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Efficient extraction and functionalization of cellulose nanocrystals through hydrochloric acid hydrolysis under hydrothermal conditions

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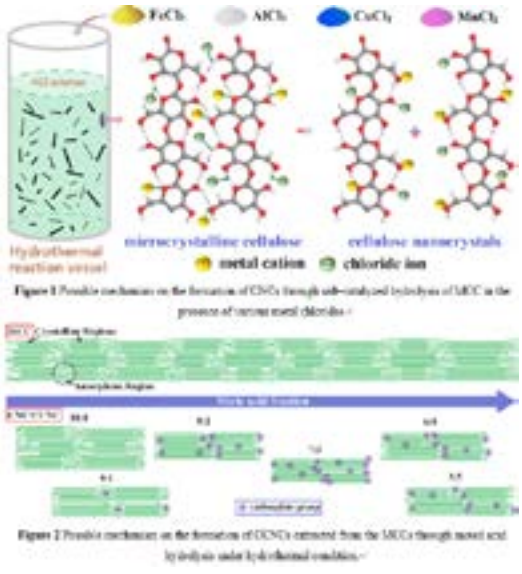
A facile and efficient approach to prepare cellulose nanocrystals (CNCs) is presented through hydrothermal procedure by using inorganic chlorides as catalyst. The role of inorganic chlorides including ferric chloride hexahydrate ($FeCl_3 \cdot 6H_2O$), copper chloride dihydrate ($CuCl_2 \cdot 2H_2O$), aluminum chloride ($AlCl_3$) and manganese chloride tetrahydrate ($MnCl_2 \cdot 4H_2O$) played on the extraction and properties of high quality CNCs were determined. It is observed that the introduction of inorganic chlorides obviously enhanced the hydrolysis process through faster degradation of disordered region of cellulose. Compared with those for pure hydrochloric acid hydrolysis, smaller diameter and larger length to diameter ratio of CNCs could be obtained through salt–catalyzed hydrolysis. In addition, carboxylated cellulose nanocrystals (CCNCs) could be obtained by a similar one–step procedure through a mixed acid system of hydrochloric acid and nitric acid (HCl/HNO_3). It is found that the addition of nitric acid could not only promote the conversion of surface groups on the CNCs, but also have significant influences on the yield, particle size and microstructure of CNCs. For the volume ratio of HCl/HNO_3 of 7:3, the as–prepared CCNCs exhibited the largest length to diameter ratio and narrowest dimension distributions as well as maximum degree of oxidation of 0.12. Furthermore, high dispersion stability for the CCNCs could be observed due to the existence of negative carboxyl groups. These results show that the using of salt–catalyzed hydrolysis especially ferric chloride has a significant improvement on achieving high quality CNCs and the mixed acid system treatment could greatly simplify the preparation of CCNCs with high yield and high crystallinity under mild hydrothermal conditions.



Biography

Miao Cheng is a student at College of Materials Science and Engineering at Donghua University. His research interests involve the sustainable production of materials from biomass, development of high performance nanocomposites with the incorporation of cellulose nanocrystals, extraction and functionalization of cellulose nanocrystals, and all-cellulose nanocomposites.

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