Sustainable production for efficient and affordable cellulose nanofiber

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Impact in a nutshell

Cellulose nanofibers (CNFs) are tiny cellulosic fibers with a significant social impact due to unique properties that enhance products in a wide range of applications. Their environmental benefits are related to their biodegradability, lightweight nature and renewable origin, making CNFs an eco-friendly alternative to synthetic materials, with a high economic potential impact in green technology sectors.

CNFs provide sustainable bioproducts to replace plastics. In food packaging, nanocellulose could improve the shelf-life of products and enhance food safety by creating barrier properties against contaminants. They may impact energy storage with the development of new types of batteries, supercapacitors and flexible electronics. In medicine, they have potential uses in wound dressings, scaffolds for tissue engineering and as carriers for drug delivery.

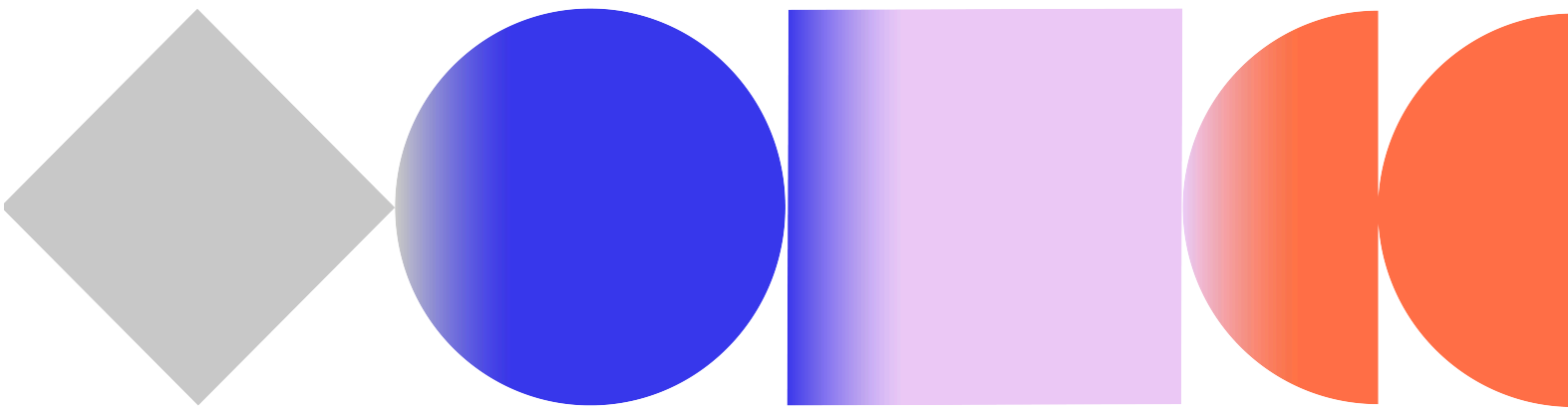
Research details

This research aims to make the CNF production process faster and cheaper and to minimize its environmental impact, facilitating its large-scale implementation.

CNFs can be produced from agricultural and forestry by-products. They are produced through mechanical processes as high-pressure homogenization, which break down the cellulose structure from macro to nanoscale. This energy-intensive process requires pretreatments like TEMPO-mediated oxidation (TMO). TMO reduces energy consumption, but TEMPO is expensive and it is a hazardous substance that can cause harm to aquatic ecosystems.

The main objective of this research is to generate new knowledge on the TMO process to produce CNF more efficiently and sustainably, facilitating its industrial production and application. One of the most notable achievements in this research is the reduction of the catalyst doses by 75% for TEMPO and 50% for NaBr, crucial for lowering both costs and environmental impact. Additionally, the process efficiency has been highly improved by reducing the reaction time from 2 hours to as little as 50 or even 4 minutes, while maintaining the same CNF quality measured by the degree of fibrillation.

Furthermore, it has been possible to reuse 75% of the reaction medium in the TMO process which minimizes the residual effluent, contributing to a more sustainable process. To further improve sustainability, a magnetic catalyst was synthesized, enabling the easy recovery of the TEMPO catalyst from the reaction medium using an external magnetic field.



What is or will be the impact of your research?

The use of CNF technology in different applications may lead to economic benefits through enhanced product value and functionality. Results show a substantial reduction in the amount of chemicals needed in the TMO process. These improvements not only lower production costs but also reduce energy consumption, making large-scale CNF production more economically viable.

Our research represents a significant breakthrough in CNF production efficiency. Reducing production costs is crucial for the economic viability of CNF at industrial scale. The research also focused on minimizing the environmental impact of CNF production.