JOM, Vol. 68, No. 9, 2016
DOI: 10.1007/s11837-016-2058-z

Recent Advances in Forest Products Research and Development

JOSEPH E. JAKES[1,2]

1.—Forest Biopolymers Science and Engineering, USDA Forest Service, Forest Products Laboratory, One Gifford Pinchot Drive, Madison, WI 53726, USA. 2.—e-mail: jjakes@fs.fed.us

Wood has always played an integral role in meeting our materials needs. The earliest evidence of woodworking dates back 1.5 million years to the modern human ancestor *Homo erectus*.[1] Many characteristics that made wood a favorable material for our ancestors—relative abundance, ease of forming and shaping, exceptional strength-to-weight ratio, aesthetic appeal—are the same characteristics that continue to make wood and forest products the material of choice for numerous applications today. Traditional forest products (e.g., paper, cardboard, dimensional lumber, plywood, oriented strandboard, laminated veneer lumber, medium density fiber board, and particleboard) have long played major materials roles in the packaging and building materials industries. However, during the past few decades, forest products have been expanding into new areas. This *JOM* special topic aims to bring attention to some of the most recent advances that are bringing wood and new forest products into increasingly diverse areas of materials research and development, with applications ranging from flexible electronics to skyscrapers. One increasingly attractive characteristic of wood as a natural resource is that, through proper management, wood resources can be utilized in a sustainable and environmentally friendly manner. Forest products have the capability to play a major role in the development of advanced materials solutions to overcome our energy and environmental challenges.

The first review article, "Overview of Cellulose Nanomaterials, Their Capabilities and Applications," by Moon et al., is a timely review highlighting the increasingly promising research creating and utilizing cellulose nanomaterials. Cellulose nanomaterials are nano-sized cellulose particles with advantageous properties that include high mechanical strength, high aspect ratio, low thermal expansion, and chemically active surface hydroxyl groups. Additionally, cellulose nanomaterials are produced from sustainable resources, can be biodegradable, and so far have been shown to have minimal environmental, health, and safety risks. Research and development of cellulose nanomaterials are accelerating, and over the past decade they have gone from scientific curiosity to industrial demonstration trials and the introduction of commercial products. This review defines what cellulose nanomaterials are, how they are made, their properties, and their diverse applications, which have grown to include reinforcements for polymer composites, drilling fluid additives, cement-based material additives, food coatings, transparent flexible electronics, and catalysis support structures.

The second review article, "Not Just Lumber—Utilizing Wood in the Sustainable Future of Materials, Chemicals, and Fuels," by Jakes et al., gives an overview of wood structure and chemical composition and also highlights some current topics in forest products research, including (1) industrial chemicals, biofuels, and energy from woody materials; (2) wood-based activated carbon and carbon nanostructures; (3) development of improved wood protection treatments; (4) massive timber construction; (5) wood as a bio-inspiring material; and (6) atomic simulations of wood polymers. The review concludes with a discussion of the sustainability of wood as a renewable forest resource.

The final paper in this *JOM* section is the research article, "Structure–Property Characterization of the Crinkle-Leaf Peach Wood Phenotype: A Future Model System for Wood Properties Research?" by Wiedenhoeft et al. The basis of this paper is a field observation that an easily observed leaf feature, a leaf with crinkles, in a peach tree genotype corresponds to trees with branches that are much easier to mechanically prune than the wild-type peach tree. The motivation for this paper

Joseph E. Jakes is the *JOM* advisor for the Nanomechanical Materials Behavior Committee of the TMS Materials Processing & Manufacturing Division, and guest editor for the topic Recent Advances in Forest Products Research and Development in this issue.

relates to a future of designing wood for particular material uses. On the one hand, researchers could concentrate on modifying harvested wood for specific end uses. On the other hand, a potentially easier and more productive route would be to manipulate the tree itself to grow wood with the desired properties. The crinkle-leaf could potentially be a useful tool for researchers as an easily field-observable vegetative marker for altered wood properties. This paper reports on initial efforts to uncover which part of the complex hierarchical wood structure controls the differences observed during pruning. The multiscale experiments included measurements of bulk specific gravity, quantitative anatomical measurements of wood cells, cell wall histochemistry, and nano-indentation of wood cell wall mechanical properties. Although not conclusively elucidating the underlying structures responsible for the observed differences in pruning, which is extraordinarily difficult because of the complexity of wood structure, this paper clearly demonstrates the need for multidisciplinary research teams (geneticists, wood anatomists, material scientists, and chemists) to approach and solve these materials problems in complex natural materials like wood.

In addition to contributing to our sustainable materials future, advanced materials research in forest products is also becoming increasingly important to maintain healthy forests and restore unhealthy forests. Healthy forests are vital to the environment, economy, and overall well-being of people throughout the world. Current threats to forests include changes in land use, diseases, invasive insects, catastrophic wildfires, and climate change, often with interdependencies between threats. For example, in the United States, a major threat to forests is catastrophic wildfires fed by an excessive amount of accumulated biomass in the forests, often the result of trees killed by disease or invasive insects. Wildfires fed by excess low-value woody biomass cause devastating loss of life and property, release terrestrial carbon, and cost billions of dollars annually to fight. About 400 million acres of forest in the United States are in need of restoration, which often includes costly mechanical removal of the low-value woody biomass. Unfortunately, available funding for forest restoration to prevent catastrophic wildfires is not enough to make an appreciable impact. If cellulose nanomaterials can be developed into a high-volume market, then a potential solution to funding forest restoration could be to convert low-value woody biomass removed during restoration efforts into cellulose nanomaterials.[2] Restoration costs may not be completely recovered from the cellulose nanomaterials, because much of the forests needing restoration are in remote locations; however, recovering at least part of the restoration costs would increase the acreage of forests that could be restored for a given amount of funding, thereby accelerating forest restoration efforts.

The following papers being published under the topic of Recent Advances in Forest Products Research and Development provide excellent details and research on the subject. To download any of the papers, follow http://link.springer.com/journal/11837/68/9/page/1 to the *JOM* contents page for the September 2016 issue (vol. 68, no. 9).

- "Overview of Cellulose Nanomaterials, Their Capabilities and Applications" by Robert J. Moon, Greg Schueneman, and John Simonsen
- "Not Just Lumber—Utilizing Wood in the Sustainable Future of Materials, Chemicals, and Fuels" by Joseph E. Jakes, Xavier Arzola, Rick Bergman, Peter Ciesielski, Christopher G. Hunt, Nima Rahbar, Mandla Tshabalala, Alex C. Wiedenhoeft, and Samuel L. Zelinka
- "Structure–Property Characterization of the Crinkle-Leaf Peach Wood Phenotype: A Future Model System for Wood Properties Research?" by Alex C. Wiedenhoeft, Rafael Arévalo, Craig Ledbetter, and Joseph E. Jakes

REFERENCES

1. M. Dominguez-Rodrigo, J. Serrallonga, J. Juan-Tresserras, L. Alcala, and L. Luque, *J. Hum. Evol.* 40, 289 (2001).
2. M.T. Rains, A.W. Rudie, and T.H. Wegner, *Consult. Mag.* (Assoc. Consult. For.) 34 (2014).