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Technology and Costs

Biorenewable Insights: Lignin

Lignin is one in a series of reports published as part of NexantECA's 2017 Biorenewable Insights program.

Overview

As investigated here, carbon fiber applications for lignin are not a near term reality, while phenolic resins based upon lignin chemistry are being commercially produced and are showing promise from an economic standpoint. Furthermore, considering that many phenolic resin consumers are in the forest products industry, this is a solution that is convenient for the sector. Carbon fiber, on the other hand, is economically disadvantaged, and has inferior performance (tensile strength and tensile modulus) as compared to either PAN or pitch based carbon fiber.

The following uses, once practiced in reasonably large scales, have shut down due to no longer being competitive with petroleum-based technologies, and have been discontinued with the exception of vanillin a plant in Sweden.

- Phenolics by alkaline hydrolysis
- Vanillin production
- Organic acids by strong oxidation include: benzoic, toluic, methoxybenzoic, acetic and formic acids
- Lignin hydrogenolysis to phenols and aromatic hydrocarbons
- Recovery of mixed formaldehyde plus substituted phenol stream for plywood and oriented strand board manufacture

The scope of this report is concerned with lignin conversion to chemicals and products, not as-is use of lignin or lignosulfonates.

Technologies

The following additional applications have been suggested and investigated to some degree, for lignin to be converted into an intermediate to be used in applications:

- A renewable Bisphenol-A replacement
- Antimicrobial nanomaterial
- Aromatics and aromatic oxygenates
- Carbon nanomaterials for electrodes in lithium-ion batteries
- Carbon materials
- Energy storing films
- Flocculant, combined with acrylamide, to coagulate aluminum and remove dissolved organic carbon from wastewater
- Food packaging applications
- Biofuels
- Hydrogels
- Polyurethane
- Surfactant
- Smart polymers

Additional applications have been suggested and investigated, to use lignin as-is in applications—some of which are currently in commercial use, which include bio-power, composites, adsorbents of selected heavy metals and toxic organic compounds, antioxidants, cement additives to improve flow properties and enhance curing rates, drilling liquids/muds, and industrial composting.

The two main applications investigated include phenolic resins and carbon fiber. These are the most advanced, and most researched applications. Other potential applications covered at a higher level include:

- Lignin-Furfural Resins as replacements for phenol-formaldehyde resins
- Lignin as a polyol for polyurethanes
- Lignin and lignin monomers as a BPA replacement in:
  - Polycarbonate
  - Epoxy Resins

Process Economics

Cost of production models for USGC, Brazil, Western Europe and China are shown for:

- Phenol-Lignin-Formaldehyde Resin
- Lignin Carbon Fiber

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Technology and Costs comprises the Technoeconomics – Energy & Chemicals (TECH) program, the Biorenewable Insights program (BI), and the new Cost Curve Analysis. These programs provide comparative economics of different process routes and technologies in various geographic regions.

NexantECA serves its clients from over 10 offices located throughout the Americas, Europe, the Middle East, Africa, and Asia.

Americas
Tel: +1 914 609 0300
44 S Broadway,
5th Floor White Plains
NY 10601-4425
USA

Europe, Middle East & Africa
Tel: +44 20 7950 1600
110 Cannon Street
London EC4N 6EU
United Kingdom

Asia Pacific
Tel: +662 793 4600
22nd Floor, Rasa Tower I
555 Phahonyothin Road
Kwaeng Chatuchak
Khet Chatuchak
Bangkok 10900
Thailand

For more information. please contact
Technology@NexantECA.com or www.NexantECA.com