# Bioprocessing Strategies for Sustainable Nanocellulose Production from Lignocellulosic Residues

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Growing environmental concerns have increased the focus on sustainable and biodegradable alternatives to plastic-based materials [1]. Among these, nanocellulose (NC) is valued for its renewability, biocompatibility, and functional properties, making it a promising candidate for diverse applications. NC is classified into cellulose nanocrystals (CNCs), cellulose nanofibrils (CNFs), and bacterial nanocellulose (BNC), each derived through distinct processes [2]. For plant-based nanocellulose (CNCs and CNFs), the process typically involves the depolymerization of lignocellulosic biomass to remove the hemicellulose and amorphous cellulose fractions while retaining the recalcitrant nanoscale crystalline cellulose. This can be achieved enzymatically, chemically, or mechanically [2]. In contrast, bacterial nanocellulose (BNC) is synthesized through a polymerization-based process, where bacteria anabolise converts sugars into cellulose [3].

Inspired by these depolymerization and polymerization pathways, we developed a dual bioprocess that integrates both approaches, by utilizing lignocellulosic biomass as a starting material and targeting at the valorisation of all sugar streams. For this purpose, agricultural and forest residual feedstocks were initially subjected to a mild OxiOrganosolv pretreatment process [4], producing a cellulose-rich solid fraction and a hemicellulose rich aqueous liquor. Both streams were subjected to enzymatic hydrolysis and saccharification, where sugar release was quantified using spectrophotometry and other analytical methods. The fermentable sugars released were then used as a carbon source for microbial production of bacterial nanocellulose (BNC) from *Komagataeibacter* sp., while the resulting nanocellulose was subsequently characterized to confirm its properties.  By optimizing the process with various plant biomass sources, enzymatic treatments, and bacterial strains, we directed the system toward either enhanced saccharification (maximizing sugar release for BNC synthesis) or higher retention of cellulose integrity (enhancing CNF yield) [5]. Different enzyme combinations were tested to balance these outcomes, while various carbon sources were evaluated to determine their effectiveness in supporting bacterial strains for optimal nanocellulose production yield. This integrated process maximizes nanocellulose output with minimal input, offering a sustainable and scalable approach to NC production.

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