Characterization of Physicochemical Properties and Techno-economic Analysis of CNCs Derived from Pilot Production of Sweet Potato Residue

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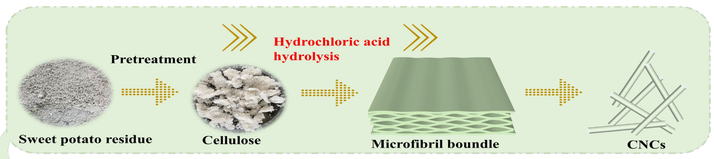
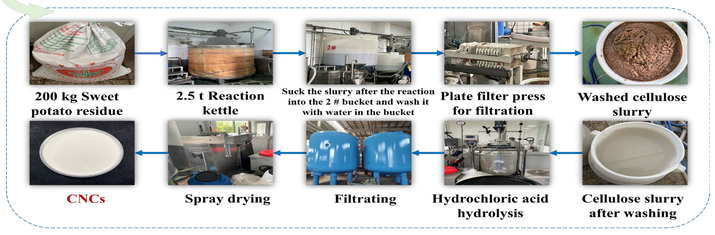
INTRODUCTION

- Cellulose nanocrystals (CNCs) possess biodegradability and high specific surface area, making them widely used in food, packaging, and other fields.
- Compared to traditional commercial methods, the economic and environmental impacts of producing CNCs from agricultural byproducts such as sweet potato residue still lack in-depth discussion and require further research to promote the sustainable development of green manufacturing.

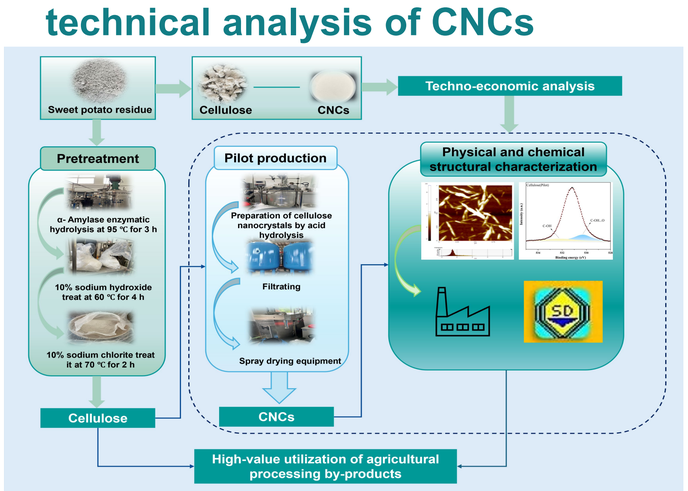
METHODS

✓ Pilot production of CNCs using sweet potato residue as raw material





✓ Physicochemical properties and economic and technical analysis of CNCs

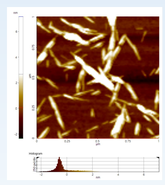


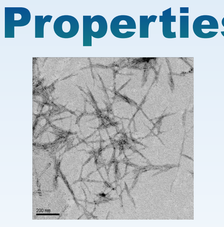
CONCLUSION

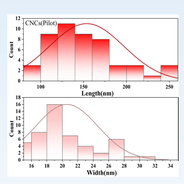
- The CNCs exhibited a highly crystalline type I cellulose structure, excellent thermal stability, storage stability, and colloidal stability.
- Pilot production of CNCs form sweet potato residue was financially more profitable than commercial CNCs and the use of SPR was economically and environmentally beneficial and reduced the use of fossil fuels.
- This study comprehensively evaluated the economic model for industrial-scale CNC production, promoting an economic model conducive to waste recycling.

KEY RESULTS

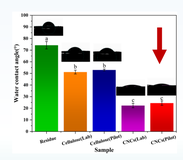
Physical and Thermal Properties

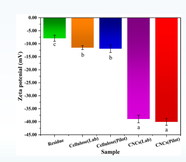


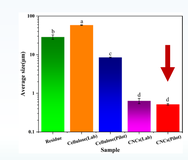




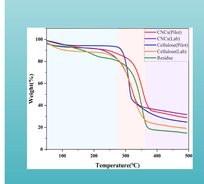
- The diameter range of **15-35** nm
- The length range of **80-260** nm.

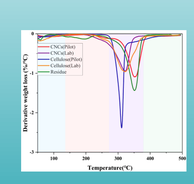


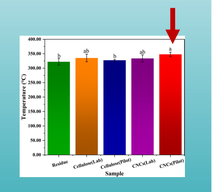




- The zeta potential (**-40.07 mV**) increased, while the water contact angle (**21.5°**) decreased.

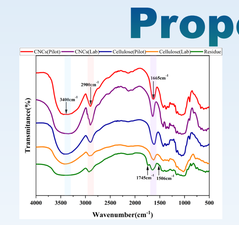


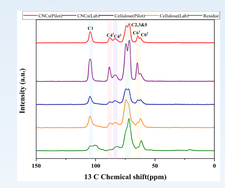


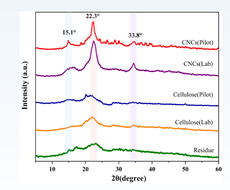


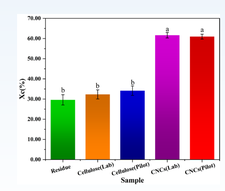
- The Tmax was **347.88℃**, and the residue mass was **31.65%**.

Chemical Structure Properties

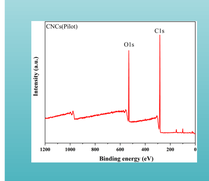


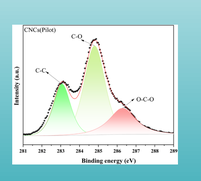


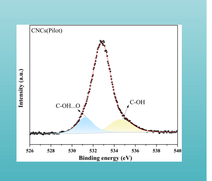




- CNCs showed a characteristic peak of **C=O** at **1665 cm^{-1}**.
- The percentage values of crystallinity of CNCs(Pilot) were **61.0%.**



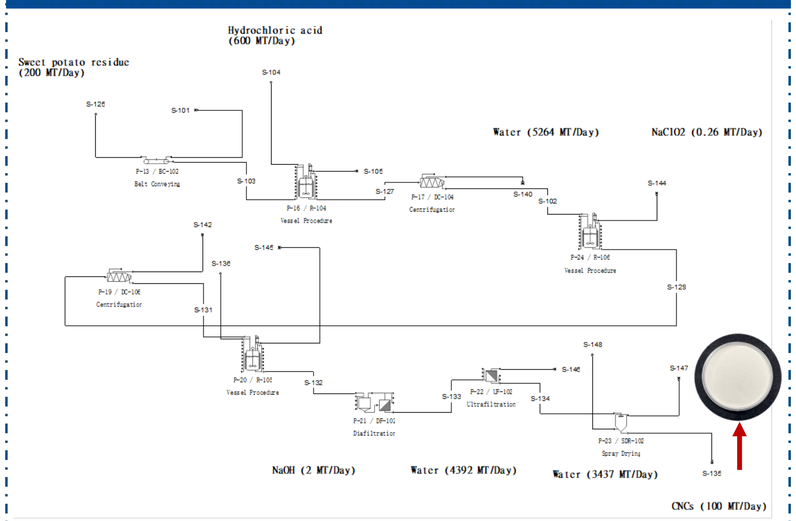




- The chemical bond types of macromolecules on the surface of CNCs were **C-C**, **C-OH** and **C=O**.

Techno-economic Analysis

Process flow diagram of CNCs production



- The **total capital investment** for pilot production of CNCs was **US$ 203.34 million**.
- Pilot production of CNCs form SPR was **more financially profitable** and **had a higher net present value** (NPV) than commercial CNCs.

Economic summary of CNCs production

Description	Commercial CNCs	CNCs (Pilot)
Total Capital Investment ($)	227.74×10^6	203.34×10^6
Operating Cost($/yr)	149.80×10^6	144.35×10^6
Main Revenue($/yr)	198.02×10^6	198.01×10^6
Total Revenue($/yr)	201.33×10^6	201.02×10^6
Cost Basis Annual Rate(kg/yr)	33.00×10^6	0.00
Net Unit Production Cost($/kg)	4.54	4.54
Unit Production Revenue($/kg)	6.00	6.00
Gross Margin (%)	24.35	12.01
Return On Investment (%)	25.38	20.47
Payback Time(yr)	3.94	2.67
IRR (After taxes) (%)	30.40	32.10
NPV (at 10.0% Interest) ($)	**257.83×10^6**	**268.68×10^6**