Guest Editorial

ART J. RAGAUSKAS | *TAPPI Journal* Editorial Board

Forest products: The nanocellulosics frontier

Editor's Note: *Art J. Ragauskas is professor, School of Chemistry and Biochemistry, Institute of Paper Science and Technology, at Georgia Institute of Technology in Atlanta, GA, USA. Ragauskas is a TAPPI Fellow and member of the TJ editorial board, working in this capacity to develop this month's special nanotechnology issue.*

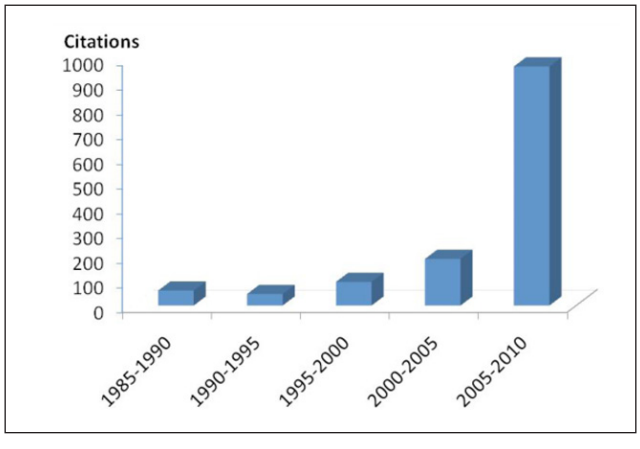
– **Monica Shaw**, Editorial Director

With the embryonic-stage of cellulosic nanotechnology now concluding, researchers in forest products are focusing on translational applications. As in the past, the sustainable, low-cost benefits of cellulosics are attracting researchers to prepare and test an assorted number of nanocellulose structures and materials for value-added applications, which is now growing daily, as **Figure 1** shows.

In a broad context, this field of study includes:

- Microfibrillated cellulose
- Cellulose whiskers
- Cellulose nano-spheres

Although the formal definition of these structures is still being developed,[1] in general microfibrillated cellulose involves the disintegration of cellulosic fibers to elementary fibril bundles ~20 nm in width and several micrometers in length.[2] Cellulose whiskers (also called nanocrystalline cellulose and cellulose nanocrystals) are rod-like structures averaging ~3-50 nm in diameter and ~100-3000 nm in length, depending on the source and methodology used for their preparation.[3] Nanocellulose balls are spherical structures with reported diameters of ~60-600 nm.[4] Each of these forms of cellulose is being actively investigated for a host of practical applications.



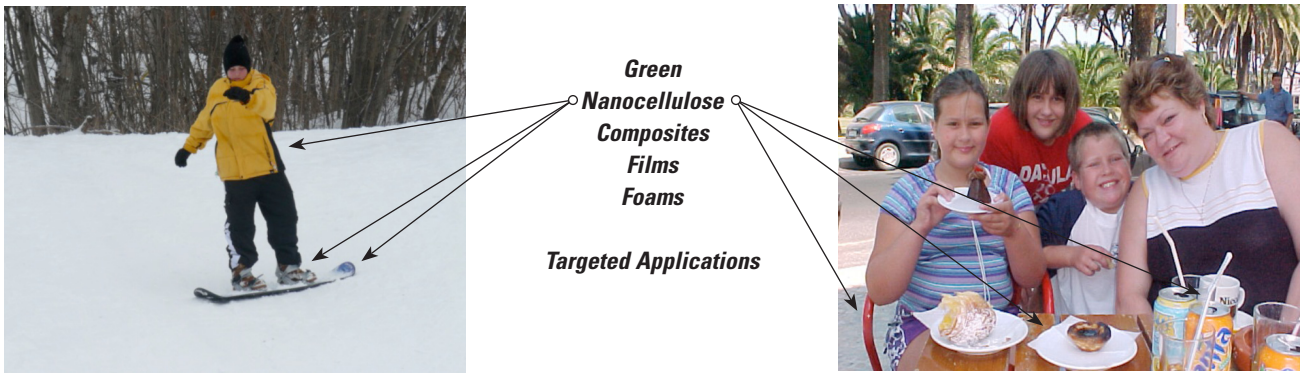
1. References to nanocellulose studies.

Cellulose whiskers have shown exceptionally promising properties as a composite additive for hydrophilic synthetic and bio-based polymers. Their incorporation, in the ~1-10 weight percent range, into composites has been shown to enhance key physical strength and thermal stability properties.

Although the blending of whiskers with polymers on a large scale was challenging a decade ago, substantial advances have been made in this field and several technological platforms are now under development. The application of whiskers with hydrophobic polymers has also seen significant advancements relying, in part, on amphophilic compatibilization additives or surface functionalization of cellulose whiskers yielding more hydrophobic whiskers. Likewise, the crosslinking of whiskers and alterative derivatization has demonstrated that cellulose whiskers can be modified to exhibit novel superabsorbent, hydrogel, film and foam properties.

Microfibrillated cellulose has also seen a renaissance in interest this past decade. An inspection of the public literature and patents highlights novel applications for coatings, films, barrier properties, composites, papermaking, and release agents. Cellulose spheres are being explored for drug delivery and molecular templating applications. Indeed, a brief examination of the public literature and the web clearly shows that nanocellulose research is now in an exponential growth phase.

The advances in the application field have been notably strengthened by recent pilot-plant investments for the synthesis of nanocellulosics. The validation of these manufacturing technologies and continuing improvements in the production of nanocellulosics suggest that



the routine commercial production of these materials is now coming within commercial reach.

As the consumer continues to demand low-cost, sustainable green bio-based materials, the forest products industry is exceptionally well positioned to address these demands. One can envisage numerous practical applications, such as the photos above summarize.

As cellulosic nano-enabled consumer products begin to become a reality, it is increasingly important that our forest products community develop and agree upon national and international materials standards for cellulosic nanomaterials, as well as generate all pertinent science-based environmental, health and safety information. This will assure consumers that nanocellulose-enabled products are safe, sustainable, and environmentally preferable.

The articles in this issue of *TAPPI Journal* highlight some of these promising applications and the science/engineering behind this rewarding future. **TJ**

REFERENCES

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TAPPI Announces New International Nanotechnology Division

TAPPI recently announced that its nanotechnology groups have created a new International Nanotechnology Division. This Division will focus on nanotechnology for renewable materials, including the advancement of research and development for nanocellulose. The International Nanotechnology Division will not only concentrate on developments for traditional forest-based products like pulp, paper and building materials, but also on applications such as coatings, plastics, digital displays, military body armors, and medical implants, among others. Comprised of producers, academia, government, consulting companies, suppliers and others in the industry, it will serve as the leading global forum for knowledge sharing in this high growth sector.

"When TAPPI volunteers suggested we take our nanotechnology efforts to the next level, we jumped at the opportunity to help the industry capitalize on this promising sector," said Larry N. Montague, President and CEO of TAPPI. "We see the new division as a platform for helping the industry respond to the rapidly changing field of nanotechnology, especially as commercialization develops in this fast-growing sector."

Creation of the new division builds on the six years of success with TAPPI's International Conference on Nanotechnology for Renewable Materials, held this year in Washington DC, June 6-8 (www.tappinano.org). Among other important contributions, this annual event has significantly accelerated the development of standards for nanocellulose, such as bringing TAPPI's ANSI Accredited Standards process to support ISO's Technical Committee on Nanotechnology.

The International Nanotechnology Division will augment the International Conference on Nanotechnology by supporting technical developments and broader industry understanding of the value of nanocellulosic nanomaterials. It will also address emerging issues around environmental health, safety and risk assessment in the development of commercial nano-based products.