

Nanocellulose in Packaging

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1. Acknowledgments

2. Introduction, Methodology, and Scope

According to a 2017 survey of 1,015 U.S. consumers by Asia Pulp and Paper, 55% rated recyclability of packaging “very important” or “somewhat important,” 52% rated sustainability “very important” or “somewhat important,” and 52% rated biodegradability “very important” or “somewhat important.”¹ At the same time, we are seeing plastic bags banned in California, India, China, Australia, the U.K and more. Plastic straws are too light to be recycled in most recycling facilities, and often end up in the oceans. Now, plastic straws are being phased out by Marriott, McDonalds, Starbucks, and Disney World, among others.

The drive for sustainability is pushing packaging producers to reduce, reuse, and recycle: light weight packages that use less material, recyclable paper and paperboard products that eliminate foil or film in flexible packaging or liquid packaging containers. Nanocellulose can provide improved strength and barrier properties and is becoming “The Rising Star in the Bioeconomy.”²

Paper and paperboard producers have led the commercial development of nanocellulose, primarily in packaging applications. This is natural, as paper and paperboard producers are both producers and users of nanocellulose, and thus are a captive market. Moreover, the customers for paper and paperboard products are customers already known to these producers. Nanocellulose also has potential in plastic, glass, and metal packaging, though these are developing more slowly.

Applications such as cement, composites, oil and gas, and cosmetics have also attracted interest from producers of nanocellulose, but involve processes and supply chains which are unfamiliar to paper and paperboard producers, and have therefore been slower to develop.

Against this backdrop, RISI and Biobased Markets have developed this Special Market Analysis Study to review the opportunities, challenges, state of the industry and market outlook for nanocellulose in paper and paperboard packaging,

Scope

The scope of this report is global, and includes opportunities for nanocellulose in containerboard, boxboard, and other paperboard, flexible packaging, wrapping papers and other specialty paper applications. It also includes an overview of the potential for applications in plastic packaging involving nanocellulose/polymer composites and the potential for applications relating to metal and glass packaging.

Applications involve a wide range of value propositions, including improved strength, improved barrier, enhanced functional coatings, lightweighting, replacement of chlorofluorocarbons (CFCs) and other undesirable materials, and replacement of less sustainable materials with bio-based, biodegradable materials containing nanocellulose.

The scope of this report includes plant-derived cellulose nanomaterials. Cellulose nanomaterials from algae, bacteria, or tunicates are not within the scope of this report.

This report covers two types of cellulose nanomaterials: cellulose nanocrystals (CNC) and cellulose nanofibrils (CNF). It also covers materials that are considered to fall under the “umbrella” term “nanocellulose,” i.e., microfibrillated cellulose (MFC), also referred to as cellulose microfibrils (CMF), and cellulose filaments (CF), even though they may not be nano-scale, because they bear some similarities to CNF and compete in the same arenas as CNC and CNF.

Older commercial materials such as microcrystalline cellulose (MCC) and carboxymethyl cellulose (CMC), while mentioned in this report, are not within the scope of this report and are therefore not discussed in detail because they have been commercial for many years and are well-known and well-documented elsewhere; they generally do not compete with CNC, CNF or MFC.

Development of nanocellulose in packaging applications includes:

- Research at universities and research centers such as FPIInnovations, VTT, and RISE, documented in technical journals, conference presentations and patent filings;
- Corporate R&D, often confidential, but sometimes reported in conference presentations and patent filings;
- Joint development between producers and customers such as compounders, converters, food service companies, brand owners, etc., again, often confidential but sometimes reported publicly;
- Commercial production, which may include sale of nanocellulose to customers, or use by paper and paperboard producers in their own products. Little of the former has been reported, while some of the latter has been, but it is likely that there is much more activity that has not been publicly reported.

The focus is nanocellulose in packaging. Therefore, we provide an overview of the markets for containerboard, cartonboard, foodservice board, flexible packaging, and specialty packaging papers, but we do not attempt a “deep-dive” to slice and dice the market by type of packaging, type of materials, and region. Rather we explore the opportunities, research into nanocellulose in packaging, and the state of commercial development. Detailed studies on various segments of the packaging market are available from RISI.

By the same token, we do not attempt to provide a detailed review of the research and technology relating to production of nanocellulose per se, rather focusing on research and technology relating specifically to packaging. For a deeper analysis of nanocellulose technology we recommend the following:

- Editors: Michael T. Postek, Robert J. Moon, Alan W. Rudie, and Michael A. Bilodeau, *Production and Applications of Cellulose Nanomaterials*, TAPPI, 2013.
- Robert J. Moon, Ashlie Martini, John Nairn, John Simonsen, and Jeff Youngblood, *Cellulose nanomaterials review: structure, properties and nanocomposites*, Chem. Soc. Rev., 2011, 40, 3941–3994. DOI 10.1039/c0cs00108b.
- Chuanwei Miao and Wadood Y. Hamad, *Cellulose-Reinforced Polymer Composites and Nanocomposites: a Critical Review*, Springer Science+Business Media, Dordrecht 2013. DOI 10.1007/s10570-013-0007.
- Youssef Habibi, Lucian A. Lucia, and Orlando J. Rojas, Cellulose nanocrystals: Chemistry, self-assembly, and applications, Chem. Soc. Rev., 2010, 110, 3479–3500.

In addition, we recommend *Nanocellulose: Technology, Applications and Markets*, by Jack Miller, published by RISI in 2014. That study provides deeper insight into the technology of nanocellulose production and applications, while this study is more focused on packaging.

We also recommend *Nanocellulose Challenges and Opportunities: End User Perspectives*, also by Jack Miller, published by TAPPI in 2018. That book includes detailed input from end users, including input from End User Panels in 2017 and 2018 at the TAPPI International Conference on Nanotechnology for Renewable Materials (TAPPI Nano), and complete results of a 2017 survey of 40 end users by Biobased Markets.

Methodology

This report was written by Jack Miller, Founder and Principal Consultant, Market-Intell LLC, which he founded in 2005 and re-branded as Biobased Markets in 2018. Jack is also an Associate Consultant with RISI

and a member of the Advisory Board of Sweetwater Energy, a biorefinery company. Jack served as Business Development Consultant with CelluForce, Inc., from 2011 to 2013, and was Consulting Manager, Global Nanocellulose Sales, American Process, Inc., in 2014 and 2015. Jack is the author of *Nanocellulose: Technology, Applications and Markets*, published by RISI in 2014, and *Lignin: Technology, Applications, and Markets* published by RISI in 2017. He is also the author of *Nanocellulose Producers, Products and Applications, A Guide for End Users*, published by TAPPI, 2017, and *Nanocellulose Challenges and Opportunities: End User Perspectives*, published by TAPPI, 2018.

This report is the result of xxx interviews in person, by phone and email, analysis of market data from RISI and other sources, and a review of xxx patents and xxx technical papers relating to nanocellulose in packaging.

This report also builds on research by Jack Miller for the earlier RISI *study Nanocellulose: Technology, Applications and Markets*, as well as work done as a consultant to leading producers of nanocellulose.

The identity of individual respondents remains confidential, but we can say that companies, associations and research organizations contacted include:

- Alberta Innovates
- ALPac
- American Process
- APPTI
- BillerudKorsnäs
- Blue Goose Biorefinery
- Borregaard
- CelluForce
- CEPI
- Clearwater
- Domtar
- FEFCO
- FiberLean
- Fibre Box Association
- FPIInnovations
- GL&V
- FEFCO
- Glass Packaging Institute
- HS Manufacturing
- ITENE
- KapStone
- Kruger
- Kyoto University
- LBP Manufacturing
- Melodea
- Monadnock
- Nippon Paper
- Oji Paper
- Performance BioFilaments
- Purdue University
- Rayonier Advanced Materials
- RISE Innventia AB
- SAPPI
- Sherpack
- Stora Enso
- Sugino Machine

- Suzano
- Sweetwater Energy
- University of Tokyo
- US Endowment: P3Nano
- US Forest Service
- University of Maine
- VTT

¹ Lingle, R. Study: Consumers see value in biodegradable food packaging, *Packaging Digest*, Sept 18, 2017.

<https://www.packagingdigest.com/sustainable-packaging/study-consumers-c-value-degradable-food-pkg1709>

² Miller, J. Nanocellulose: Rising Star in the Bioeconomy, presentation at CEPI Paper and Beyond, Brussels, Oct 17, 2018.

