TAPPI Nano Producers Committee

Research Challenges for the Production and Use of Cellulose Nanomaterials

As Identified by the TAPPI Nano Producers Committee

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(Open for Public Distribution)

Working Group Participants

Name	Affiliation	Email
Jimmy Jong	FPInnovations	jimmy.jong@fpinnovations.ca
Colleen Walker	University of Maine	colleen.walker@maine.edu
Keith Gourlay	Performance Biofilaments	kgourlay@performancebiofilaments.com
Anni Karppinen Lund	Stora Enso	anni.karppinen@storaenso.com
Robert Nilsson	RISE	robert.nilsson@ri.se
Gert Preegel	Fibenol	gert.preegel@fibenol.com
Sebastien Corbeil	Celluforce	sebastien.corbeil@celluforce.com
Lixian Xu	SAPPI	lixian.xu@sappi.com

This is not an exhaustive list of issues but reflects topics the Producers Committee Members wish the Research Committee to address in the 2024 Call for Presentations. Categories 1-4 reflect areas for the appropriate subcommittees within the Research Committee, while Category 5 is an area of interest outside of the current subcommittee structure. Abbreviations and application areas are included in the Appendix.

Blue text indicates those new items added during 31 August 2023 call, and follow up emails.

I. Production Related Issues (Nanomaterial Production Subcommittee)

A. Raw Material:

- How do the properties of the raw material impact fibrillation, energy consumption, drying, and dewatering:
  - Changes in all properties due to seasonality of wood supply
  - Chemical composition of the material
  - Impact of hemicellulose and lignin content from hybrid materials on composition of the final product
  - Fiber physical properties, moisture content, and extent of hornification
  - Hornification when using recycled and dried pulps

B. Production:

- CHARACTERIZATION – see below
- Surface treatments or other modifications to pulps or fibrillated material to improve desired properties
- More efficient and cost-effective production by reducing chemical, water and energy use, and better pathways to recover/reuse process chemicals and enzymes (for TEMPO process or sulfuric acid treated materials)
- Impact of low and high consistency processes of CNF/MFC production
- Influence of water quality on quality of CNMs
- Production processes to produce microbiologically clean products
- How recovered process chemicals (acid, water, enzymes, etc.) affect product quality
- Evaluate scalability (e.g., modeling) of new, lab-based production methods

C. **Drying/Dewatering:**
- Chemistries and/or modifications to CNM-products to aid drying
- Better drying and dewatering methods – need cost effective solutions for redispersion of final product
- Evaluation and optimization of drying conditions for spray drying and other drying methods
- Encapsulation technologies for spray drying
- Effect of product consistency/bulk density on transportation and product performance

D. **Product Handling:**
- Shelf-life and storage conditions of CNMs in different forms (wet, dry)
- Use of biocides to extend shelf life
- Effect of freezing on product properties and performance
- Effect of temperature changes during transportation and storage on CNMs on product properties and performance

II. Characterization (Nanomaterial Characterization Subcommittee)

A. On-line and lab based methods for characterization of: production, final product, health & safety, application/end user based
- Measurement of particle size distribution
  - Fines measurement versus other techniques (e.g. dynamic imaging)
  - Branching
  - Evaluation of conditions to understand impact
  - Standardized methods are needed to characterize CNMs
  - Use of surface area to provide an indication of particle size
- Measurement of surface chemistry – charge, functional groups
- For CNC: measurement of sugars on the surface
- For CNMs: Standard methods for rheology measurements

B. Characterization needed for Applications (in general)
- Product monographs for medical and other uses
- Dispersion in final material
- Mechanical properties
- Optical properties
- Rheology
- Study of CNM migration in packaging papers and films

III. Industrially feasible innovations for Applications/Product Development (Applications and Product Development: CNF & MFC Subcommittee and Applications and Product Development: CNC, Lignin and Nanomaterials Subcommittee)
- Dispersion of CNMs in polymer matrices or elastomers
  - Water-based chemistry, reactive drying or other methods for hydrophobicity
- Development of barrier properties (oxygen, water/water vapor, oil/grease) and faster measurement of these properties
- Development of the use of CNMs to provide value-added properties in targeted applications (see list below), and the mechanisms behind them.
- Synergy of CNC/MFC blends of materials in different applications.

IV. Health and Safety/Regulations (EH&S, Product Stewardship, Standards Development and Regulation Subcommittee)

- More studies on toxicity, ingestion, inhaling, dermal and other safety issue around wet and dry CNMs and modified CNMs
- Impact of impurities, including microbiological, on H&S
- Update on new definitions of Nanomaterials: A new definition for the term Nanomaterials has recently come into effect in the EU. This creates issues on what terms to use and how to properly define nanomaterials. This is affecting producers from a characterization, product safety and regulation standpoint. Identifying a standard way of measuring Nanomaterial will help to remedy these regulation concerns.
- Comparison of exiting standards to characterize CNMs and how this relates to developing regulations
- Migration, dietary exposure and toxicological studies (including absorption, distribution, metabolism and excretion) of CNMs from packaging materials to food/food simulants.

V. Sustainability/Life Cycle & System Analysis

- Development of harmonized methodology for evaluating environmental impacts (includes LCA, GHG) for CNMs
- Transparent and comprehensive LCA/GHG studies on CNM-enabled applications
- Studies on and development of standard methodology for compostability, recyclability, biodegradability, and repulpability of CNM products.

APPENDIX

Abbreviations

CNM – cellulose nanomaterials
CNC – cellulose nanocrystals
CNF – cellulose nanofiber
MFC – microfibrillated cellulose

Major application areas considered during this discussion:

Paper & Packaging (CNMs with wood and nonwood fiber materials)
Medical
Cosmetic
Construction
Textile & Nonwovens
Plastic replacements
    Polymer composites
    Film/foams
Automotive
Resource Extraction (e.g., oil & gas, mining)
Paints & Coatings
Filters (air and water)