Producing plant-based drinking bottles from FDCA

VTT Technical Research Centre of Finland has developed an environmentally sound and economical method for producing furandicarboxylic acid (FDCA) from plant sugars for the production of drinking bottles, paints and industrial resins, for example. This technology enables production of plant-based products.

The main production material of drinking bottles is still oil-based PET, although there has been news on alternatives based on renewable materials during the last few years. VTT's new method provides a route for the packaging and beverage industries to expand the use of renewable materials in their production.

VTT has patented a method for producing furan dicarboxylic acid (FDCA), the monomer for PEF (polyethylene furanoate) polymers, from sugar or sugar waste. Thanks to the solid acid catalyst and bio-based solvent with short reaction time, the method provides a considerable reduction of toxic waste compared to traditional methods. The method can be scaled-up to industrial purposes without substantial investments, and it has already raised a lot of interest in industry. The R&D work was funded by VTT and Tekes.

Green plastics from citrus fruit peels and sugar

The need for bio-plastics is growing. Brand owners are looking for sustainable solutions for packaging, fibres, paints, inks and plastics. This creates a need for high-performance bio-plastics such as polyamides (PA) and polyesters (PET).

The total global production of PET polymers was over 50 Mt and that of polyamides (PA) over 10 Mt in 2015. Furan dicarboxylic acid (FDCA) -based polyethylene furanoate (PEF) polymers offer a bio-based alternative to petroleum-based PET polymers. Polyamides are used in applications calling for high durability and strength. Muconic acid is a versatile monomer, which can be converted to multiple PA monomers such as adipic acid, terephthalic acid, hexamethylene diamine, caprolactam, caprolactone and 1,6-hexanediol. PAs are used as engineering plastics, for example in automobiles.

New prospects for the use of pectin

VTT has developed a process to convert pectin biochemically to an aldaric acid, which in turn can be chemically converted to monomers for bio-based polyesters and polyamides. Pectin is a side stream obtained from citrus fruit peels or from sugar beet pulp.

Sugar beet pulp is currently used as animal feed, but the goal is to use the pulp for higher-value applications. Pectin is currently underutilised as the production is only about 40 000 t/a, with the potential of several tens of million tonnes available annually. Its current use is in the food and beverage industry as, for example, a gelling agent. In addition to pectin, wood- or plant-based glucose can be used in the production of aldaric acid.

Parr Häkkinen van Strien of VTT.

VTT Bioplastics' David Thomas.

Competitive new technology

VTT has patented a technology combining biotechnical and chemical reaction steps to produce FDCA and muconic acid from aldaric acids. The first step consists of the oxidation of galacturonic acid, a constituent of pectin, to galactaric acid with a fungal biocatalyst. The conversion efficiency is high and this step has been scaled up to pilot scale (300 ℓ) delivering kilogramme amounts of galactaric acid for the second step conversion.

The second step converts the aldaric acid into furan carboxylic acid (FCA) and FDCA or muconic acid depending on the reaction conditions. FDCA is a monomer for polyethylene furanoate (PEF), a bio-based alternative for polyethylene terephthalate (PET). Muconic acid is a precursor for polyamide monomers.

The techno-economic analysis shows competitive pricing and the life cycle analysis shows that the carbon footprint is lower compared to petroleum-based alternatives for both monomers.

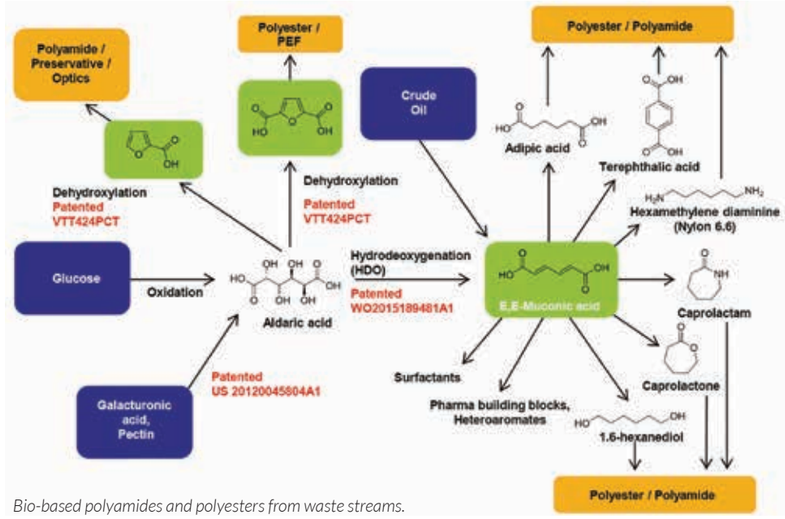
FDCA and muconic acid transforming the industry

Plastics have revolutionised our lives in every aspect, yet only 2% of the yearly production of 300 Megatons are renewable. A 10% growth rate per annum is now being proposed for bio-based drop-in PET and PLA.

Furandicarboxylic acid (FDCA) and muconic acids are also changing the face of the bio-based plastics industry. It is often assumed that these bio-based plastics will be somehow flawed and not be as good as crude-oil based products, or that they have a higher price. This misconception leads to the presumption that they cannot be produced to the same markets cost as existing materials. These bio-based plastics can actually be superior to those crude-oil products.

Using pectin and sugar, it is possible to prepare high quality materials that can be made into, for example, plastics for everyday applications, skin care, packaging materials and resins.

This industry transformation will be discussed in a Webinar to be held on Wednesday, September 27, 2017 and entitled: *FDCA and muconic acid transforming the industry: Green plastics without the bio-premium.*



Bio-based polyamides and polyesters from waste streams.

In this webinar, VTT will be releasing its latest results in bio-based plastics development. Join us to learn about how furandicarboxylic acid (FDCA) and muconic acid are transforming the industry.

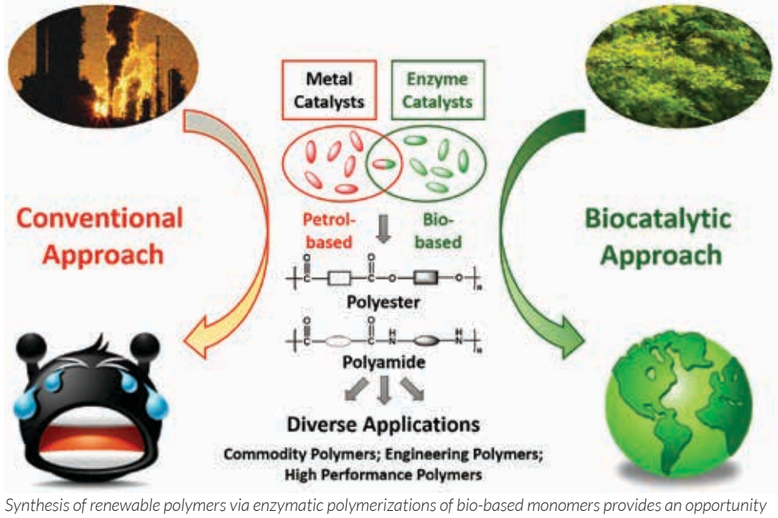
Key topics include:

- The patent landscape and the direction of R&D trends for these bio-based plastics.
- Why we are still using crude oil and why is this a problem.
- Why bio-based plastics are better with respect to both cost and properties.
- How FDCA and muconic acid can transform the bio-based plastics industry.

Presenters include:

- Dr Ali Harlin, DrSc(Tech), Research Professor in bioeconomy at VTT, who has experience from petrochemical, machinery and forest industries. He is active in research on novel and added value chemical and material applications of biomass, especially wood-based lignocellulosics.
- Dr Juha Linnekoski, DSc (Tech), principal scientist and principal investigator with 18 years' experience in development of various catalytic processes for the production of bio-based fuels and chemicals from biomass. Linnekoski has expertise in heterogeneous catalysis and in catalytic processes to convert bio-based raw materials into chemicals and monomers for bio-plastics.
- Dr David Thomas, a Senior Scientist with 13 years' experience in industrial, custom and polymer synthesis along with process optimisation. Thomas is currently actively working on bio-based platform chemicals derived from sugars and sugar acids.

For further information about the webinar, contact info@vtt.fi or phone +358 20 722 7070



Synthesis of renewable polymers via enzymatic polymerizations of bio-based monomers provides an opportunity for achieving green polymers and a future sustainable polymer industry.

Ref: Jiang Y; Loos K: Enzymatic Synthesis of Bio-based Polyesters and Polyamides. Polymers 2016, 8, 243.