

Closed Loop Production using Renewable Raw Materials

Collaboration between Peggy Notebaert Nature Museum and the
University of Illinois at Chicago's Institute for Environmental Science and Policy

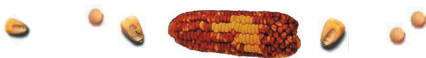
IESP Research Agenda

Recent work sponsored by the USDA and DOE suggests that promising replacements for petrochemical goods are products derived from biomass (renewable raw materials such as agricultural feedstocks), often termed biocommodities. The life cycle analysis of a biomolecule, commercially available biopolymer polylactic acid (PLA), includes all four critical areas: agriculture, processing, production and product cycles. The decrease in reliance on fossil fuels accompanied by the benefits of the 'net zero' CO₂ emissions of biomass feedstocks are two of the main drivers in the transition from a hydrocarbon to a carbohydrate economy. Past investigations into the life cycle impacts of bio-based production have therefore closely focused on the energy and CO₂ flows associated with bioproduction from cradle to gate, while neglecting important trade-offs, such as agricultural impacts on the nitrogen cycle.



Environmental Impact

PLA is a biodegradable polymer: in a compost heap it degrades in 45-60 days (140 degrees). Some studies show that when compared to petroleum-based polymers, PLA uses 30-50% less fossil fuel during production and emits fewer greenhouse gases during its life. Thinking about the entire life cycle of the bio-based polymer may lead to new figures. What about the farming fossil fuels, the energy in fermentation and polymerization, the fossil fuels used to transport and ship PLA? Just because something is made from renewable materials, doesn't mean that it is better for the environment.



Reference Websites

IESP home: www.iesp.uic.edu

Cargill Dow Natureworks PLA: www.cargilldow.com

US DOE Biomass R&D: www.bioproducts-bioenergy.gov

DuPont 'Sorona 3GT' biopolymer: www.dupont.com/sorona

US EPA's LCA Access: www.epa.gov/ORD/NRMRL/lcaccess

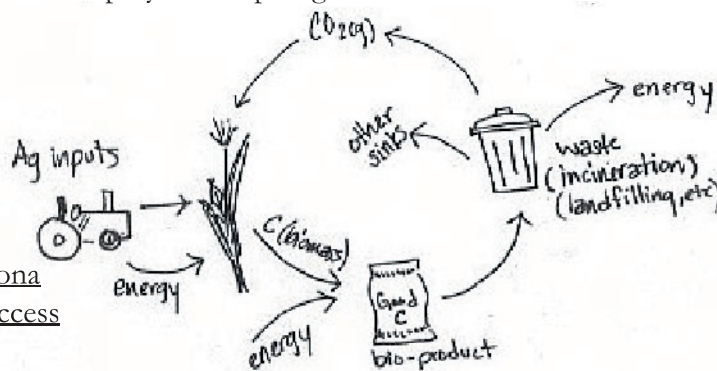
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Life Cycle Assessment Tool

LCAs are used to assess the material and energy flows throughout a product's entire life cycle. We can use the emissions and energy use assembled in a life cycle inventory to compare products like the PLA biopolymer to traditional petroleum-based polymers, such as polyethylene (PE). LCA requires scientists, engineers, and policy makers to think broadly, in terms of the 'bigger picture' by investigating all of a product's inputs.

'Net zero' carbon emissions

The carbon released at the end of the product's life is taken up by the crop to grow more raw materials



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Researchers are looking for new feedstocks for bio-based production, like wheat and grass

Agriculture



Biodegradation returns CO₂ to the atmosphere for uptake by plants



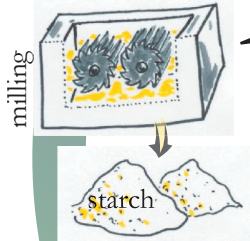
PLA products are disposed of via composting (biodegradation turns material into CO₂ and H₂O), landfilling (no degradation), and incineration for energy value

Disposal



Processing

Milling separates starch, corn oil, and meal from corn grain

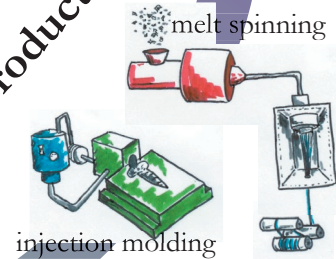


life cycle

Use



Production



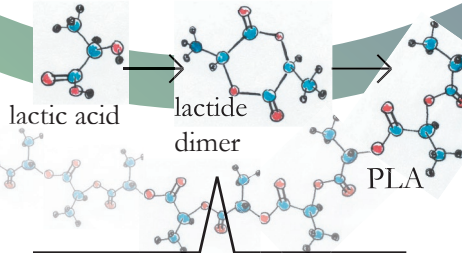
Fermentation

lactic acid



Starch in the form of glucose is fermented by microorganisms with lots of heat and water to make lactic acid

Polymerization



Adding heat, pressure and a catalyst creates the polymer

The PLA pellets can be transformed into many types of products, including fiber and heavier applications

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