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 Dongyang Sun (Email: d.sun@napier.ac.uk)
- 2ND SUPERVISOR: tbc

Subject Group: Engineering & Mathematics

Research Areas: General Engineering

Project Title: 3D forming of cellulosic biopolymer materials using electrohydrodynamic atomisation

Project description:

Three-dimensional forming refers to the fabrication of structure through layer-by-layer deposition
of material using a printer head, a nozzle or other printing techniques. It is broadly used in applications including automobile manufacturing, aerospace manufacturing and medical applications. 3D forming enables lighter structure of complex geometries, through 'direct
forming' process thus with low cost and high production rate and additionally, the fruition of personalised products and mass customisation (e.g. forming implants of personalised shapes or
tailored structure in tissue engineering and wound-healing applications).

Cellulose, one of the most abundant polymers on earth, has attracted substantial industrial and research interests in a wide range of applications. Nanocellulose, including cellulose nanofibrils

(CNF) and nanocrystals (CNC), have extraordinary properties and valuable potentials in the area such as in biomedicine, composite and packaging materials and electric devices and so on, because of their renewability, biocompatibility and biodegradation potentials coupled with improved mechanical strength, lightweight properties, optical properties, barrier properties and structuring capabilities. A lot of attempts have been made to process cellulose structures using
conventional 3D printing techniques (e.g. extrusion-based or droplet-based), although some challenges and shortages have been seen.

Electrohydrodynamic atomization (EHDA), also called electrospray technique, is a versatile processing method that utilises both electric and hydrodynamic force applied on liquid. The latter will be delivered through a nozzle and deformed in a stable cone-jet mode at the tip. The jet beneath the cone is eventually broken up into small droplets (atomisation). Recent study has shown that structures as small as 20μm can be deposited under the stable jet, which could be
developed as a novel 3D forming processing method for cellulose structures of micron- or submicron range.

One of the biggest challenges for forming cellulose structure using the above method is the preparation of feedstock fluids containing CNF/CNF, because the formation of stable cone-jet mode in EHDA is determined by the competition of the electric stress and the surface tension stress on the liquid-gas interface and by the kinetic energy of the liquid leaving the nozzle. Various form of feedstock have to be prepared and characterised before being applied in the EHDA process.

The work will also have an opportunity to the intra university collaboration with School of Applied Science to form cellulosic biopolymer structure with tailored biochemical functionality
(e.g. antimicrobial equipment), by the functionalisation of cellulose molecules or incorporation of functional chemicals during the preparation of feedstock fluid.

Candidate characteristics

Education:

A first degree (at least a 2.1) ideally in Materials Science

Subject knowledge:

Polymer engineering

Essential attributes:

- Experience of fundamental laboratory skills
- Competent in electron microscopy
- Knowledge of cellulosic polymers
- Good written and oral communication skills
- Strong motivation, with evidence of independent research skills relevant to the project
- Good time management

Desirable attributes:

- Biomedical engineering