Correlative characterizations of structure and properties of ZnO/cellulose nanocrystal hybrids

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Correlative Characterization of Structure and Properties of ZnO/Cellulose Nanocrystal Hybrids

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Background

Food Loss& Waste Problems

FIGURE 6. Estimates of Food Loss and Waste across the Food Supply Chain in North America

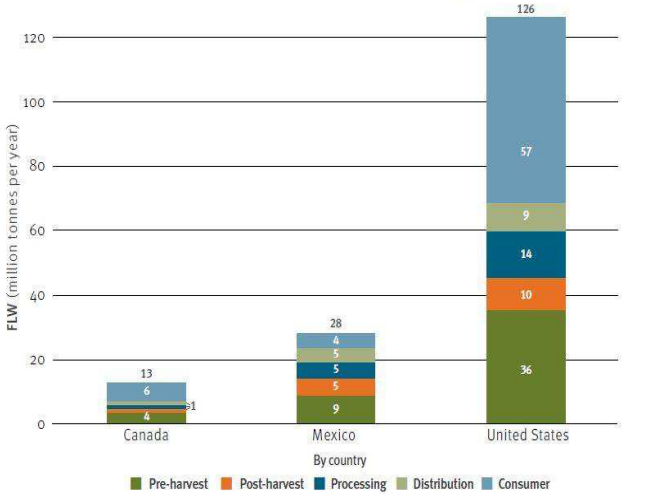


TABLE 5. Approaches to Source Reduction of Food Loss and Waste

Approach	Description	Causes of FLW Addressed by Approach	Stages of Food Supply Chain Involved*
1 Reducing Portion Sizes	In foodservice settings, reducing portion sizes as a way to reduce plate waste, either through serving smaller portions or making operational changes that encourage customers to take less food.	▪ Over-preparing ▪ Over-serving ▪ Plate composition ▪ Use of trays	▪ **Foodservice**
2 Increasing Marketability of Produce	Accepting and integrating second-grade produce into retail settings, typically sold at a discounted rate.	▪ Grading requirements for size and quality as set by retail and/or government ▪ Inaccurate forecasting of supply and demand ▪ Increasing merchandising standards ▪ Rejection of shipments	▪ **Post-Harvest** ▪ Processing ▪ Distribution ▪ **Retail** ▪ Foodservice
3 Standardizing Date Labels	Collaborating among stakeholders to standardize date labels so they are clear and consistent, to reduce confusion at all stages of the food supply chain.	▪ Inaccurate forecasting of supply and demand ▪ Inconsistent/confusing date labels ▪ Food safety concerns	▪ **Processing** ▪ **Distribution** ▪ **Retail** ▪ Foodservice
4 Implementing Packaging Adjustments	Collaborating among processors, packagers, retail and foodservice to improve shelf-life, using both packaging and sizing (e.g., flexible pack sizes to meet customer demands) and technology (e.g., intelligent packaging).	▪ Damage during transport ▪ Inconsistent/confusing date labels ▪ Cold-chain deficiencies ▪ Food safety concerns ▪ Over-purchasing	▪ Post-Harvest ▪ **Processing** ▪ **Distribution** ▪ **Retail** ▪ Foodservice
5 Improving Cold-Chain Management	Improving or upgrading infrastructure such as trucks, cold rooms and warehouses to maintain appropriate food temperatures during transportation.	▪ Rejection of shipments due to spoilage ▪ Cold-chain deficiencies ▪ Inappropriate storage conditions (e.g., temperature not regulated or does not meet sanitary standards)	▪ **Post-Harvest** ▪ Processing ▪ **Distribution** ▪ **Retail** ▪ Foodservice
6 Expanding Value-Added Processing	Extending the usable life of food through processing into shelf-stable products, including processing byproducts into food products through innovative technologies.	▪ Low market prices and lack of markets for second-grade products ▪ Damage from handling ▪ Inaccurate forecasting of supply and demand ▪ Cold-chain deficiencies ▪ Trimming and culling	▪ Post-Harvest ▪ **Processing**

CEC. 2017. Characterization and Management of Food Loss and Waste in North America. Montreal, Canada: Commission for Environmental Cooperation. 48 pp.

Renewable, Smart Packaging

Blending CNC nanorods with the renewable-derived packaging only adds passive reinforcement.

Interested in multifunctional, smart, renewable packaging solutions.

Add smart functionality to CNC particles by synthesizing designer hybrids with active materials.

Degenerately doped ZnO nanoparticles for optical sensing of biogenic amines -> smart, renewable packaging that can sense meat spoilage.

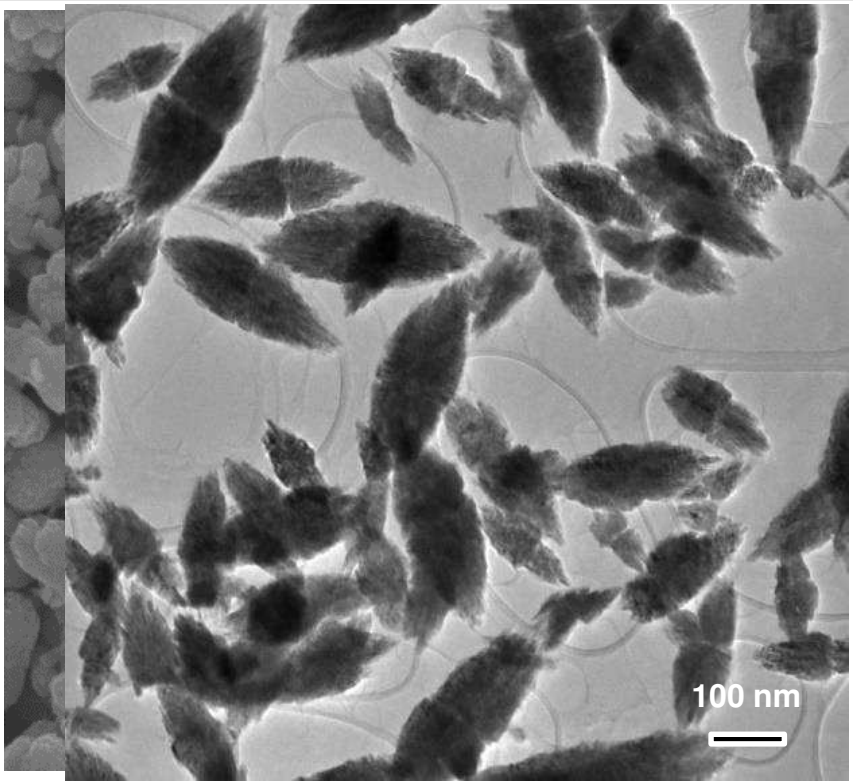
Renewable

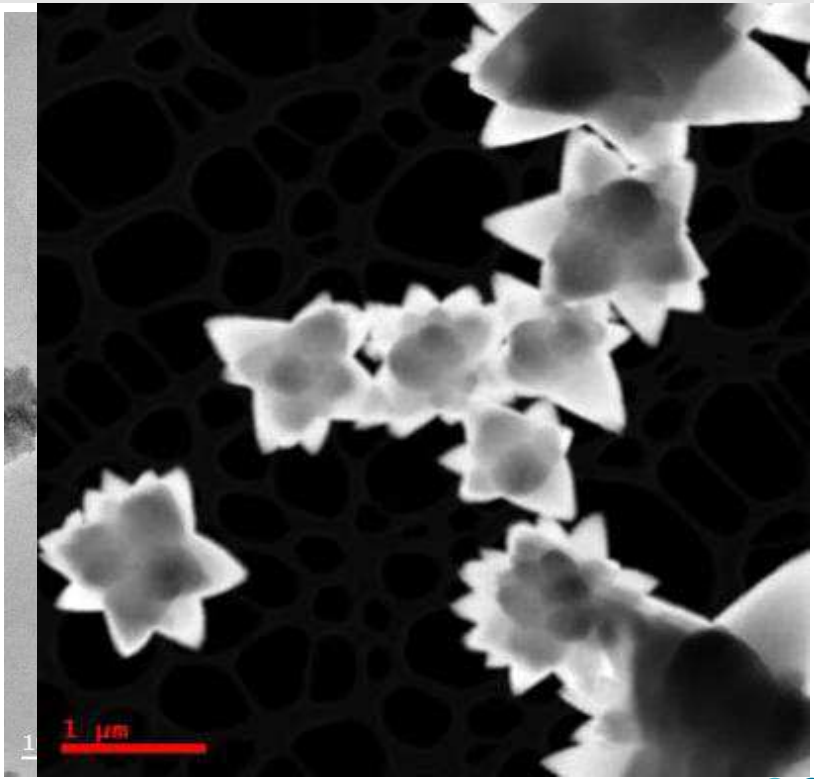
- Derived from biomass
- Needs reinforcement
- Passive packaging

Smart

- Responsive to stimuli
- Multi-functional
- Active packaging

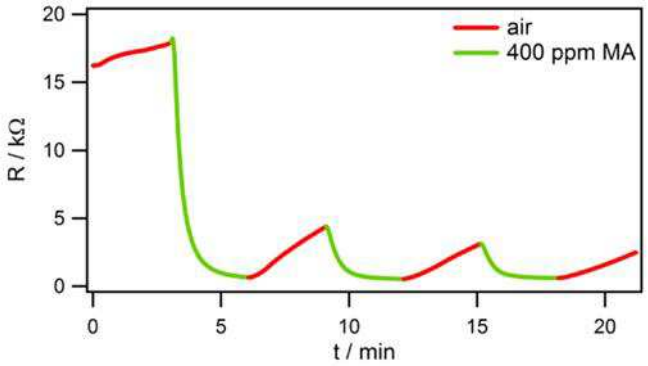
Nanostructured ZnO

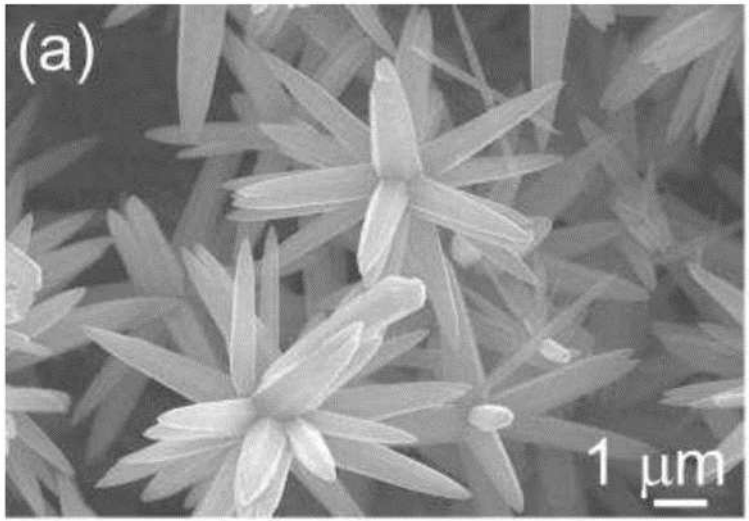




ZnO Nanorod Chemiresistive Sensing

Response to methyl amine in air

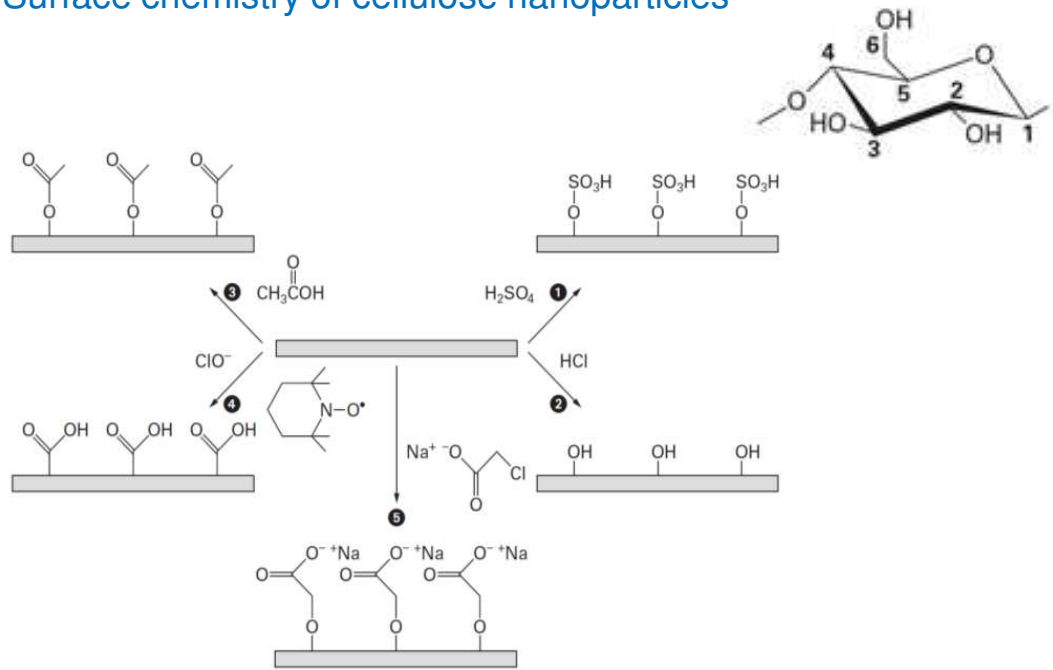


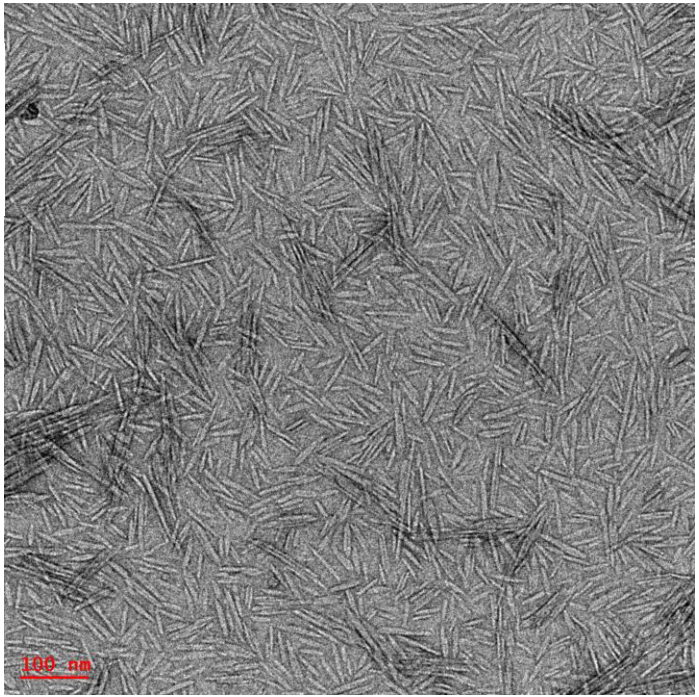


K Bosnick et al, "Meat Spoilage Sensing Devices", *Advanced Materials. Vol. 3 Biotech, Biomaterials and Biomedical, pp. 12-15*, 2018.

Cellulose Nanocrystals

Surface chemistry of cellulose nanoparticles



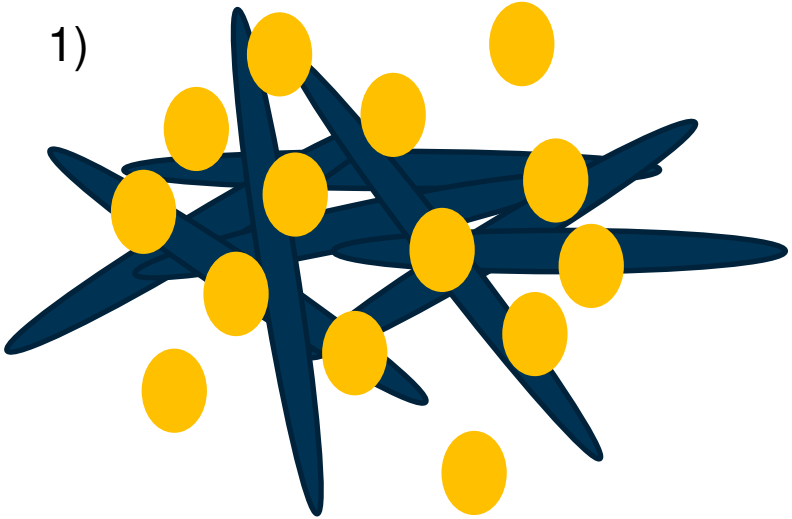


TEM image of negative stained CNCs

How to Combine ZnO and CNCs?

ZnO in the matrix of CNCs

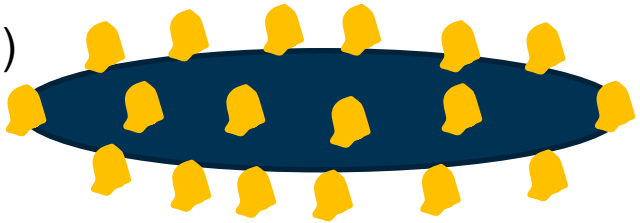
1)



CNCs coated or decorated with ZnO

2)

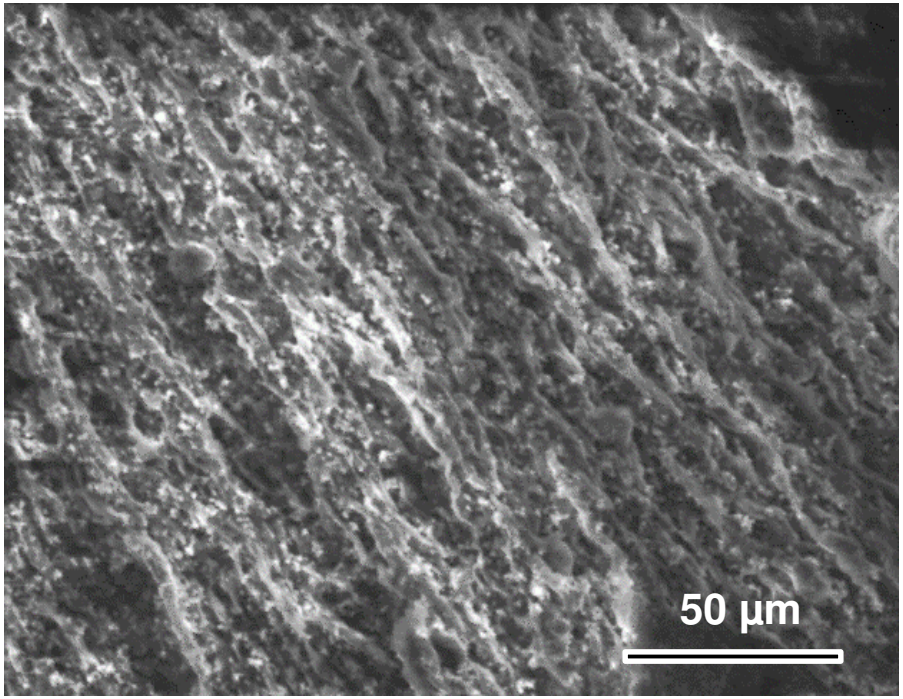
3)

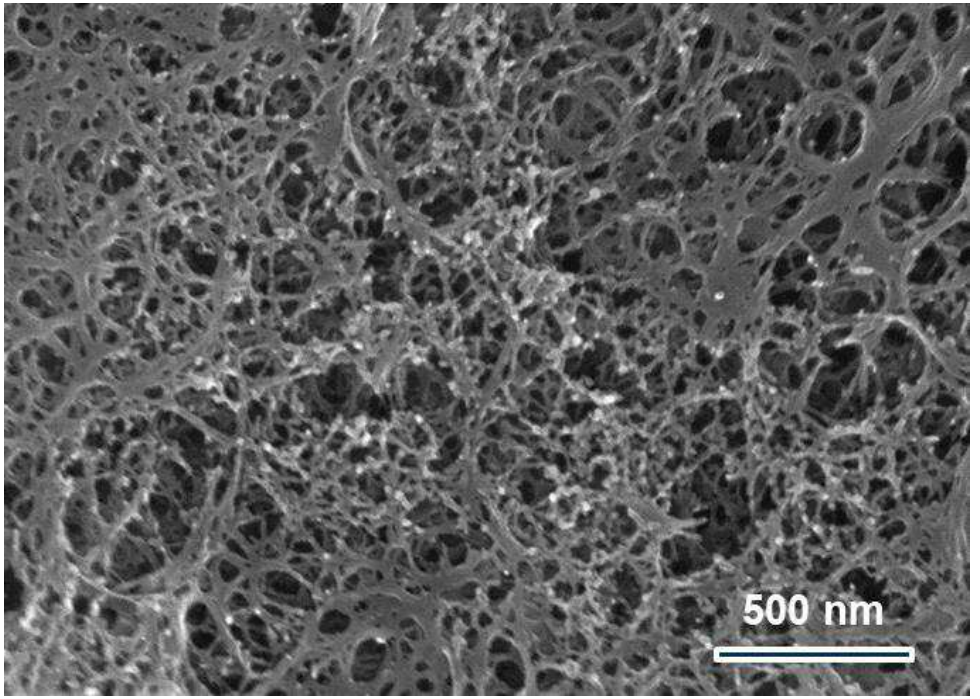


Importance of Characterization of ZnO/CNCs Hybrids

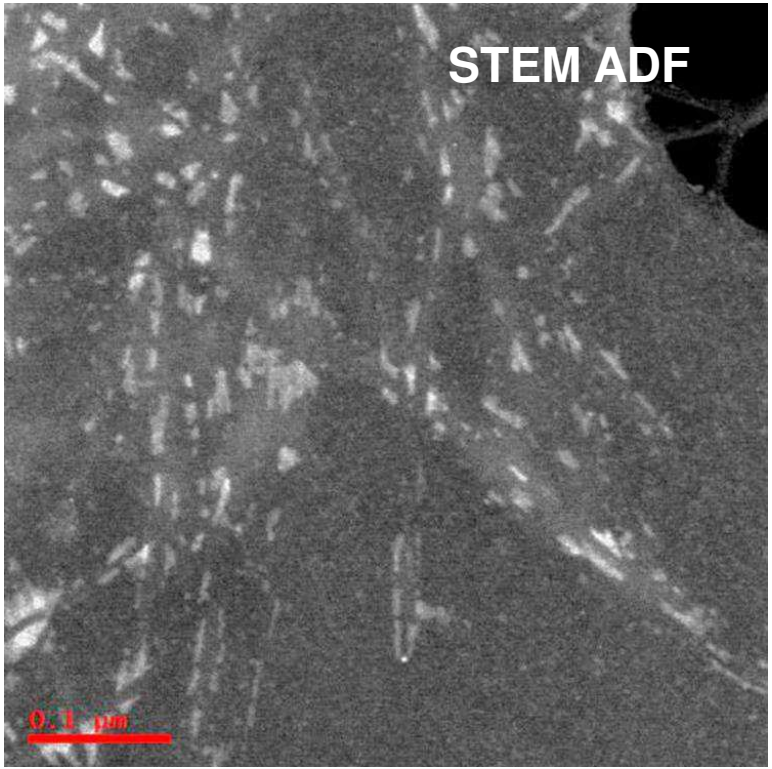
- **To confirm:**
  - Morphology& structure - incorporate to composites or smart device
  - Thermal stability – packaging
  - or other property
- **To provide feedback to optimize synthesis including drying approaches**
- **Analysis approaches:**
  - SEM, TEM/STEM, SEAD, EELS, XRD etc.
  - Raman Scattering, FTIR, TGA, UV-Vis, PL etc.

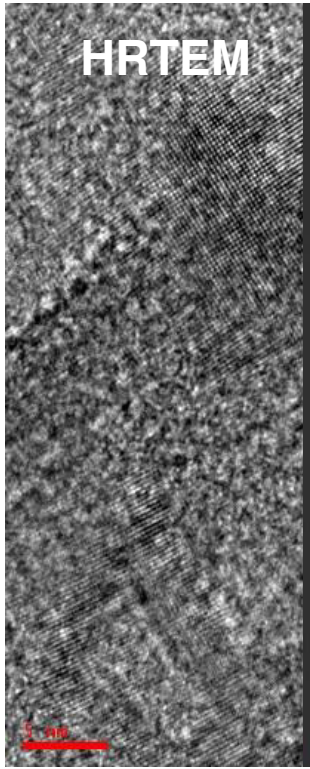
1) ZnO NPs within CNCs Matrix

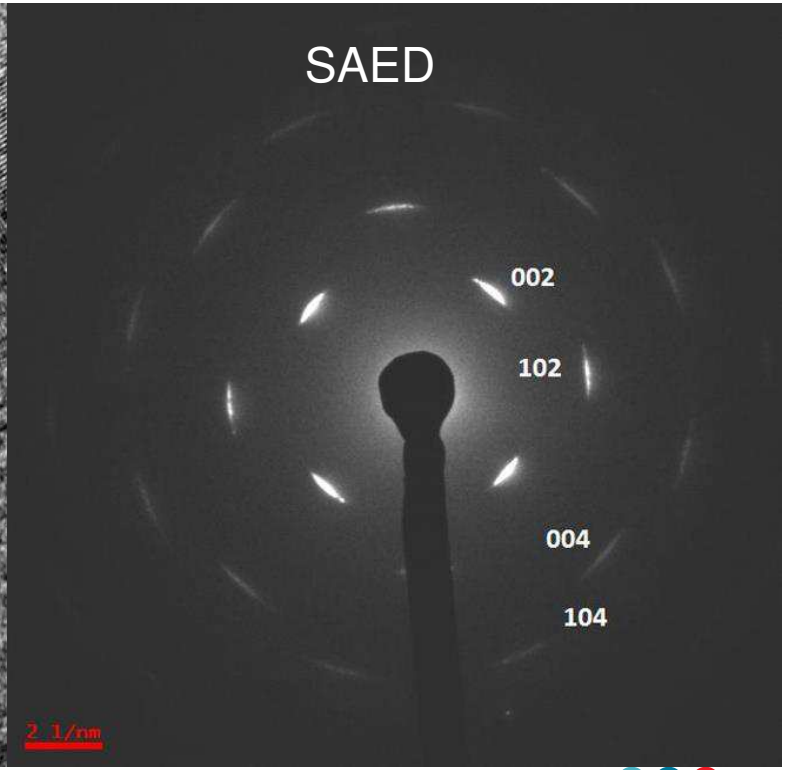




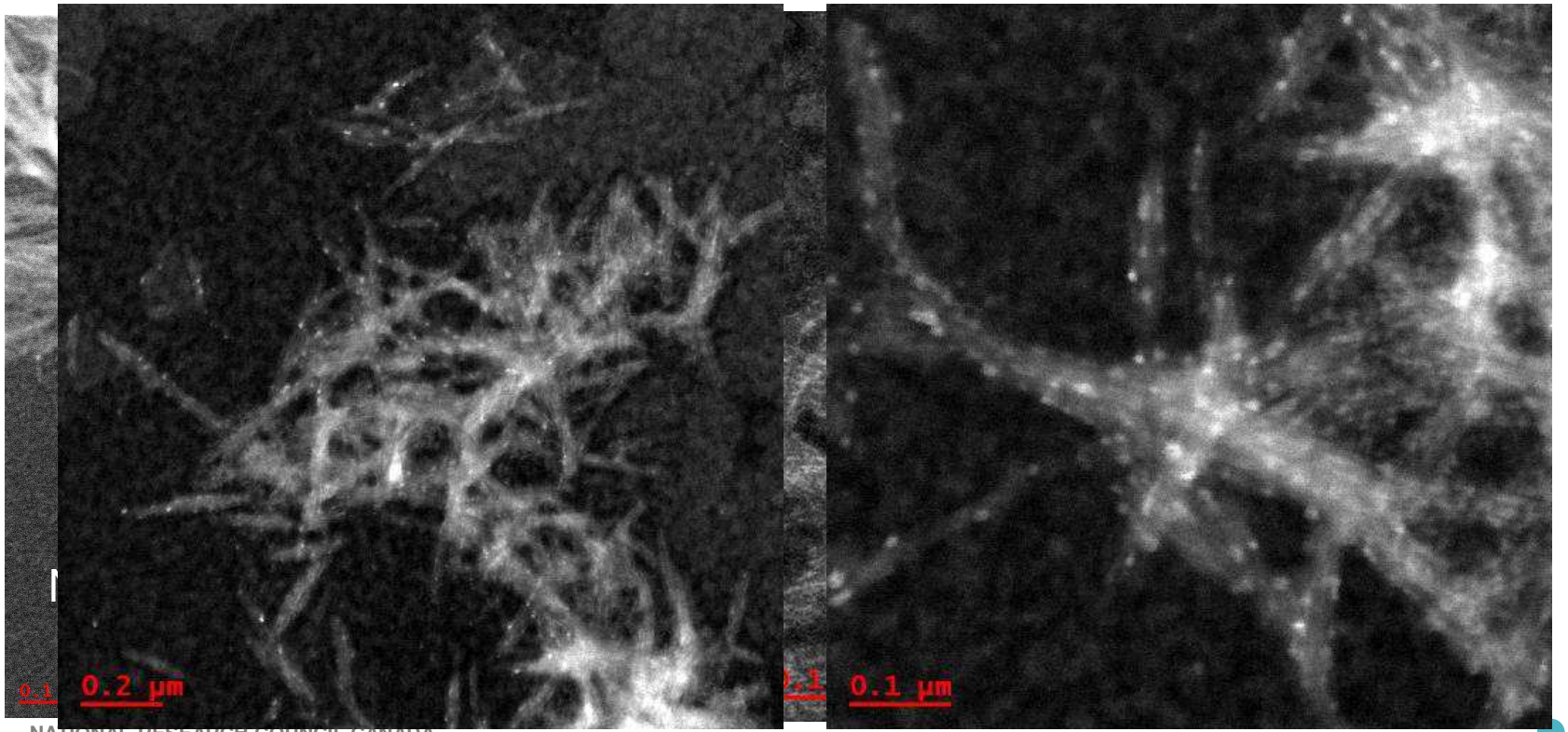
2) CNCs@ZnO Hybrids in TEM/STEM



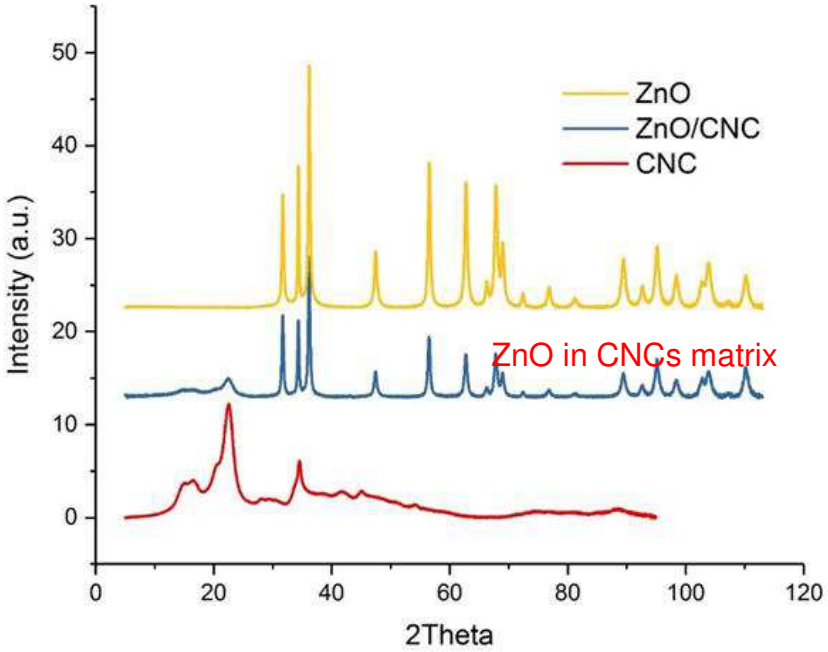




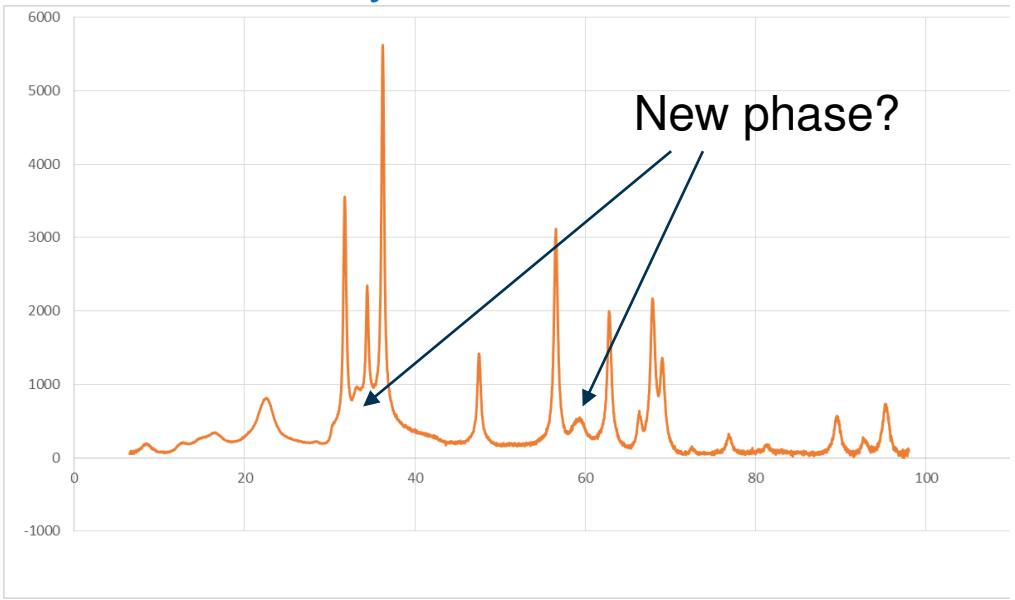
3) CNC@ZnO Hybrids in TEM/STEM



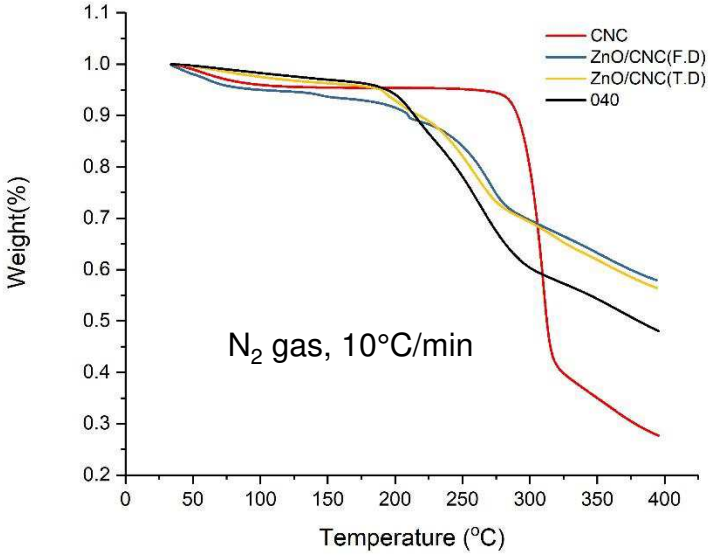
XRD – CNCs/ZnO

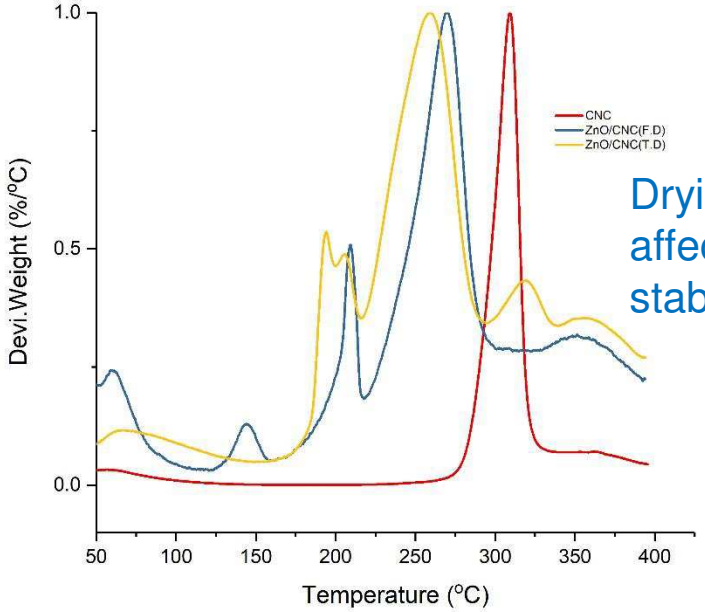


Hybrids



Thermal Stability
- *Thermal Gravimetric Analysis*

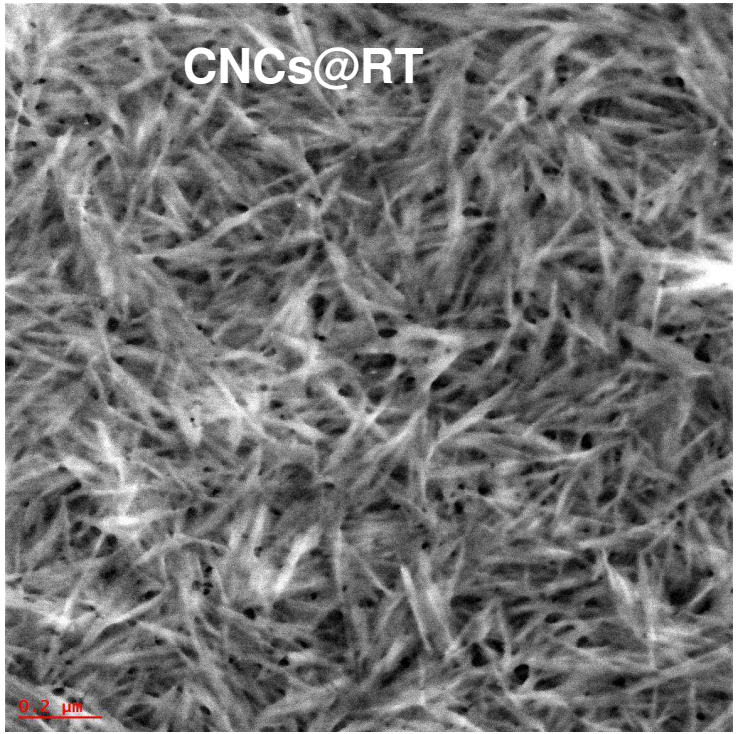


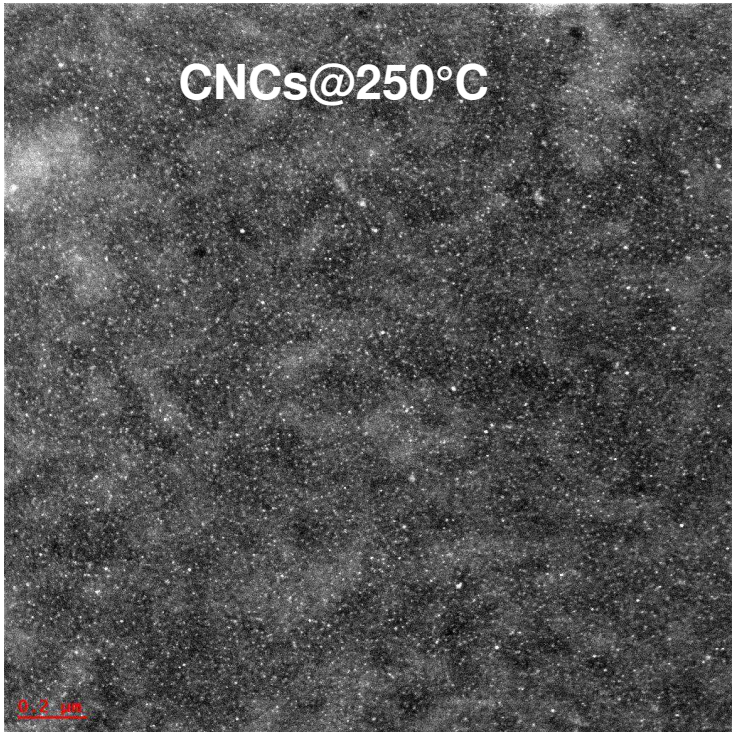


Drying methods affecting thermal stability measurement

Before the mass loss, is the structure changed due to heating?

Thermal Stability
- in situ TEM Heating (CNCs)



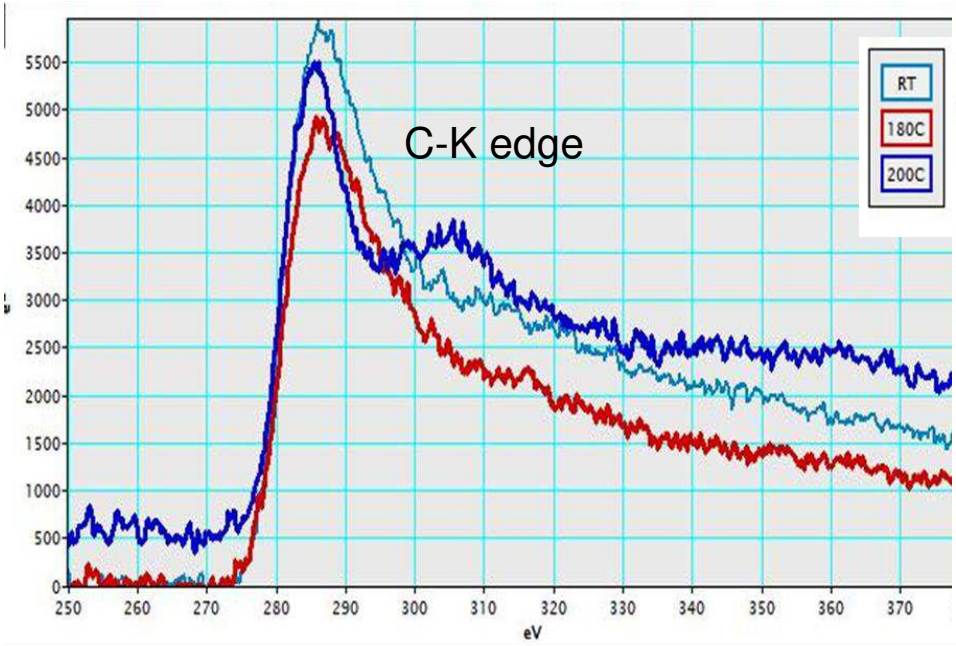


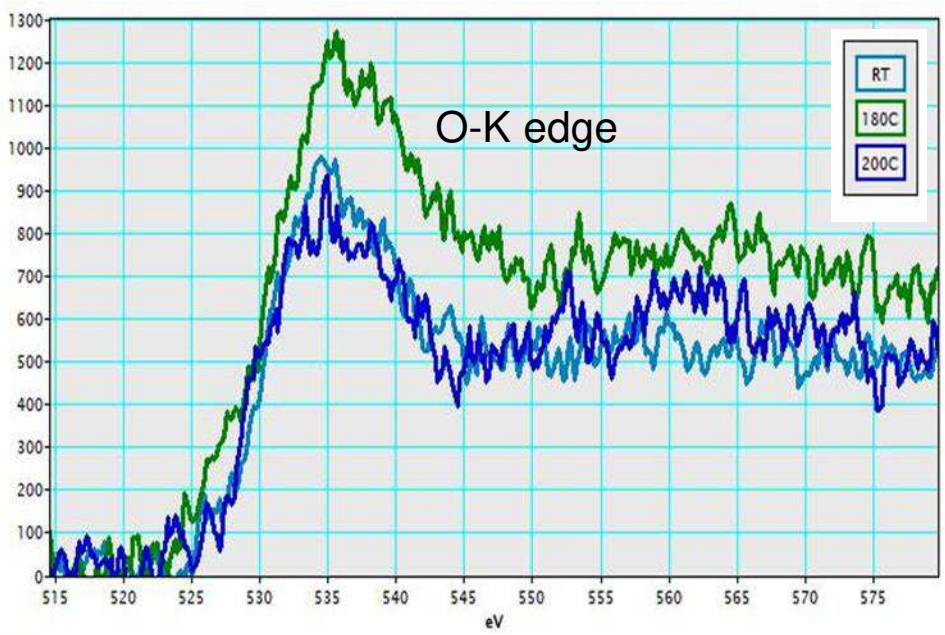
STEM ADF

Heat to desired T
-hold for 10-15mins
-cool down to RT
-imaging & analysis

Minimize electron beam induced damage

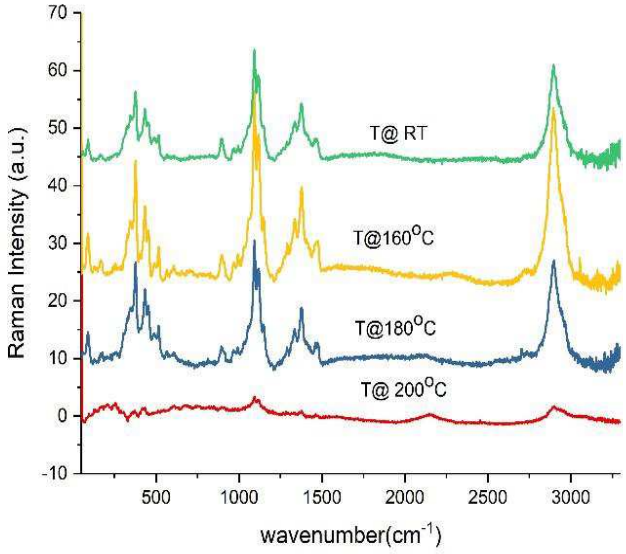
C-K, O-K Near Edge Fine Structure of CNCs after Heating

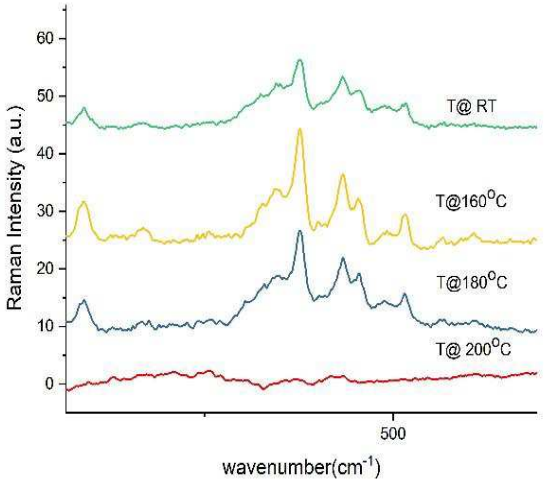


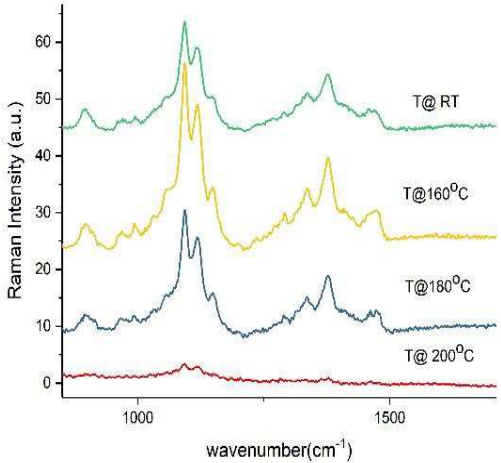


Electron energy loss spectroscopy of carbon and oxygen K-edges of CNCs

Raman Spectroscopy
- crystallinity (ex-situ heating of CNCs)







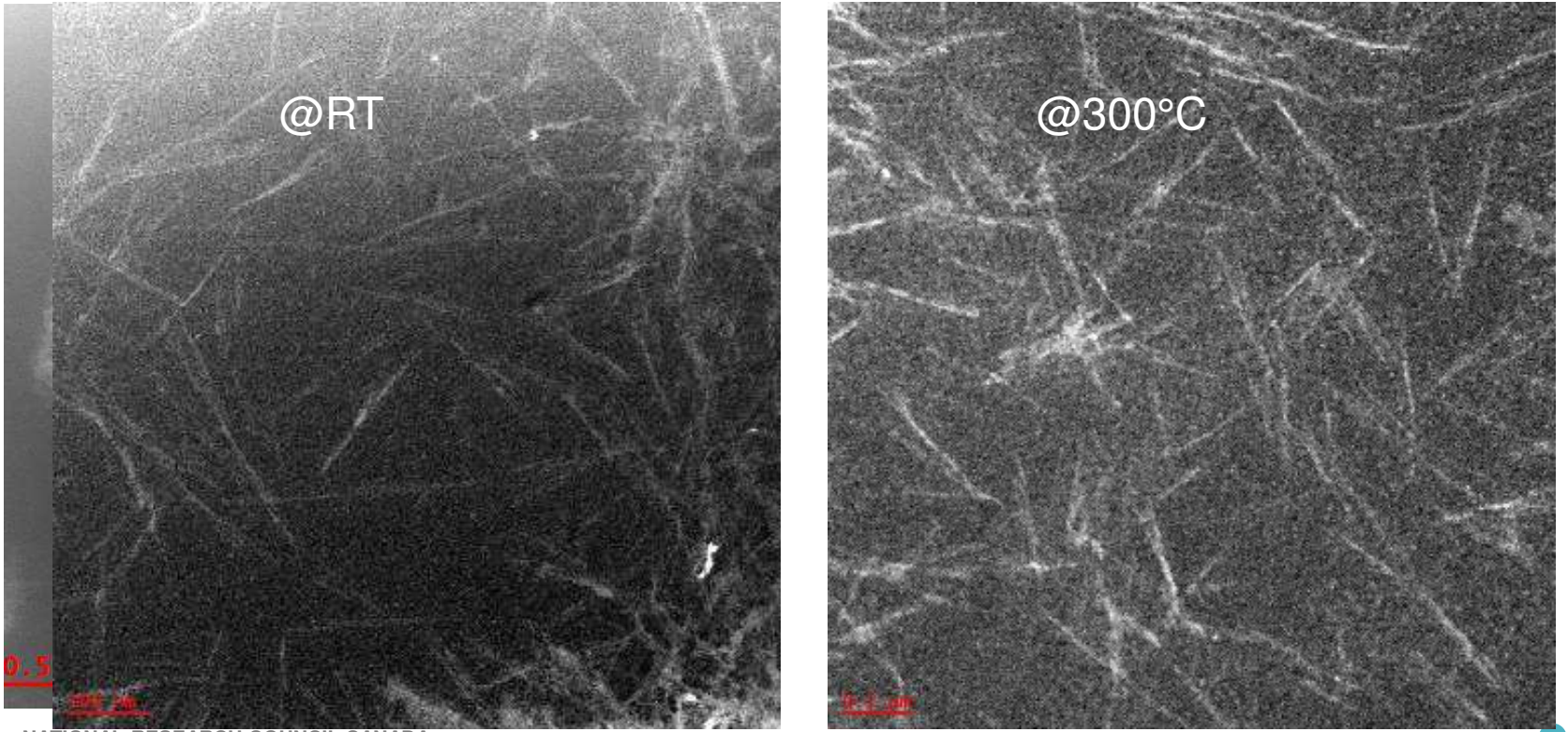
Thermo Scientific DXR2 Raman microscope, 785nm laser, 30mW power, 10x objective

"380 Raman peak"

Peak intensity ratios: 380/1095, 437/1095 etc.

Thermal Stability

- *in situ TEM heating (CNCs@ZnO)*



Summary

- Synthesis of CNCs@ZnO hybrids
- Correlative characterizations of hybrids including morphology and structure using EM & XRD
- Thermal stability - Heating influence on the structure of CNCs

More to be done or answer:

- ➢ Heating effect on CNCs/ZnO, -> optimize the synthesis
- ➢ Response to biogenic amines

THANK YOU

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