

COLIAD - Production process of colloidal lignin particles

Lignin is one of the most abundant amorphous biopolymers from biomass, and because of its renewability, biodegradability and biocompatibility, bio-refineries, pulp and paper industries are seeking techno-economically feasible way to utilize it from their side-streams and wastes into value-added products. However, because of the low solubility and poor miscibility of lignin, the development of large-scale applications of lignin-based products are limited. This research presents a scalable way to produce water-dispersible and non-toxic colloidal lignin particles (CLP) of ca. 200 nm in size from industrial lignin. The produced CLP's can further be modified with, for instance, oxidative enzymes into reinforced spherical and surface activated lignin for adhesive formation. In this case, CLP's can be used to replace toxic phenol-formaldehydes in wood adhesives. Moreover, as a natural broad spectrum sun-blocker, lignin can introduce UV protection to wood coatings, and these lignin-based coatings are of comparable quality to the commercial wood coatings from nonrenewable materials. Furthermore, the biodegradability of these lignin-based products simplifies the recycling process in the end of their lifecycle.



Key areas of research activities include development of scalable methods for the production of colloidal lignin particles, modifying these particles for applications in wood adhesives and coatings, and modelling work to evaluate potential for scaling-up the processes towards industrial production. The objective is to design and construct a larger laboratory scale production unit of colloidal lignin particles (CLP), gather data from the unit, study the operational (and investment) costs and conduct a feasibility analysis of the process.

CLP have been produced by nanoprecipitation of dissolved lignin with organic solvents. This process produces stable aqueous dispersion of lignin particles, and this research investigates the manufacture and scale-up of the CLP production and the recycling of solvents. The thermodynamic modeling and simulation have been performed to determine and optimize the process conditions such as temperature, pressure, concentration and composition.

A continuous flow tubular reactor was designed and constructed for the formation of uniform CLP dispersion. Successful experiments have been carried out to test the working of the tubular reactor and the industrial scale production (50 kt/a) of CLP's has been simulated with mass balance and process flowsheet. The project includes techno-economic assessment that has been carried out to determine the overall feasibility of the process.

Researchers: Rahul Bangalore Ashok, Yao Xiao

Project-related publications:

Bangalore Ashok, R.P., Xiao, Y., Lintinen, K., Oinas, P., Kostiainen, M.A., Österberg, M. (2019) Self-assembly of colloidal ligning particles in a continuous flow tubular reactor. *Colloids and Surfaces A: Physicochemical and Engineering Aspects*. [Preprint]

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Lintinen, K., Xiao Y., Bangalore Ashok, R.P., Leskinen, Leskinen, T., Sakarinen, E.T., Sipponen, T.M.H., Farooq, M., Oinas, P., Österberg, M., Kostiainen, M.A. (2018) Closed cycle production of concentrated and dry redispersible colloidal lignin particles with a three-solvent polarity exchange method, *Green Chem.* 20, 843-850.

Leskinen, T., Smyth, M., Xiao Y., Lintinen, K., Mattinen, M-L., Kostiainen, M.A., Oinas, P., Österberg, M. (2017) Scaling up production of colloidal lignin particles, *NPPRJ* 32, 586.

Xiao, Y., Golam, S., Oinas, P. (2017) High-quality green wood adhesives and coatings from colloidal lignin nanoparticles" 7th Nordic Wood Biorefinery Conference 28-29.3.2017, Stockholm, Sweden.