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# A new type of CNCs: From extraction to applications

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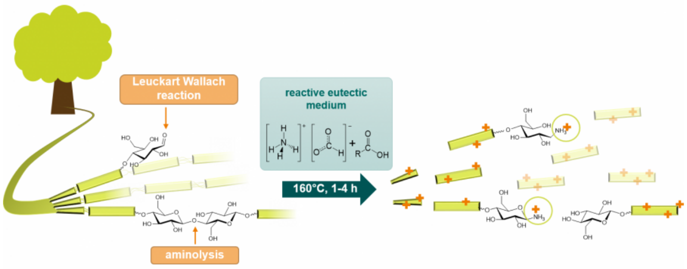
## PURPOSE OF THE ABSTRACT

With ever-increasing environmental pollution, the need for more sustainable and environmentally friendly materials is obvious. Cellulose, the most abundant biopolymer, represents a promising candidate for many applications due to desirable material properties comparable to plastics. However, native cellulose is relatively inaccessible due to strong intermolecular hydrogen bonding, which makes it difficult to dissolve and extract in conventional solvents, let alone in safe and sustainable solvents. Derivatization is possible but involves toxic chemicals and changes the native cellulose structure, aggravating its biodegradability. An alternative approach is to break down the cellulose fiber into colloidal fragments. This is standardly done by hydrolysis in concentrated sulfuric acid, cleaving the amorphous domains and thereby releasing the highly crystalline, rod-shaped cellulose nanocrystals (CNCs), characterized by a high negative surface charge caused by sulfate half ester groups.
Herein, we present an alternative method for the extraction of CNCs with a high thermal stability, a low degree of derivatization, and a low positive charge. This method involves the use of a deep eutectic solvent (DES) made from ammonium formate and lactic acid as a reactive medium, or reactive eutectic medium (REM).[1] Ammonium formate has been chosen as a cheaper alternative to choline chloride, the most common hydrogen bond donor compound used in deep eutectic solvents. Thanks to its smaller molecule size, the use of ammonium formate ensures a higher mobility in the mixture and thus a significant decrease of viscosity compared to choline chloride-based eutectics, facilitating processing. Lactic acid is synthesized sustainably by fermentation of glucose, improving the green credentials of the DES.
While being the reaction medium, the eutectic solvent also serves a functionalization purpose at two sites in the cellulose fiber: It cleaves the ?-1,4-glycosidic bond in the amorphous, more accessible parts, and, with ammonium formate being a Leuckart Wallach reagent, causes reductive amination of the carbonyl group in the reducing end of the polymer chains. Both reactions produce an amino group, which is protonated in neutral and acidic media, yielding positively charged, water-dispersible CNCs as a stable colloidal suspension.
This new type of low positively charged CNCs expands the scope of classic CNCs, which is explored in this talk. Potential applications include Pickering emulsifiers in emulsion gels for direct ink writing, enabled by their low surface charge which ensures wettability in both aqueous and oil phase without requiring additional functionalization, as is necessary in the case of sulfonated CNCs.[2] CNC-stabilized Pickering emulsions are explored as a platform for additive manufacturing in multiple fields, including tissue engineering, where the CNCs' biocompatibility and biodegradability due to the low degree of modification are especially appreciated. Moreover, the new CNCs find applications as immobilizers for functional fluids like ionic liquids or DESs, enabling high-end applications such as gas separation or conductive membranes or gels. In fact, the use of ion-conducting DESs allows to build semi-solid electrolytes that can be used in harmless and biodegradable electrical components. Here, the REM-extracted are especially attractive due to their high thermal stability, which is an important criterion

for such devices.

## FIGURES




### FIGURE 1
Overview of the process of CNC extraction using a reactive eutectic medium

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### FIGURE 2


## KEYWORDS
deep eutectic solvents | cellulose nanocrystals | sustainable materials | biomass


## BIBLIOGRAPHY

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[2] Chunxia Tang et al., Langmuir 2018, 34 (43), 12897-12905