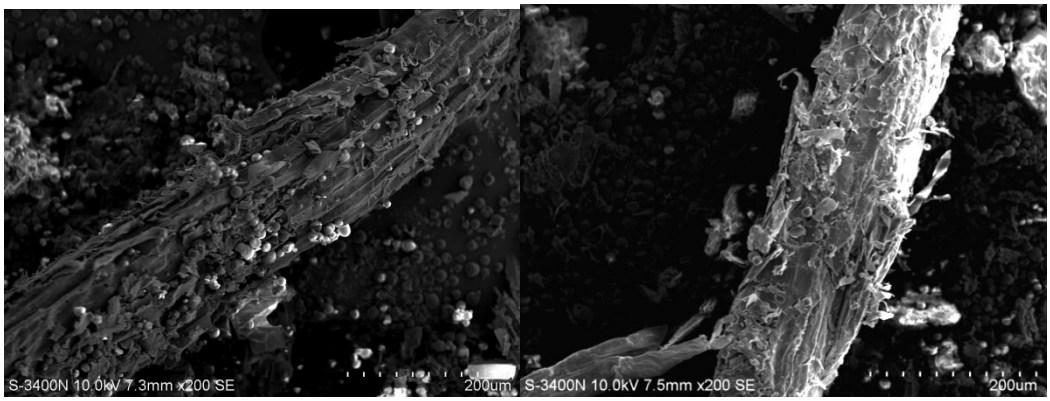
Supplementary Information

Title: Properties of thermoplastic starch films reinforced with modified cellulose nanocrystals obtained from cassava residues



(200×) (200×)

Figure 1 SEM images of raw cassava residues

The SEM images shown that the size of raw cassava residue fiber is micrometer. CNC prepared by mechanochemical method in this manuscript, which size reduced obviously to 6.281 diameter nm and 437.232 nm length. So the particle size is significantly reduced.

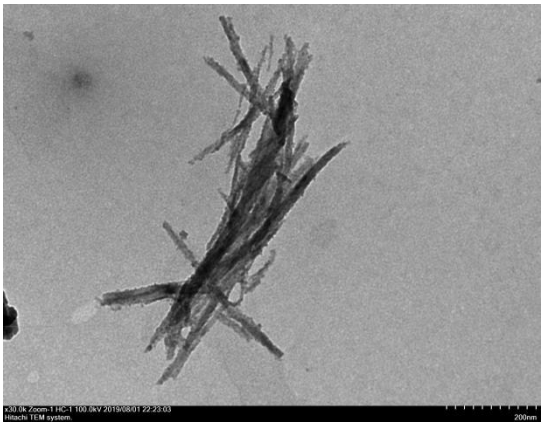
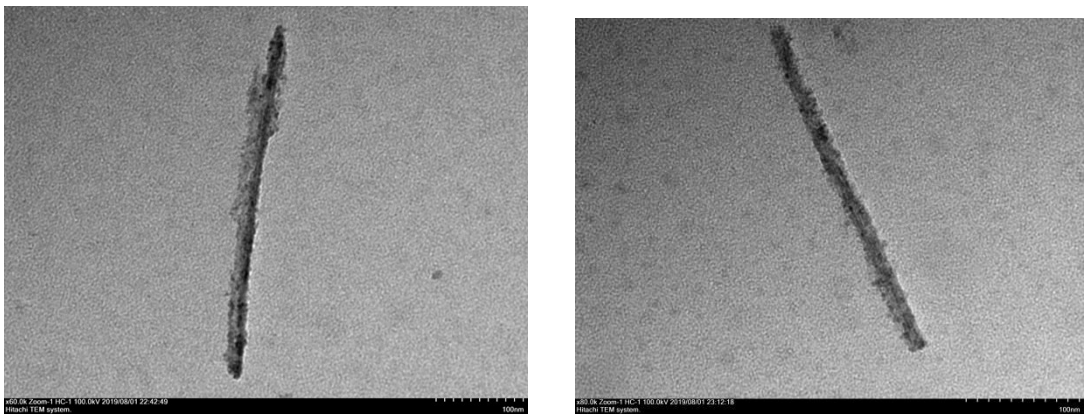


Figure 2 TEM image of aggregated cellulose nanocrystals(30000×)

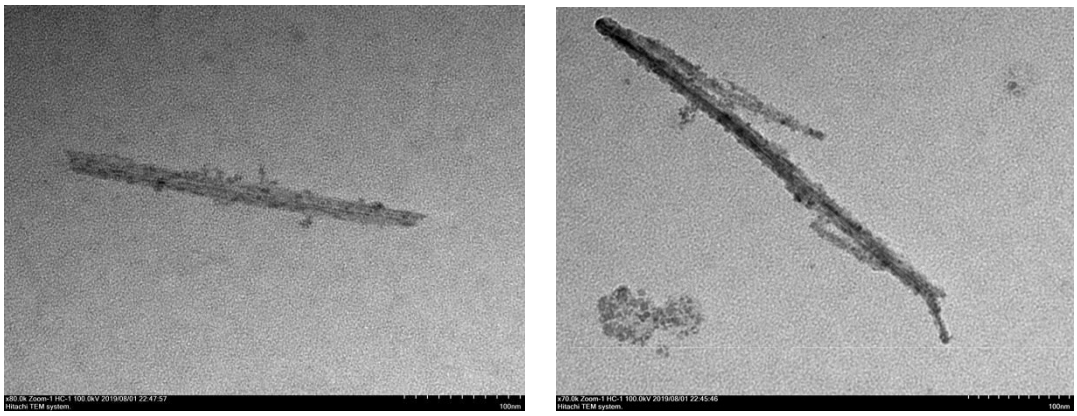
The aggregation of CNCs was due to the large specific surface area of CNCs with a small particle size and multitudinous active hydroxyl groups on the surface.



(60000×) (80000×)

Figure 3 TEM images of a cellulose nanocrystal

The cellulose is exposed, which enlarges the contact area and specific surface area, this is conducive to esterification modification, providing an improved hydrophobic effect.



(80000×) (70000×)

Figure 4 TEM images of a modified cellulose nanocrystal

The modified cellulose nanocrystal still maintains a needle-like structure. The morphology of M-CNC has no apparent change compared to CNC.

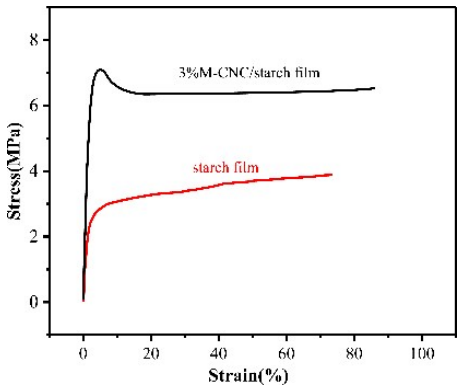
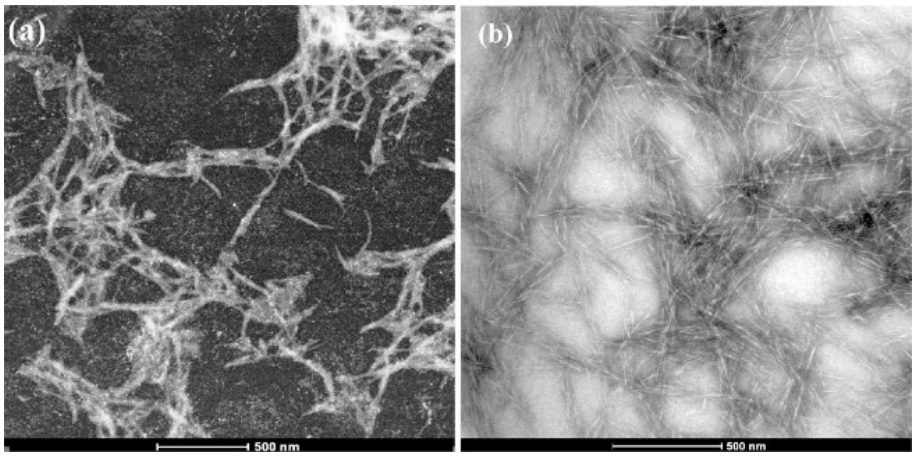


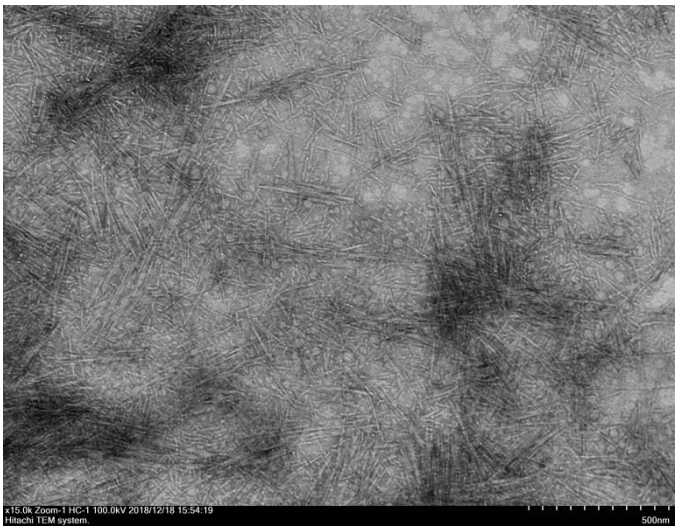
Figure 5 Stress–strain curves of composites

The tensile strength of 3% M-CNC/starch film is 66% higher than starch film, and the elongation at break of 3% M-CNC/starch film is 85% higher than that of the starch film.



(1) CNC extracted by sulfuric acid hydrolysis (Screenshot from Reference 20)

Reference[46]: Travalini, A. P, Prestes, E, Pinheiro, L. A, Demiate, I. M, Extraction and Characterization of Nanocrystalline Cellulose from Cassava Bagasse, Journal of Polymers and the Environment, 2018,26(4): 789-797.



(2) CNC extracted by mechanochemical method (15000×)

Figure 6. TEM images of CNC by two methods

The cellulose rods had a certain degree of agglomeration for three samples in Figure 6. Comparing the TEM images of the CNC prepared by sulfuric acid hydrolysis and mechanochemical method, we can find that this average size of CNC by mechanochemical method (see Figure 6 (2)) is smaller than that obtained by the acid hydrolysis treatment (see Figure 6 (1)) .