ionoSolv

Ethanol production using cheap pretreatment to retrofit 2G to 1G existing processes

Background

The ionoSolv process efficiently fractionates a wide variety of lignocellulosic plant biomass using ultra-low-cost organic salts (ionic liquids). The main advantage is low capital investment for the pretreatment step leading to low-cost glucose of around $250/t.

Replacing an increasing proportion of petroleum with biofuels and renewable chemicals is a major trend today. Bioethanol is at present the most important renewable replacement of gasoline and almost exclusively derived from food-grade sugars, however, there is legislative and consumer demand to derive more bioethanol from non-food feedstocks.

Lignocellulosic biomass is the most abundant plant biomass on earth, consisting of roughly 40% glucose and of 30% other sugars, the remainder being lignin or minor components. Major lignocellulosic feedstocks are agricultural residues, commercial forests and wood waste. Using lignocellulose as a feedstock for producing bioethanol has the potential to increase yields per land area and improve CO_2 emission savings. However, it has been difficult to develop cost-effective processes for converting lignocellulose into bioethanol. High capital and operating cost, especially in the pre-treatment step, are major issues for cost-effective production of cellulosic or second generation bioethanol.

Technology

At Imperial College London, we have developed a novel process that can pre-treat (fractionate) a wide range of lignocellulosic feedstocks, including agricultural residues for second generation bioethanol production. Our ionoSolv process uses low-cost ionic liquid solutions; solutions of organic salts that are liquid at ambient temperature. The ionoSolv technology is unique in that the solvent costs are in the range of common organic solvents (~$1.24/kg). A major difference with other processes is that ionic liquids do not evaporate, which increases safety and lowers capital expenditure. The main products of the ionoSolv pre-treatment are separate fractions of cellulose, hemicellulose or furfural, lignin, and acetic acid.

Quick Info

Benefits

- Glucose price of $250/t
- Pretreatment CapEx reduced by 30%
- 50% increase in glucose production
- Retrofit 1G plants
- Sustainable bioethanol (from wheat and corn stalks and other lignocellulosic biomass)
- Increased production capacity of existing 1G bioethanol plants
- CO_2 reduction of bioethanol production (output can be classified as advanced biofuel)
- High quality lignin and other saleable by-products

Lamia Baker, PhD, MBA
Senior Technology Licensing Executive
e: lamia.baker@imperialinnovations.co.uk
t: +44 (0)20 3053 8839
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The ionic liquid solution is able to dissolve lignin and hemicellulose, while leaving the glucose as a filterable solid in the form of cellulose. The cellulose can be hydrolysed to glucose and directly fed into fermenters without lignin or inhibitors interfering with speed of the conversion or the final yields. The lignin is recovered after addition of water to the solvent and can be burned for heat and electricity. It can also be used as chemical feedstock. The hemicellulose can be pre-extracted and fermented as a separate C5 sugar stream, or isolated as furfural (current market value $1200/t). The water added for isolating the lignin is evaporated (which will also recover the furfural and acetic acid) and the ionic liquid reused. Since the ionoSolv process separates the lignin at the pre-treatment stage and yields a separate glucose stream, it is possible to add the ionoSolv process to existing 1G plants and produce bioethanol from grain, sucrose and agricultural residue at the same time.

Industry Overview

A number of pre-treatment technologies have been developed. The first cellulosic ethanol plants use aqueous pre-treatment, such as autocatalysis (steam explosion, e.g. DSM POET) and base catalysis (dilute ammonia, DuPont) on a commercial scale. None of these processes remove lignin at the pre-treatment step, hence the lignin is carried over into the hydrolysis tank and sometimes also the fermentation tank. Solid lignin and unwanted side-products created during pre-treatment and carried over can interfere with operating the plant and severely reduce fermentation yield. Carrying over lignin increases the size of reactors and piping down-stream, increasing capital cost.

These processes produce glucose at prices over $300/t. The ionoSolv process offers 30% less capital costs of the pretreatment, 50% more glucose production (due to the use of the full plant). Thus producing glucose at a price of $250/t, competitive with sugars from corn or sugarcane.

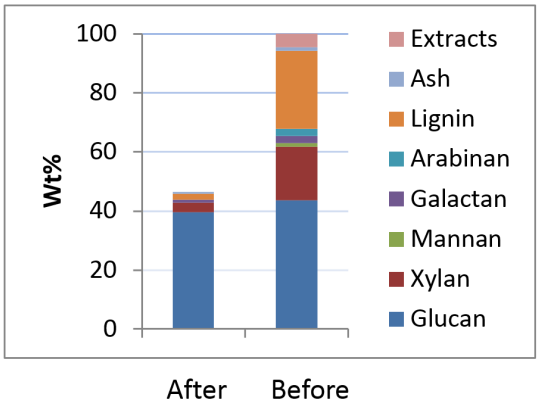

Figure 1: the ionoSolv solvent dissolves the lignin and the hemicellulose.

Applications

- Bioethanol
- Other:
  - ◊ Furfural: is a reactive solvent in lubricant oil refining and can be transformed into a variety of other chemicals, such as furfuryl alcohol and tetrahydrofuran, which are sold on the bulk chemical market.
  - ◊ Lignin: can be used for energy recovery or sold as chemical feedstock for creating resins used in particle board industry, and as dust suppressants. A host of novel applications for lignin are under intense investigation.
  - ◊ Other co-products are silica, acetic acid and a water-insoluble fraction such as tall oil, which may contain interesting compounds such as lipids.

IMPERIAL INNOVATIONS

London Office
52 Princes Gate,
Exhibition Road,
London, SW7 2PG

Tel: +44 (0)207 581 4949

Email: info@imperialinnovations.co.uk

Web: www.imperialinnovations.co.uk