Nanolime Templated Cellulose Nanofibers for Controlled Atmosphere (CA) Food Packaging Films

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- Objectives
- Preparation of cellulose nanofibers (CNF)
- Growth of $Ca(OH)_2$ nanoparticles on CNF
- Carbonation and CO_2 control
- Preparation of packaging material
- Concluding remarks

Controlled Atmospheric Packages

- Respiration of fruits and vegetables varies with the temperature of the surrounding atmosphere.
- Therefore, oxygen and carbon dioxide concentration in the enclosed food packaging vary due to the respiration of fresh produces and also the permeability of the packaging film.
- An intelligent packaging material has to control the confined atmosphere of food by allowing slow but reduced oxygen absorption of the produce and forming a selective barrier to carbon dioxide and water vapor.
- Thus, the packing film creates a modified atmosphere that internally regulates gas composition within the package, regulates the ripening process, and extends the postharvest life of packaged fresh produces.

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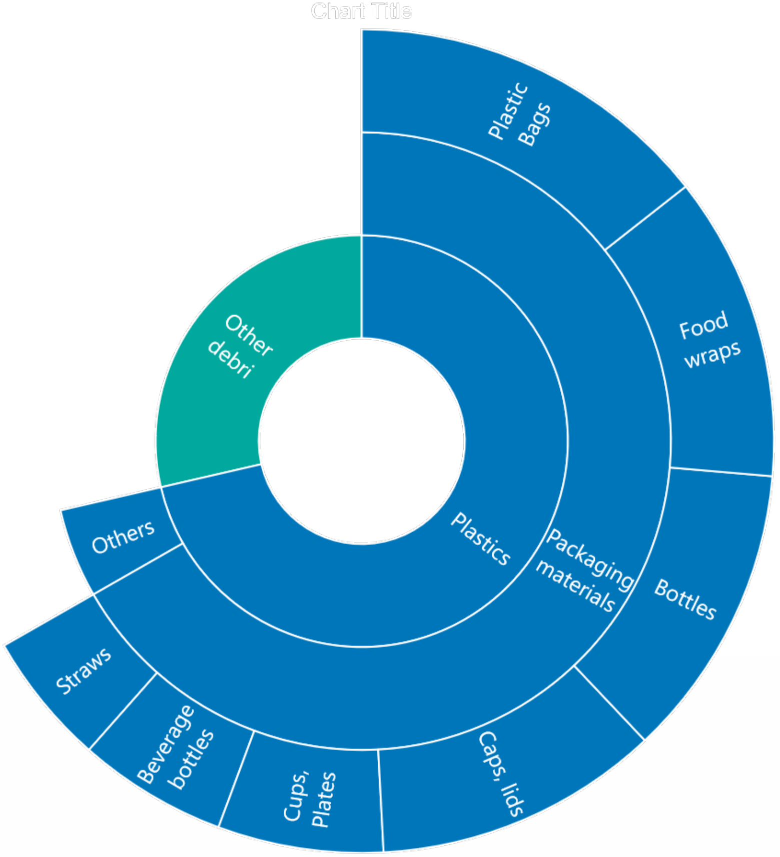
Passive Packaging

Modified atmosphere Packaging

Active Packaging

Microplastics: Marine Anthropogenic Litter



Melanie Bergmann, 'Marine Anthropogenic Litter', Springer, 2015

Preparation of Cellulose Nanofibers (CNF)

Cellulose nanofibers are prepared following the procedure:

- *Harwood BCTMP*
- *TEMPO mediated oxidation following:*

T. Saito, A. Isogai, TEMPO-mediated oxidation of native cellulose. The effect of oxidation conditions on chemical and crystal structures of the water-insoluble fractions, Biomacromolecules, 5 (2004) 1983-1989.

- *Mechnical defibrillation by Supermasscolloider*

http://www.masuko.com

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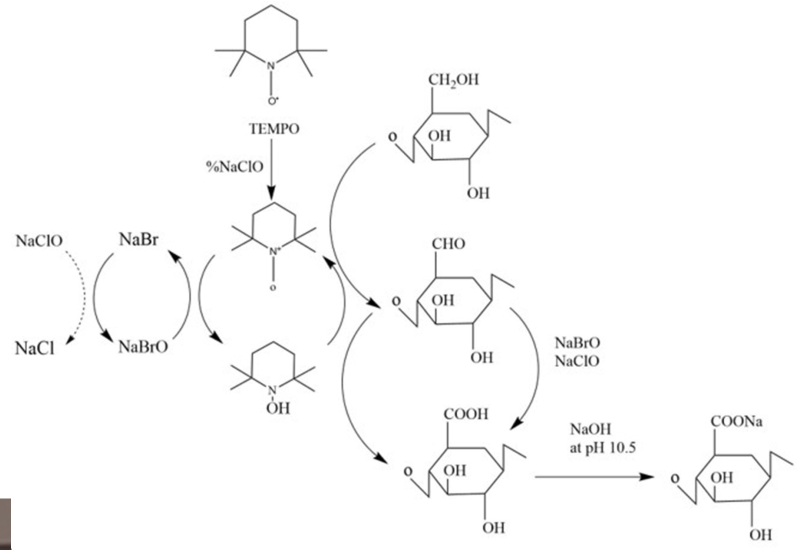
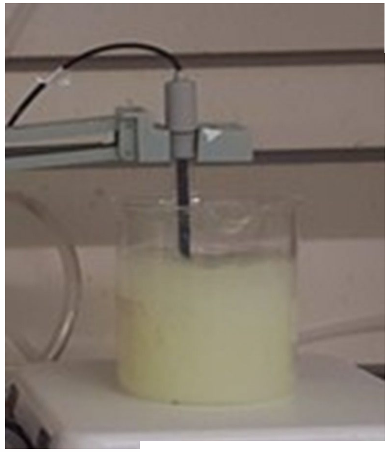
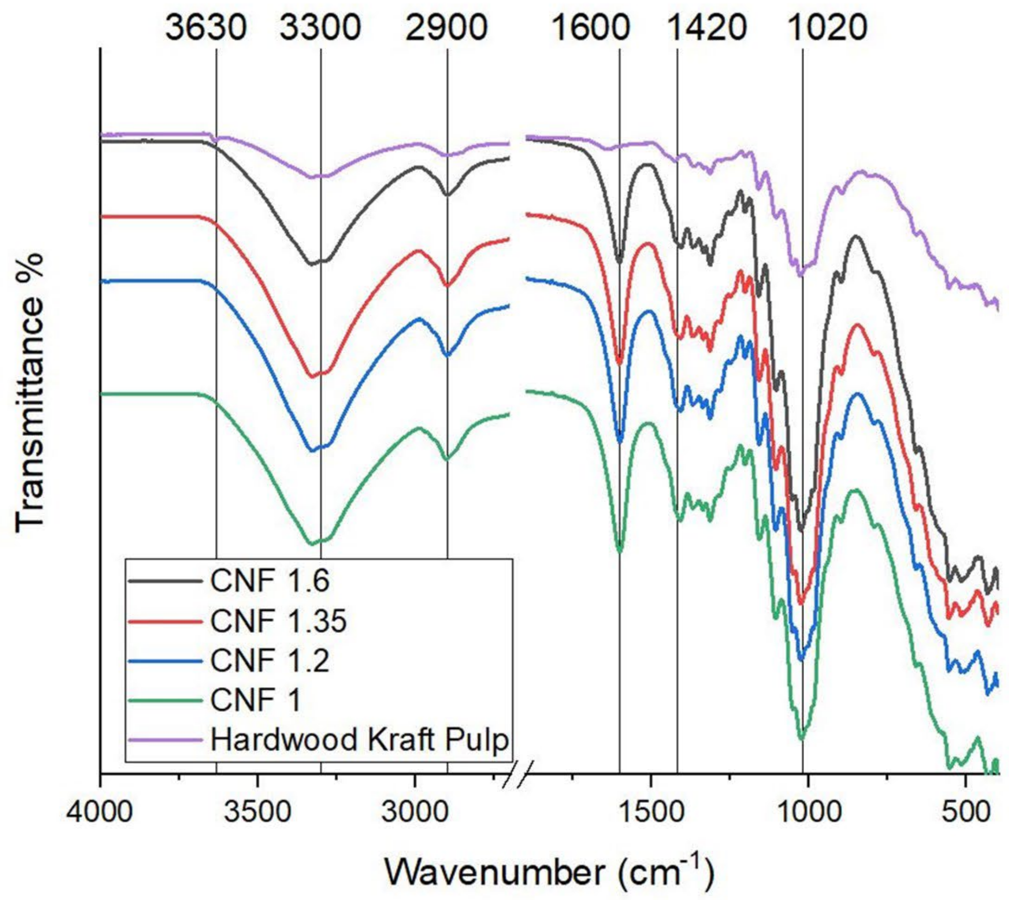




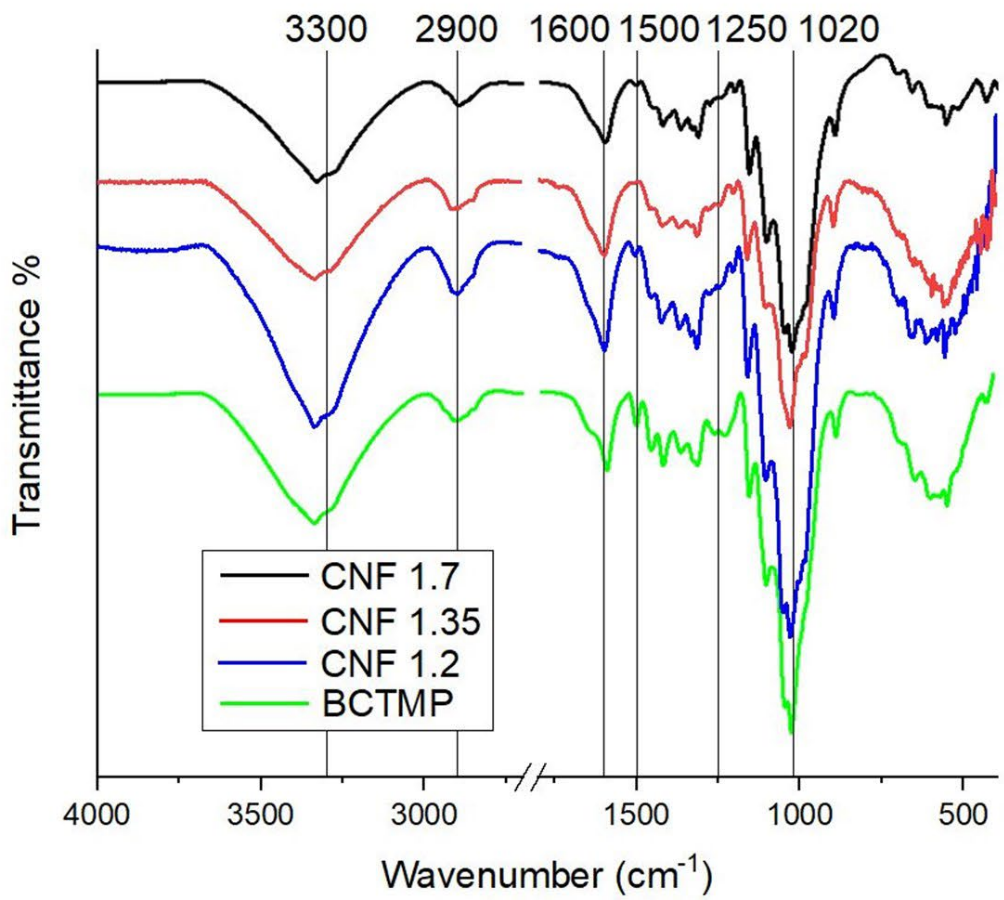
TEMPO oxidation

Mechanical Defibrillation

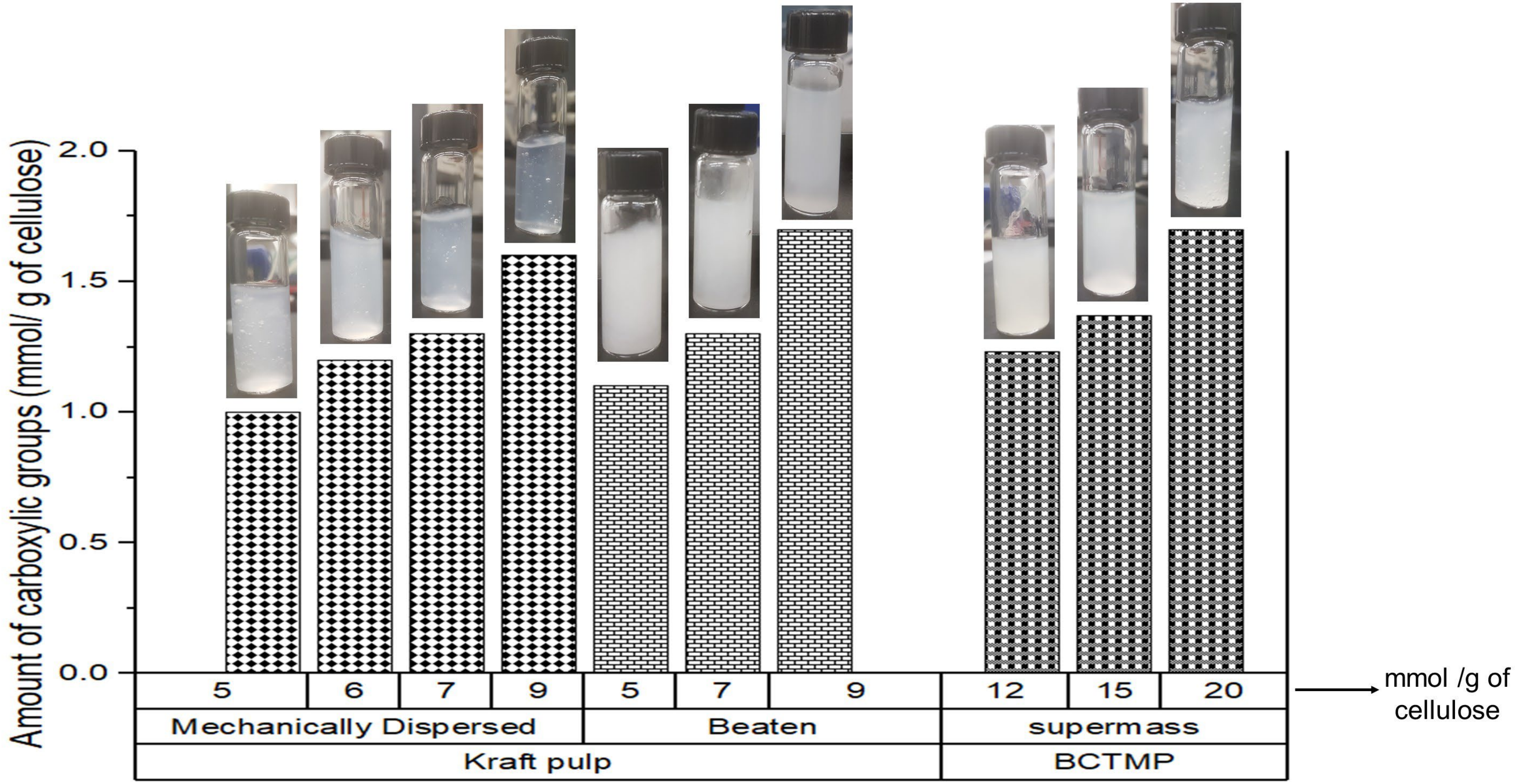
CNF - Kraft pulp



CNF - BCTMP

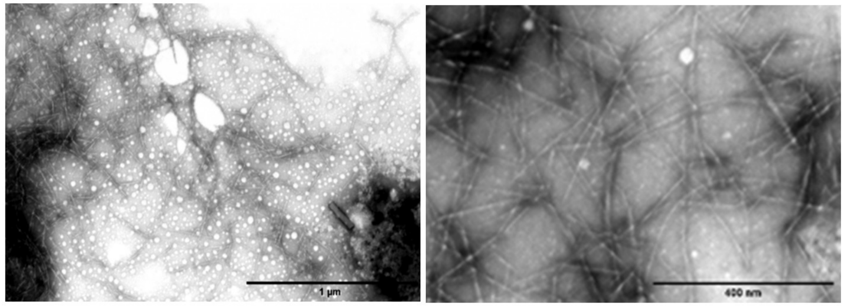


Extent of oxidation

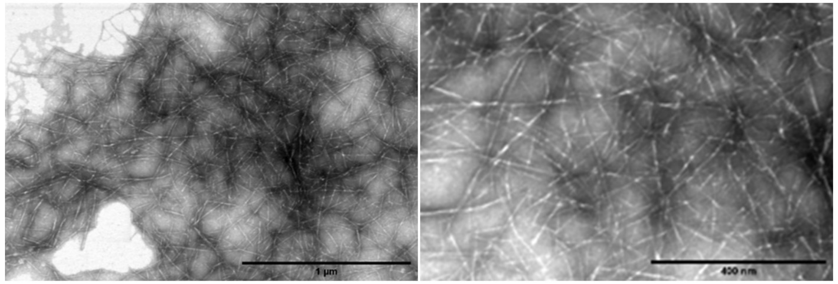


TEM – CNF made from Beaten Kraft pulp

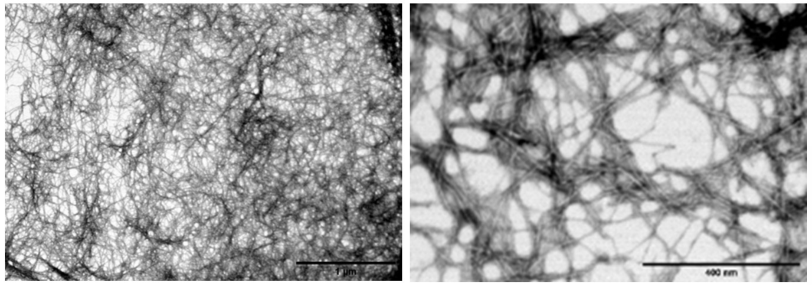
CNF COO- 1.7 mmol



CNF COO- 1.3 mmol



CNF COO- 1.1 mmol



Nanolime Templated Cellulose Nanofibers

Growth of $Ca(OH)_2$ nanoparticles on CNF

Growth of $Ca(OH)_2$ Nanoparticles Without Cellulose Nanofibers

❖ Reaction condition:

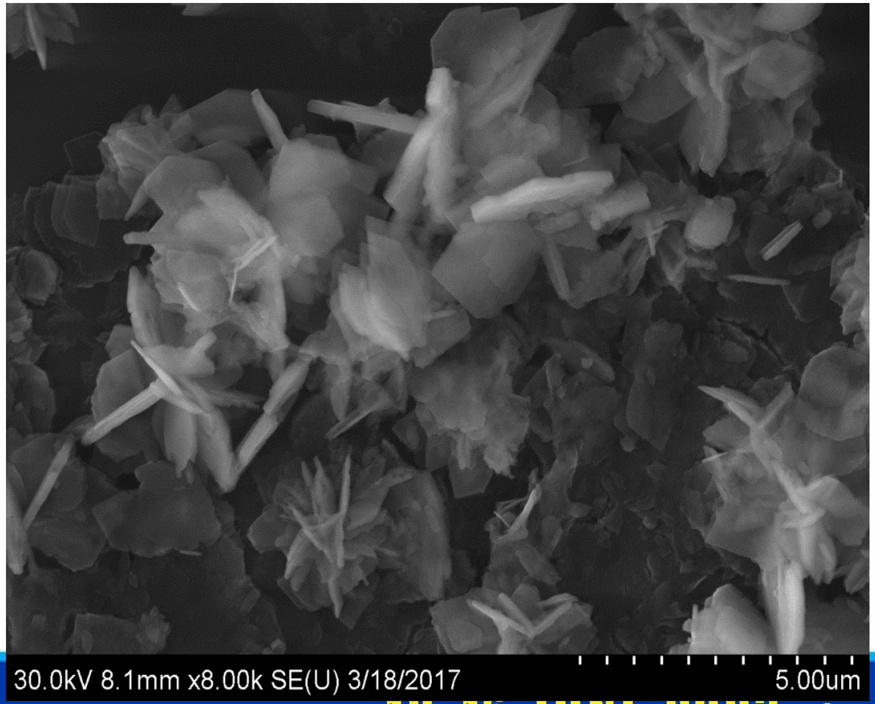
1.25 mL (0.4M) $Ca(NO_3)_2$ + 1.25 mL (0.4M) NaOH

Sol-gel and solvothermal synthesis

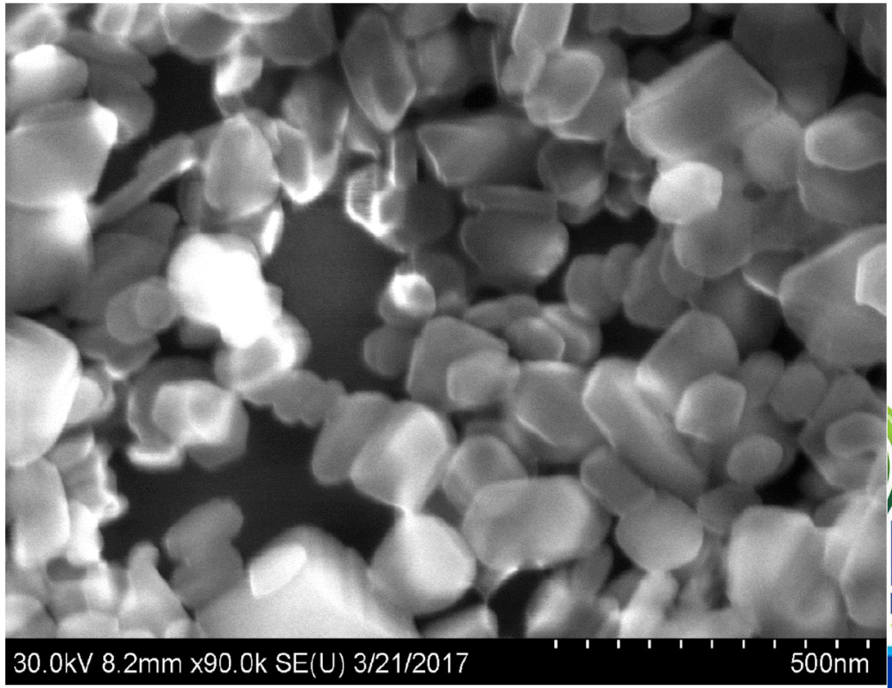
IBZ - Salzchemie GmbH & Co. KG
https://ibz-freiberg.de/en/our-company

using an alkoxide route were given the trade name CaLoSil®

SEM image after 90min reaction in water



SEM image of CaLoSil®

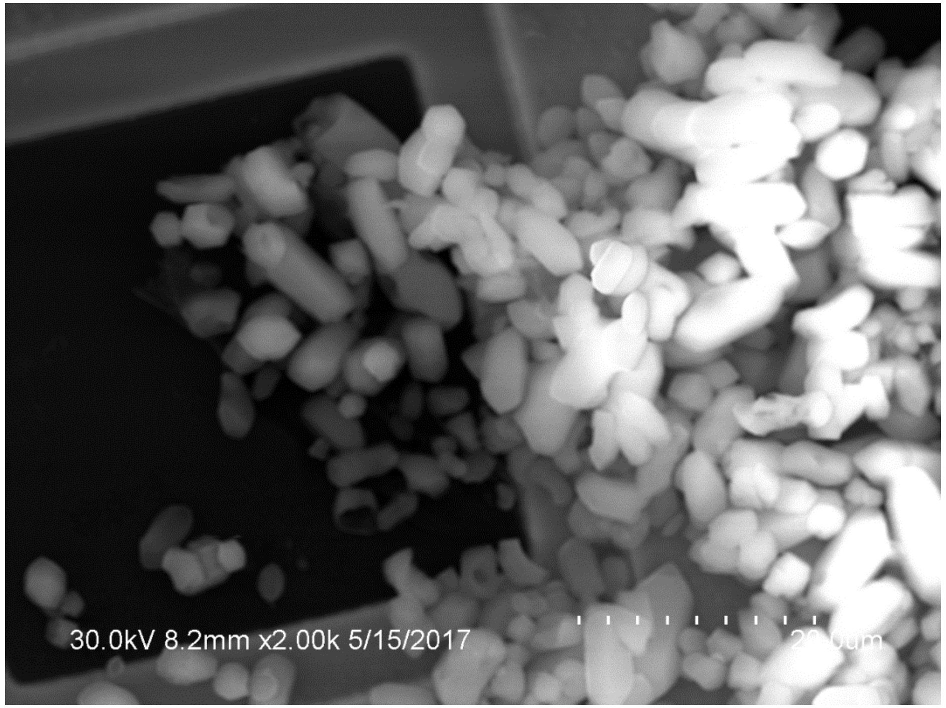


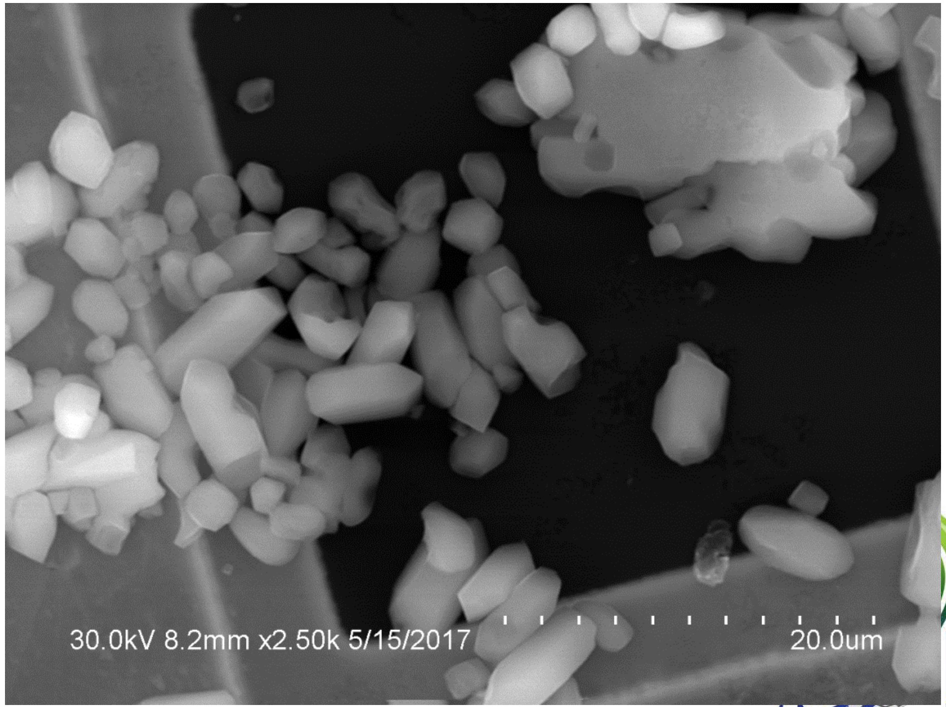
Growth of $Ca(OH)_2$ Nanoparticles on CNF (0.1%)

Reaction MEB-214: *Small scale*

1 mL (0.1% CNF) (0.7mmol/g COOH) + 2.5 mL (0.4M) Ca(NO3)2 + 2.5 mL (0.4M) NaOH

SEM images af 1h Reaction after 6 days suspension in water



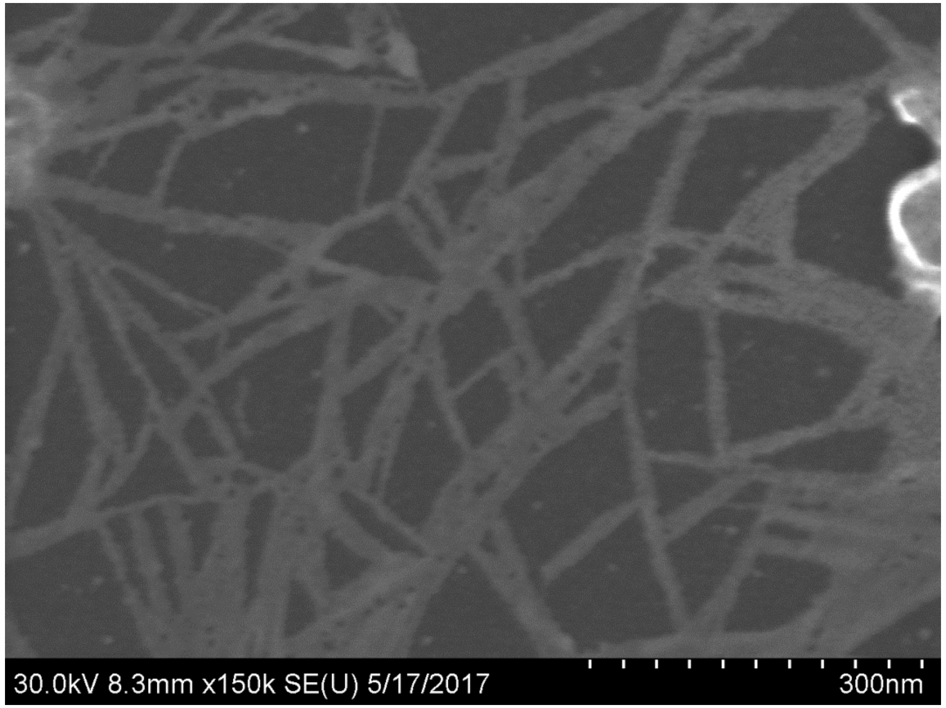


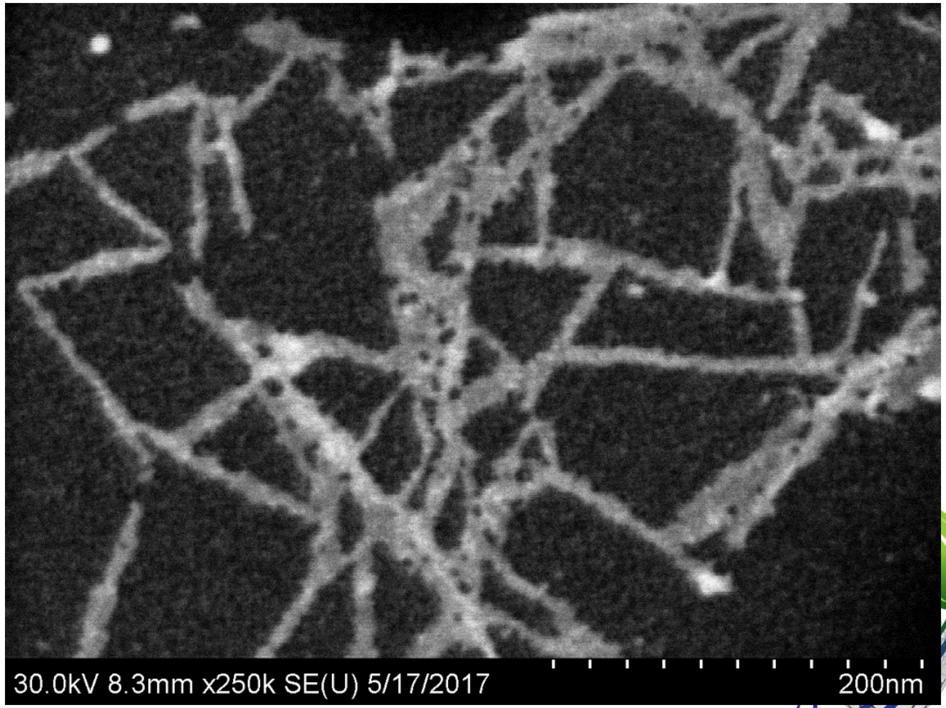
Growth of $Ca(OH)_2$ Nanoparticles on CNF (0.3%)

Reaction MEB-222: ***Medium scale***

100 mL (0.3% CNF) (0.7mmol/g COOH) + 250 mL (0.4M) Ca(NO3)2 + 250 mL (0.4M) NaOH

SEM images af 1h Reaction after 1 day suspension in water





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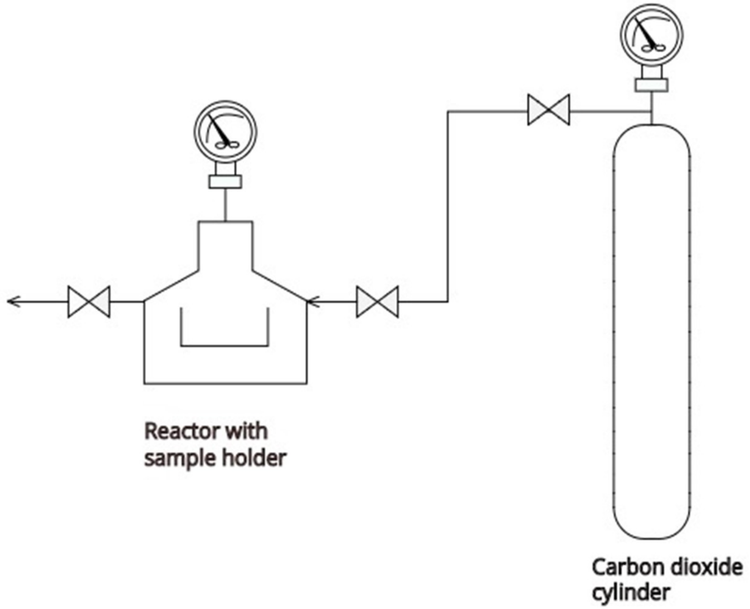
Carbonation of Nanolime Particles

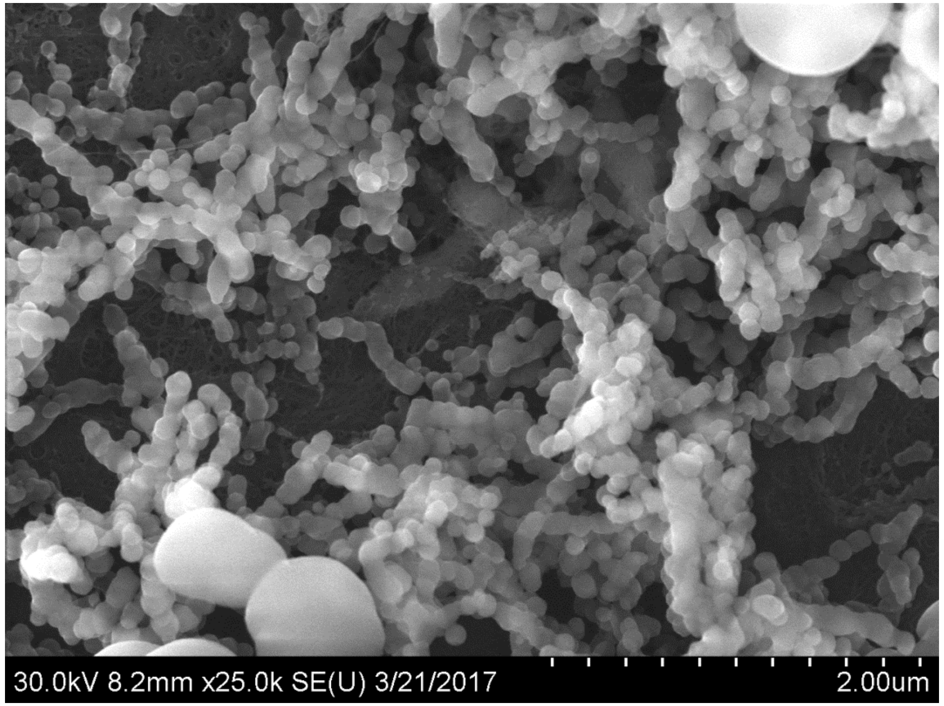
Experimental Setup

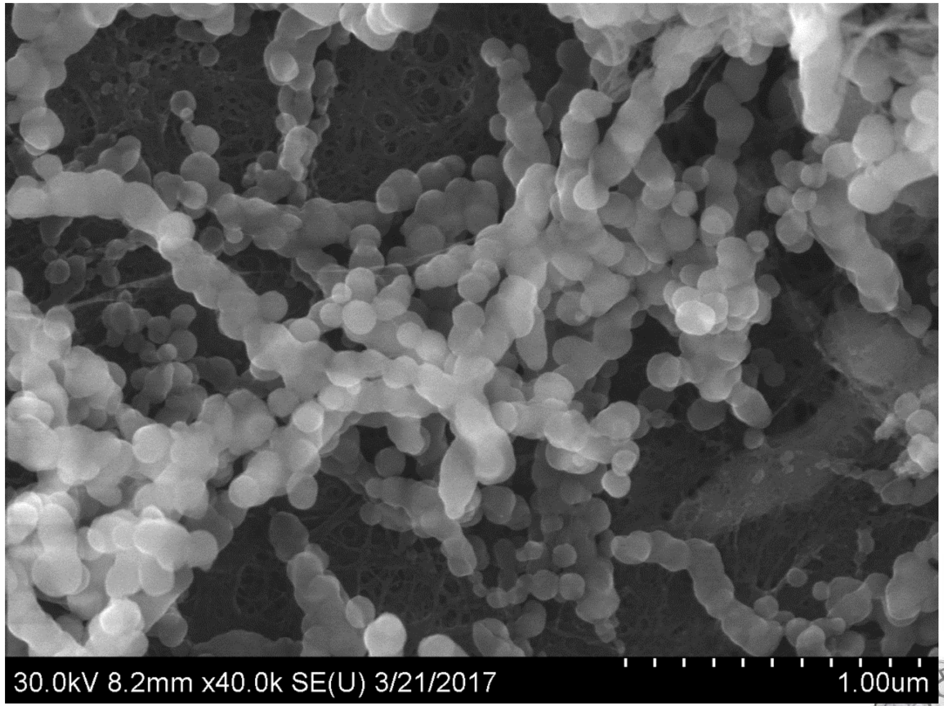
- 50% CO_2 – Air cylinder
- CO_2 pressure
- RH% was maintained at 100% by placing a vial filled with water
- Samples were removed after 7 days



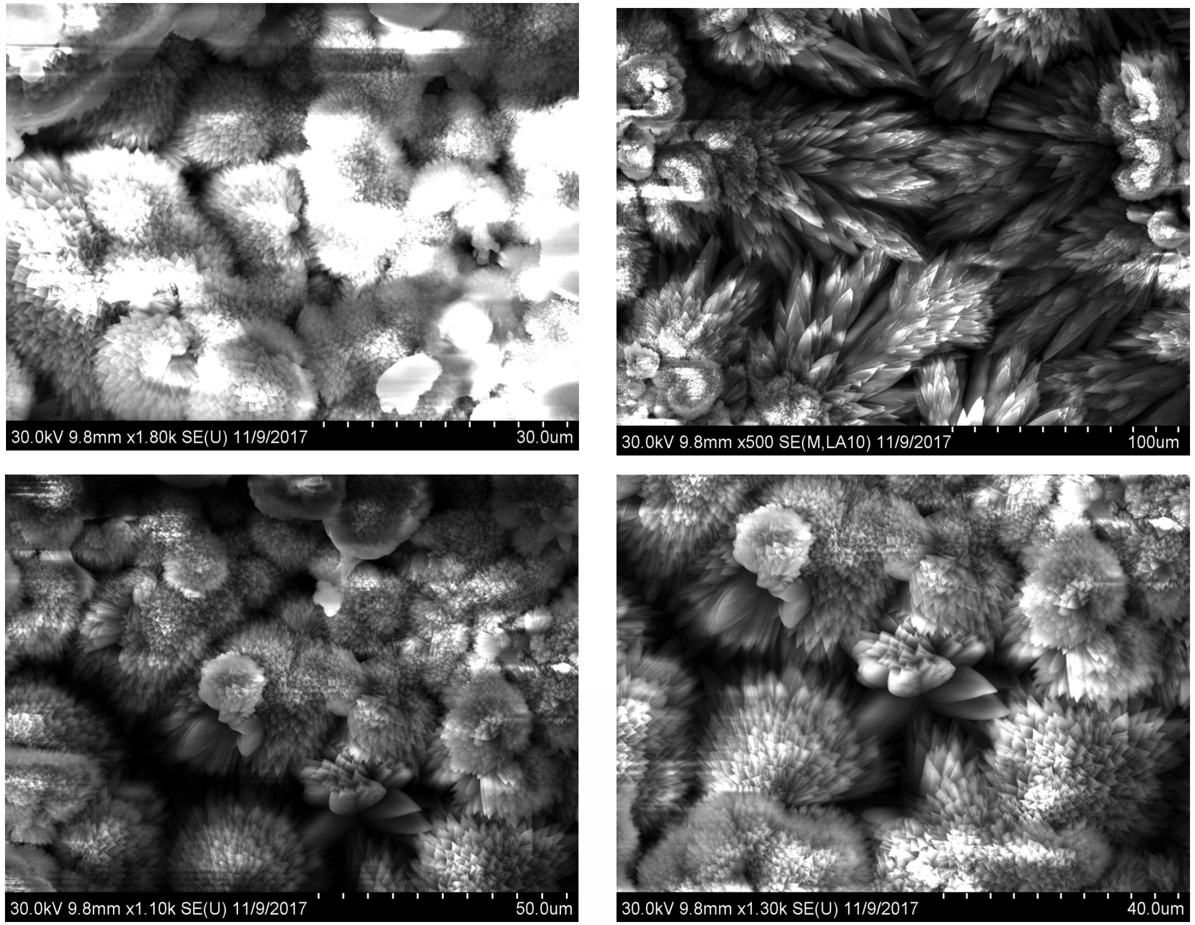
Growth of $Ca(OH)_2$ Nanoparticleson CNF

SEM images after 4 days suspension in water





Carbonation in CO2-rich atmosphere



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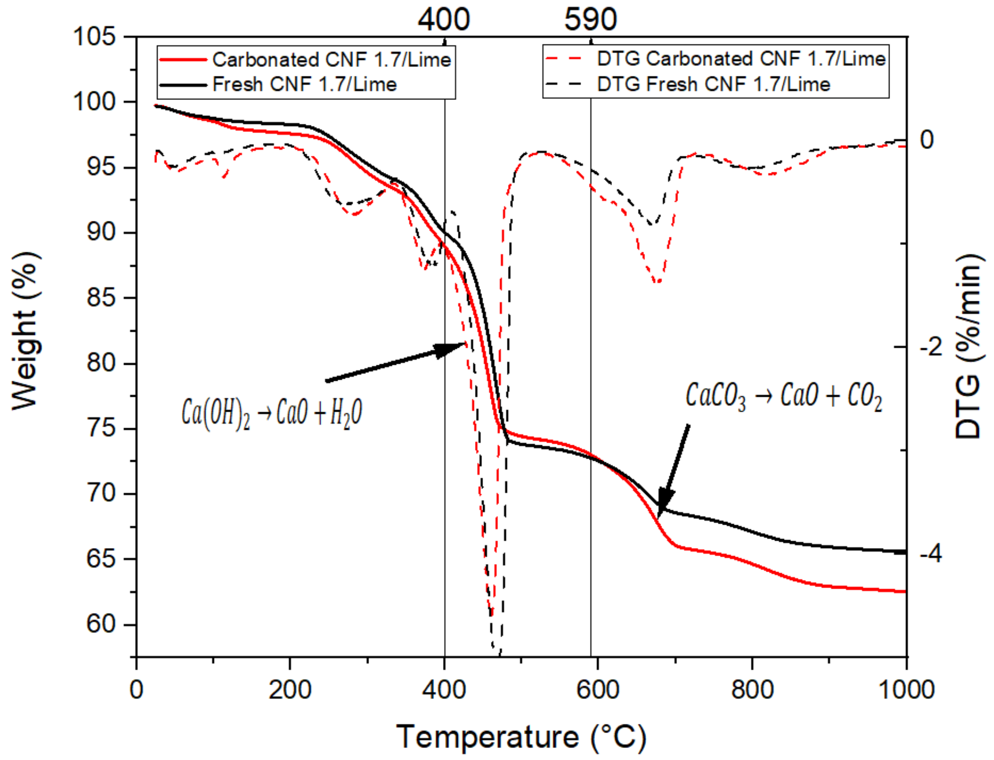
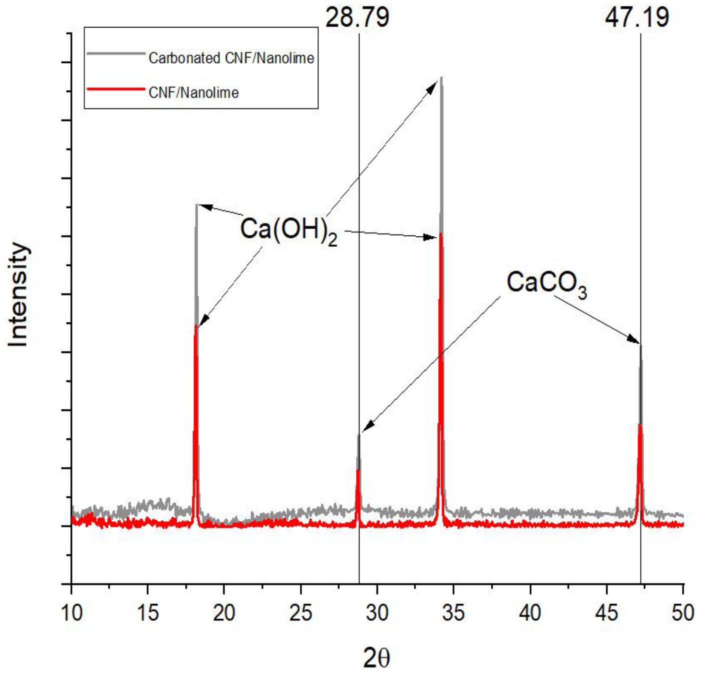
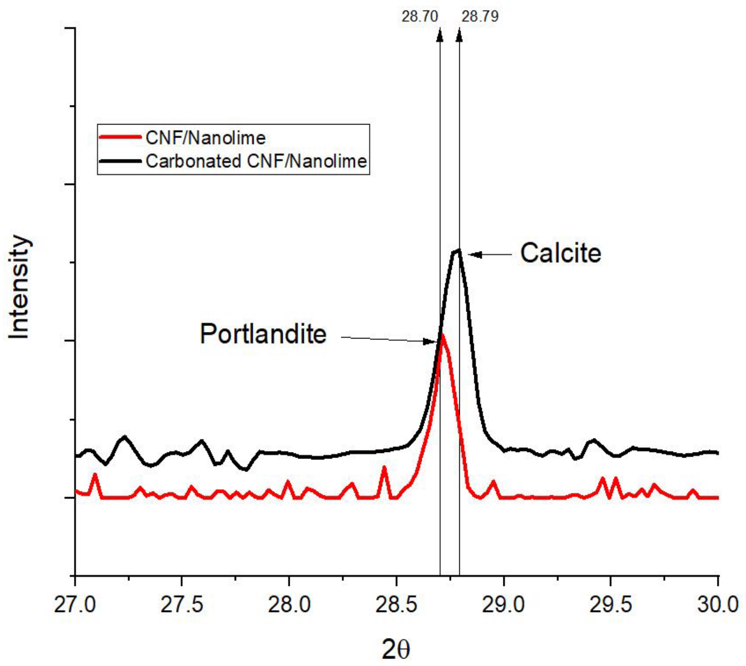
CNF-1.7/Lime Fresh vs Carbonated

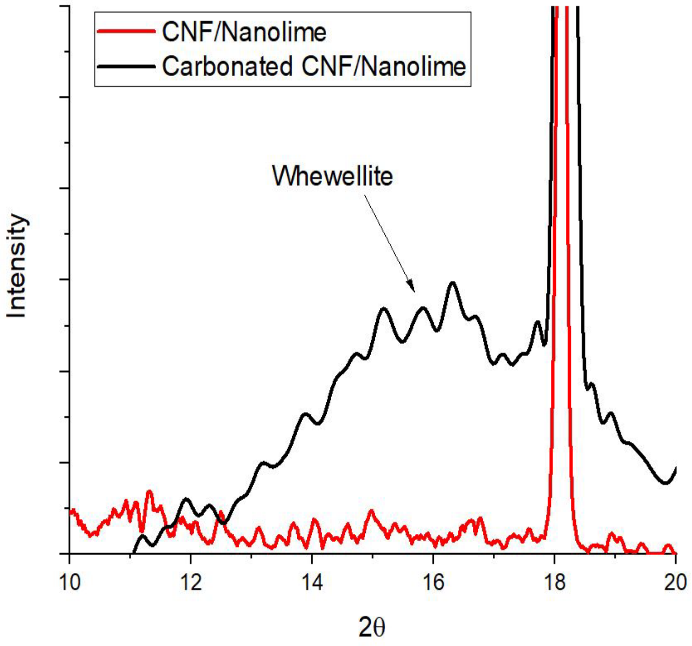


X-ray diffraction

CNF-1.35/Lime Fresh vs Carbonated

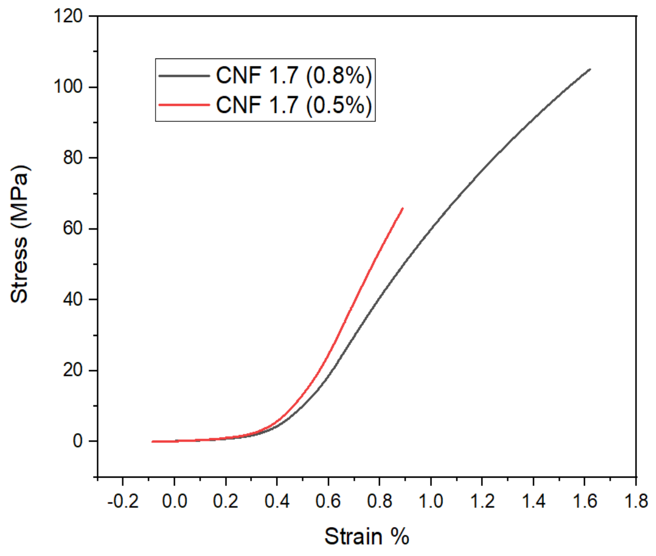


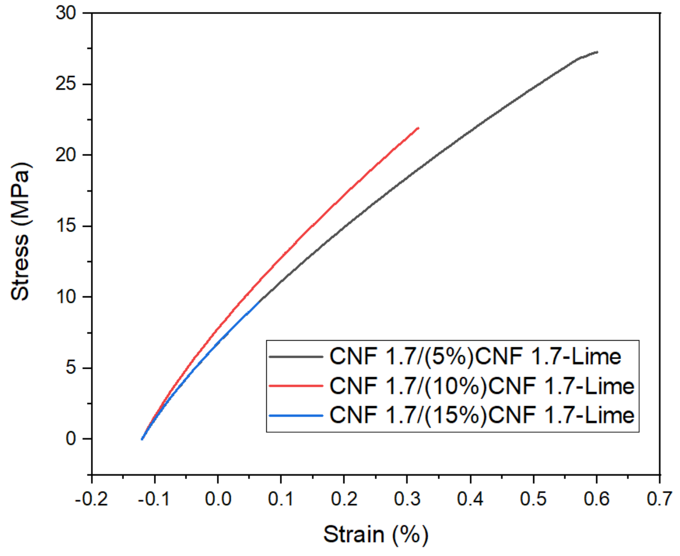


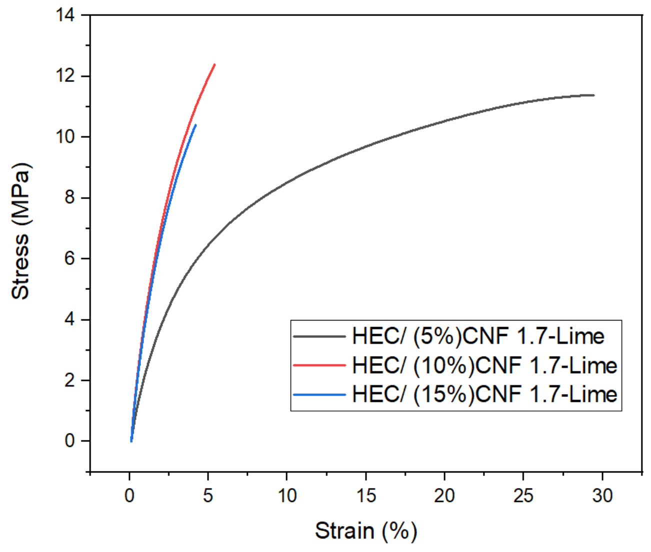


Preparation of Nanolime templated CNF coated paperboard

Cellulose Nanofiber	Cellulose Nanofiber blended with CNF 1.7/Lime	CNF and HEC blended with CNF 1.7/Lime







BOX coated with HEC

BOX coated with HEC + 10% CNF 1.7/Lime

Concluding Remarks

- TEMPO-prepared carboxylate CNF surfaces are excellent templates for growing nanosized $Ca(OH)_2$.
- Nanosized Ca(OH)2 particles are good means to control CO_2 adsorption.
- Nanolime-deposited CNF particles can be used to coat paperboard and prepare boxes for fresh food packaging.

Thank you

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