabilized Phase Change Materials (SS-PCMs), evaluation into passive energy applications and Life Cycle Analysis (LCA). This innovative project tackles energy challenges by harnessing a readily available resource: agricultural waste and its transformation into high-value SS-PCMs promoting energy savings and improved efficiency for clean energy applications.

The innovation potential of this project can directly contribute to two sustainable development goals: climate action and affordable and clean energy and the proposed project is aligned with the principles of responsible innovation to generate a positive impact on society ethically and responsibly.

References:

Costa, T., Sanchez-Vicente, Y., Yang, Z., Stevens, L. A., Dias, F. D. S., & Costa Pereira, S. C. (2024). Thermophysical properties of tetrabutylammonium chloride, paraffin and fatty acids for thermal energy applications. RSC advances, 14(36), 26246-26258.

D'Oliveira, E. J., Costa Pereira, S. C., Groulx, D., & Azimov, U. (2022). Thermophysical properties of Nano-enhanced phase change materials for domestic heating applications. Journal of Energy Storage, 46, 103794.

Pervin, F., Olawumi, T. O., & Sun, D. (2023). Development and Characterization of Bio-Degradable Fibre from Living Organism-Microalgae.

Sun, D., Saw, B. L., Onyianta, A. J., Wang, B., Wilson, C., O'Rourke, D., ... & Lu, Z. (2023). Preparation of elastomeric nanocomposites using nanocellulose and recycled alum sludge for flexible dielectric materials. Journal of Advanced Dielectrics, 13(01), 2242008.

Candidate characteristics

Education:

A first degree (a minimum 2:1) in Material Science and Engineering, Mechanical Engineering, Energy Engineering, Chemical Engineering

Subject knowledge:

This project will require an interest in holistic engineering challenges, including material science, thermodynamics, heat transfer and experimental work

Essential attributes:

- Self-motivated
- Hard working
- Self-directed
- Active learner
- Enthusiastic and passionate
- Good communication and interpersonal skills.

Desirable attributes:

- Laboratory experience, Life Cycle Analysis (LCA), Computational Fluids Dynamics (CFD) and data analysis