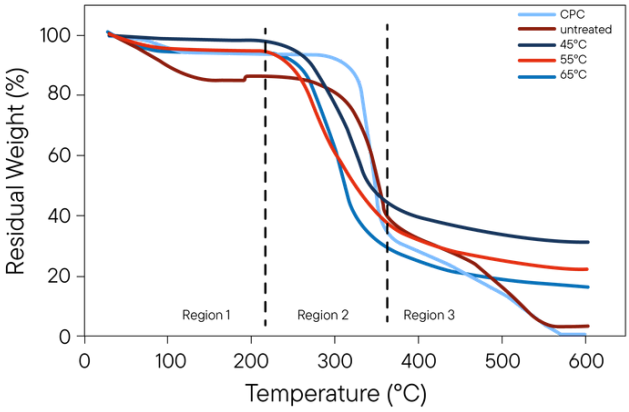
Thermal Stability of Cellulose Nanocrystals

TGA L81 Analysis of Sulfuric Acid Hydrolyzed Ramie Fibers

Cellulose nanocrystals (CNCs) are renewable nanomaterials with high crystallinity and strong potential as reinforcing fillers in sustainable nanocomposites. Their thermal stability is strongly influenced by the conditions used during acid hydrolysis. In this study, the LINSEIS TGA L81 was used to investigate the thermal degradation behavior of CNCs extracted from ramie fibers at different hydrolysis temperatures. The measurements provide valuable insight into the relationship between processing conditions and the resulting thermal properties of the nanocellulose.

Measurement Setup

- Instrument: LINSEIS TGA L81
- Material: Ramie Fibers, CPC & Cellulose Nanocrystals (CNCs)
- Hydrolysis Temperatures: 45, 55 and 65 °C
- Temperature Range: 30–600 °C
- Heating Rate: 10 K/min
- Atmosphere: Nitrogen
- Gas Flow: 4 L/h



The TGA curves clearly show the influence of hydrolysis temperature on the thermal stability of cellulose nanocrystals.
Key observations include:

- Three characteristic degradation regions
- Main degradation between approx. 220 and 360 °C
- Lower thermal stability of CNCs compared with CPC
- Highest CNC thermal stability at 45 °C hydrolysis temperature

The CNC prepared at 45 °C for 30 min exhibited the best thermal stability among the investigated CNC samples, with a maximum degradation temperature of approximately 320 °C.

Interpretation

The observed behavior can be attributed to:

- Sulfate groups introduced during hydrolysis
- Changes in cellulose crystallinity
- Increasing degradation at harsher hydrolysis conditions

This results in:

- Reduced CNC thermal stability
- Temperature-dependent degradation behavior
- Identification of optimal hydrolysis conditions

Industrial Relevance

Thermogravimetric analysis supports:

- Cellulose nanocrystal development
- Bio-based nanocomposites
- Sustainable reinforcing materials
- Process optimization
- Biomass valorization
- Thermal stability assessment

Conclusion

The LINSEIS TGA L81 reliably characterizes the thermal degradation of cellulose nanocrystals. The results show that hydrolysis conditions significantly influence thermal stability, with 45 °C for 30 min providing the best thermal performance among the investigated CNC samples.

Source:
Kusmono, Listyanda, R.F., Wildan, M.W., Ilman, M.N.
Preparation and characterization of cellulose nanocrystal extracted from ramie fibers by sulfuric acid hydrolysis.
Heliyon, 2020.
Adapted from thermogravimetric measurements performed using a LINSEIS TA PT 1600 (now designated as TGA L81).