Faculty of Engineering

Summer Research Program 2023-2024

Project Title: Surface charge modification of lignin nanoparticles and its application

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Objective

Develop a new generation of renewable barriers based on waste biomass.

Project Details

Lignin nanoparticle (LNP) is an emerging nanomaterial based on lignin, which is the most abundant bio-based aromatic polymer on Earth. Whilst lignin can be obtained as a by-product of the paper making process, more than 98% of them is just burned for energy due to its complex chemical structure and incompatibility with other polymers, which hampers further valorisation of this bio-based material [1,2]. LNP has been proposed and investigated in the last decade as a pathway to overcome the drawbacks of lignin.

Whilst the particles of pristine lignin from the paper industry, which is often called technical or industrial lignin, are usually in micron scale, the size of LNP typically ranges from 20~30 nm to a few hundreds nm. This smaller size allows LNP to have a better dispersibility and maximise its effect thanks to larger surface areas than pristine lignin. On the other hand, the surface of LNP without any modification is always negatively charged due to phenolic hydroxyl groups and carboxylic groups in the structure, which behave as acid in water. If this surface charge can be efficiently converted to positive, the technique may open a new LNP application, such as nanofillers for composite[3], flocculant for wastewater treatment[4] and bio-based and biodegradable surfactant.

In this project, you will start by optimising the preparation process of LNP to make the material, and exploring several methods to convert the LNP surface charge in published literature. Using the methods, you will try to prepare positively charged LNP and characterise it in terms of some important aspects of LNP, such as particle size and pH in addition to surface charge. As the final step, the positively charged LNP will be used to form films along with nanocellulose matrix. The properties of the obtained films, such as mechanical strength and gas barrier properties, will be also evaluated.

References:

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3. Farooq, M., Zou, T., Riviere, G., Sipponen, M. H., & Österberg, M. (2019). Strong, Ductile, and Waterproof Cellulose Nanofibril Composite Films with Colloidal Lignin Particles. *Biomacromolecules*, *20*(2), 693-704. https://doi.org/10.1021/acs.biomac.8b01364

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