# Engineering lignocellulosic nanomaterials: from Pickering emulsions to air-dried high-performance foams

Nissa Nurfajrin Solihat [a,*], Muhammad Farooq [a], Juan José Valle-Delgado [a], Monika Österberg [a]

[a] *Department of Bioproducts and Biosystems, School of Chemical Engineering, Aalto University, Espoo, Finland.*

*nissa.solihat@aalto.fi*

As the main components of plant biomass, lignin and cellulose are natural, renewable and abundant polymers that, in the form of nanoparticles, are a promising and more sustainable alternative to fossil-based materials, in particular in the fabrication of solid foams [1]. Despite growing environmental awareness, preparing mechanically stable solid foams from renewable lignocellulosic building blocks remains challenging. Sufficient solid content is needed to produce foams that resist collapse, yet removing water from such systems at ambient conditions is difficult. Avoiding energy intensive processes such as freeze drying and supercritical drying while retaining foam integrity remains an open challenge, particularly for cellulose-based systems where high concentrations also hinder uniform dispersion. This study aims to reduce drying energy by designing an oil-in-water Pickering emulsion template that enables the fabrication of high-performance dry foams at room temperature without surfactant and cross-linker, and with a scalable process. Lignin nanoparticles (LNPs) served as Pickering stabiliser for an oil-in-water emulsion with a volatile hydrocarbon as the oil phase. As the oil evaporated, it generated pores, while cellulose and polyvinyl alcohol provided structural and mechanical integrity. By tuning cellulose content, this method resulted in high mechanical stability (0.63 MPa compressive stress at 50% strain), low thermal conductivity (36 $mWm^{-1} K^{-1}$) and promising sound adsorption properties [2]. These properties were comparable to those of fossil-fuel-based rigid polyurethane. In addition, we investigated how the surface chemistry of the LNPs affected the type of emulsion obtained. Unmodified LNPs with water contact angle in oil of 82° favor oil-in-water emulsions, whereas chemically modified LNPs with water contact angle in oil of 106° produce water-in-oil, as confirmed by microscopy, electrical conductivity, and surface free-energy analysis. Our findings establish a practical, low-energy platform for manufacturing high-performance renewable-foams from widely available plant resources. Furthermore, the type of emulsion can be tuned by changing the surface chemistry of lignin nanoparticles.

**Keywords:**
Air-dried foam, lignocellulose nanoparticles, Pickering emulsion, wettability

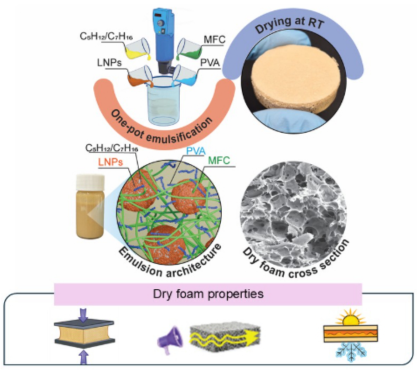


*Illustration on air-dried foam production*

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