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Trees Used to Create Recyclable, Efficient Solar Cell

(Reprinted from the Georgia Tech Daily Digest, March 25, 2013)

Solar cells are just like leaves, capturing the sunlight and turning it into energy. It's fitting that they can now be made partially from trees.

Georgia Institute of Technology and Purdue University researchers have developed efficient solar cells using natural substrates derived from plants such as trees. Just as importantly, by fabricating them on cellulose nanocrystal (CNC) substrates, the solar cells can be quickly recycled in water at the end of their lifecycle.

The technology is [published](#) in the journal *Scientific Reports*, the latest open-access journal from the Nature Publishing Group.

The researchers report that the organic solar cells reach a power conversion efficiency of 2.7 percent, an unprecedented figure for cells on substrates derived from renewable raw materials. The CNC substrates on which the solar cells are fabricated are optically transparent, enabling light to pass through them before being absorbed by a very thin layer of an organic semiconductor. During the recycling process, the solar cells are simply immersed in water at room temperature. Within only minutes, the CNC substrate dissolves and the solar cell can be separated easily into its major components.

Georgia Tech College of Engineering Professor Bernard Kippelen led the study and says his team's project opens the door for a truly recyclable, sustainable and renewable solar cell technology.

"The development and performance of organic substrates in solar technology continues to improve, providing engineers with a good indication of future applications," said Kippelen, who is also the director of Georgia Tech's Center for Organic Photonics and Electronics (COPE). "But organic solar cells must be

recyclable. Otherwise we are simply solving one problem, less dependence on fossil fuels, while creating another, a technology that produces energy from renewable sources but is not disposable at the end of its lifecycle."

To date, organic solar cells have been typically fabricated on glass or plastic. Neither is easily recyclable, and petroleum-based substrates are not very eco-friendly. For instance, if cells fabricated on glass were to break during manufacturing or installation, the useless materials would be difficult to dispose of. Paper substrates are better for the environment, but have shown limited performance because of high surface roughness or porosity. However, cellulose nanomaterials made from wood are green, renewable and sustainable. The substrates have a low surface roughness of only about two nanometers.

"Our next steps will be to work toward improving the power conversion efficiency over 10 percent, levels similar to solar cells fabricated on glass or petroleum-based substrates," said Kippelen. The group plans to achieve this by optimizing the optical properties of the solar cell's electrode. "We will also coat these cells with an eco-friendly, thin environmental barrier coating to protect the cells from water and oxygen when operating in the field."

Purdue School of Materials Engineering associate professor Jeffrey Youngblood collaborated with Kippelen on the research.

A provisional patent on the technology has been filed with the U.S. Patent Office.

There's also another positive impact of using natural products to create cellulose nanomaterials. The nation's forest product industry projects that tens of millions of tons of them could be produced once large-scale production begins, potentially in the next five years.

The research is the latest project by COPE, which studies the use and development of printed electronics. Last year the center created the first-ever [completely plastic solar cell](#).

Trend Indicators from Industry Intelligence Inc.

[Industry Intelligence Inc.](#) has provided market intelligence to more than 600 companies worldwide since it began as Forestweb in 1999. Industry Intelligence delivers a daily report featuring news of the paper and forest products industries. For your subscription visit: <http://www.industryintel.com>

Below is a selection of recent headlines chosen to mirror significant trends in and around the paper and forest products industries.

US paperboard packaging sector sees promise in move to bring business back to US, shift toward more sustainable packaging, advances in digital printing that allow for small-batch, sort-run, customizable jobs, other trends, says PPC president

The growing consumer focus on sustainable packaging is creating an environment in which innovation and design opportunities can flourish; expect to see more creative, eco-friendly paperboard packaging designs.

Cascades launches first unbleached, 100% recycled facial tissue as part of its Moka line; facial tissue product has beige color, 25% less environmental impact via life cycle when compared to pulp mix used in its 100% recycled fiber facial tissue

The new facial tissue follows the January 2012 launch of the Cascades Moka bathroom tissue.

Folding carton consumption to grow globally by 5.1% a year, to reach 63 million tonnes, valued at US\$184B by 2018, up from 47 million tonnes, valued at US\$140B in 2012, according to new study by Smithers Pira

Key technologies influencing the folding carton market include retail-ready packs, anti-counterfeit technologies and barrier coatings.

Book publishing increases use of recycled paper

In 2010, recycled materials made up 24% of books from U.S. publishers, marking a jump from 5% in 2004, according to a report from the Book Industry Environmental Council (BIEC) and Green Press Initiative.

UPM reshaping its business to boost earnings, valuation, says CEO at company's annual meeting; strategy includes plan to increase company's pulp,

energy, label and Asian paper business to more than 50% of sales by latter part of this decade

Since 2007, UPM's Pulp, Energy, Label and Asian Paper Business grew by 43 % in the topline. Meanwhile, sales of paper, timber and plywood dropped by 11 %.

Sappi addresses issue of recycled content in newly-released installment of its eQ Journal 005, cites example in which 10% boost in recycled content of paper produced at its Somerset Mill in Maine increased the product's carbon footprint by 16%

A study of Sappi's Somerset Mill revealed that adding 10 percent recycled content increases the product's carbon footprint by 16 percent.

South America's planned chemical pulp expansion of up to 30 million tonnes/year by 2020 will give the region a growing influence, competitive position in global markets; up to 8 million tonnes of the new output set to come onstream in 2014, says study

European companies have already made significant investments in South America. The new technology and more efficient processes in the state-of-the-art mills serve as a competitive advantage to companies in the region.

India's paper, paperboard industry to grow at the CAGR of about 9.6% during 2012-2017, reach around US\$11B by 2017, due to growing GDP, population, improved literacy, leading especially to increased paperboard demand, study finds

Specialty papers such as tissue papers, fine art papers etc. are becoming increasingly common.

Global tissue paper demand growth forecast at 4%-5%; capacity expansion remains focused on China, which will account for nearly 62% of the total increase in 2013 as regions like US slow down, pause to absorb new capacity amid market concerns

The world market for tissue is valued at more than \$62.9 billion according to Swedish tissue producer Svenska Cellulosa Aktiebolaget.

University of Alberta researchers propose startup company to convert cellulose left over from the paper recycling process into chemicals for use in fragrances, pharmaceuticals, flu vaccine; but the work is still in the laboratory phase

A fourth-year chemical engineering student at the University of Alberta, is one of the academic forces that developed the idea for Upcycled Aromatics, a startup biotech company.

US paper, paperboard capacity down 1.6% in 2012 from previous year, will decline 0.4% in 2013, yet rise 0.6% in 2014, 0.2% in 2015; tissue paper, containerboard grades to add capacity while newsprint, printing-writing paper grades to decline: AF&PA

Boxboard capacity is expected to hold essentially stable.

Statistics Corner: Recycling of Old Corrugated Containers

In 1993, the industry produced about 29,000 tons of corrugated containers. About 16,000 tons was gathered

up and either used to make new products or exported. The recovery rate, the percentage of containers that was re-used or exported, was 54.5%. Most of the rest ended up in landfills. The picture in 2012 was very different, reflecting changing attitudes of both producers and consumers towards the environment. As Figure 1 shows, the amount of fiber recovered is now approaching the amount produced. The recovery rate (Figure 2) is now greater than 90%. ■

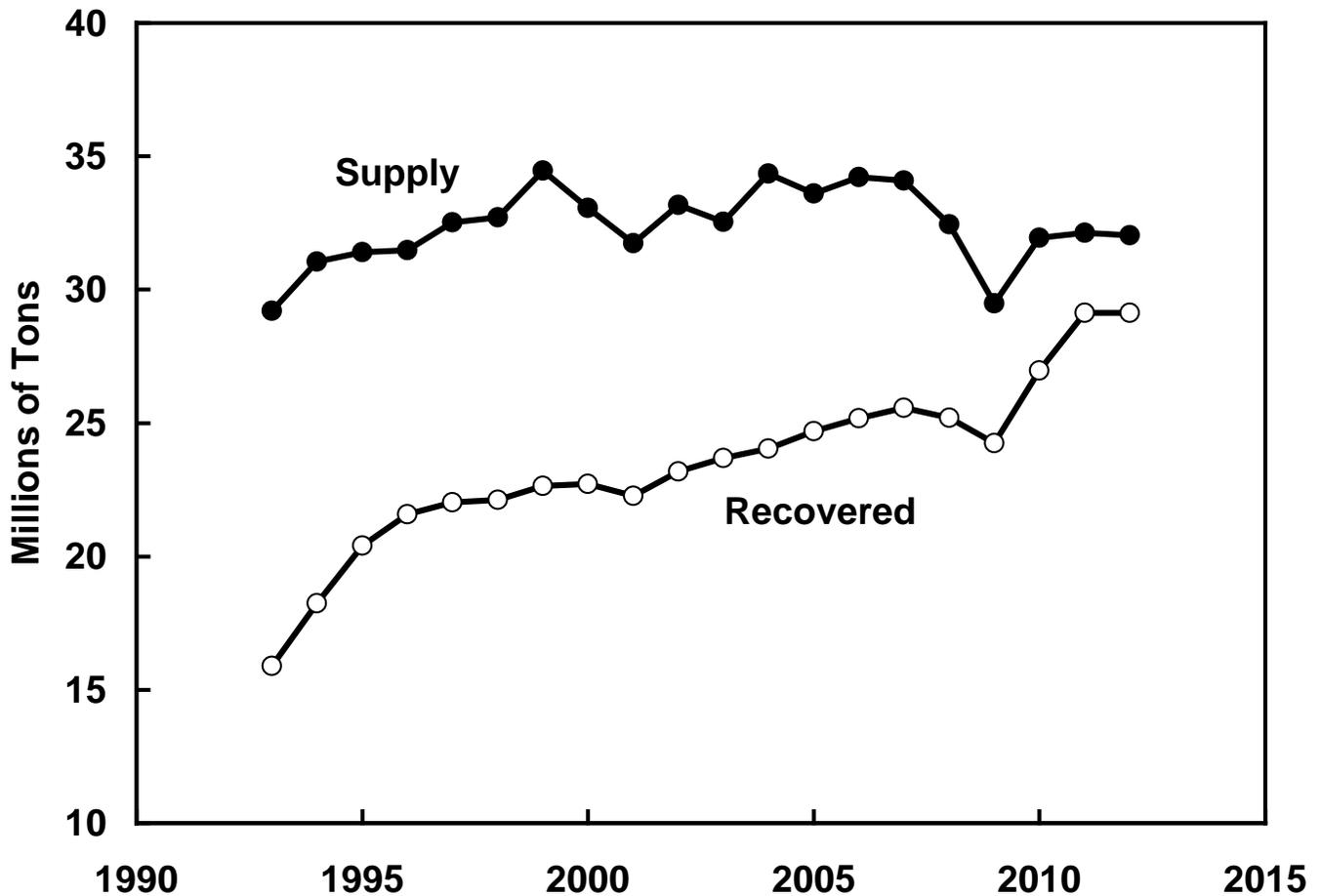


Figure 1. Old corrugated container supply and recovery. (AF&PA)

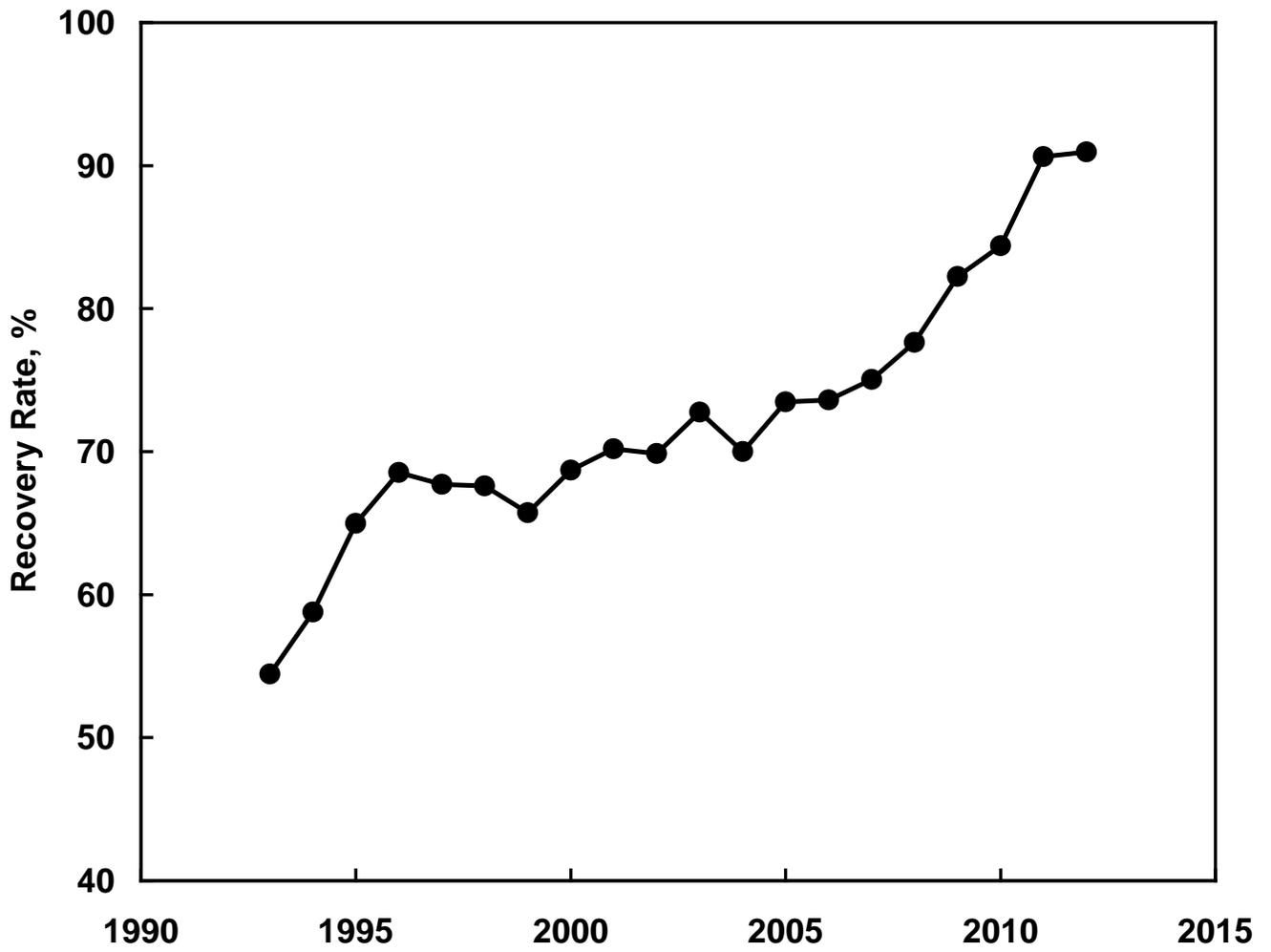


Figure 2. Old corrugated container recovery rate. (AF&PA)