The Bioeconomy and Circular Plastics

14/12/2019 VTT – beyond the obvious

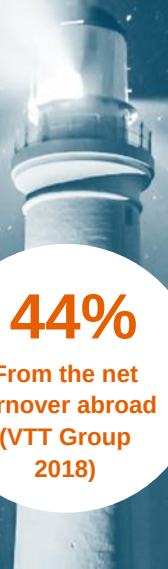
VTT – beyond the obvious

VTT is one of the leading research, development and innovation organizations in Europe. We help our customers and society to grow and renew through applied research. The business sector and the entire society get the best benefit from VTT when we solve challenges that require world-class know-how together and translate them into business opportunities.

Our vision
A brighter future is created through science-based innovations.

Our mission
Customers and society grow and renew through applied research.

Strategy
Impact through scientific and technological excellence.



Established in **1942**

268 M€
Net turnover and other operating income (VTT Group 2018)

2,049
Total of personnel (VTT Group 31.12.2018)

Owned by **Ministry of Economic Affairs and Employment**

31%
Doctorates and Licentiates (VTT Group 2018)

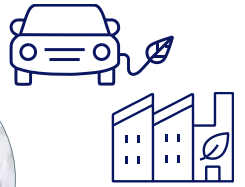
44%
From the net turnover abroad (VTT Group 2018)

VTT's business areas

- Sensing and integration
- Connectivity
- Data-driven solutions
- National Metrology Institute VTT MIKES
- Micronova manufacturing services

KNOWLEDGE INTENSIVE PRODUCTS AND SERVICES

SMART INDUSTRY AND ENERGY SYSTEMS

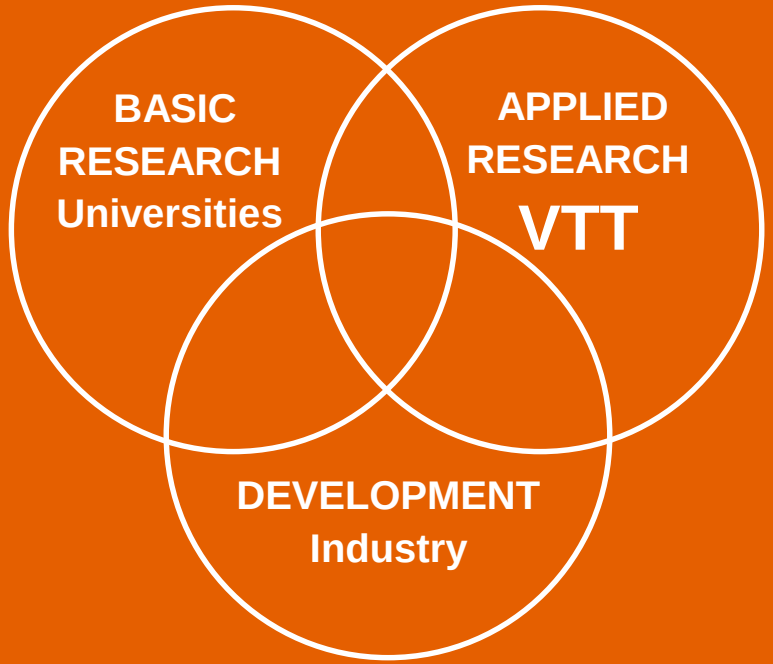


- Lifecycle solutions
- Nuclear safety
- Smart energy and transport solutions
- Digital engineering
- Business innovation foresight

- Industrial biotechnology and food solutions
- Biomass processing and products
- Sustainable energy and chemical technologies

SOLUTIONS FOR NATURAL RESOURCES AND ENVIRONMENT

VTT's status as performer of R&D work



VTT's research projects

1 COMMERCIAL PROJECTS

Impact:

- Building competitiveness for VTT's customers through world-class research and innovation services

2 JOINTLY FUNDED PROJECTS

Impact:

- More efficient technology transfer
- Foundation for new innovations and political decision-making

3 SELF-FINANCED PROJECTS

Impact:

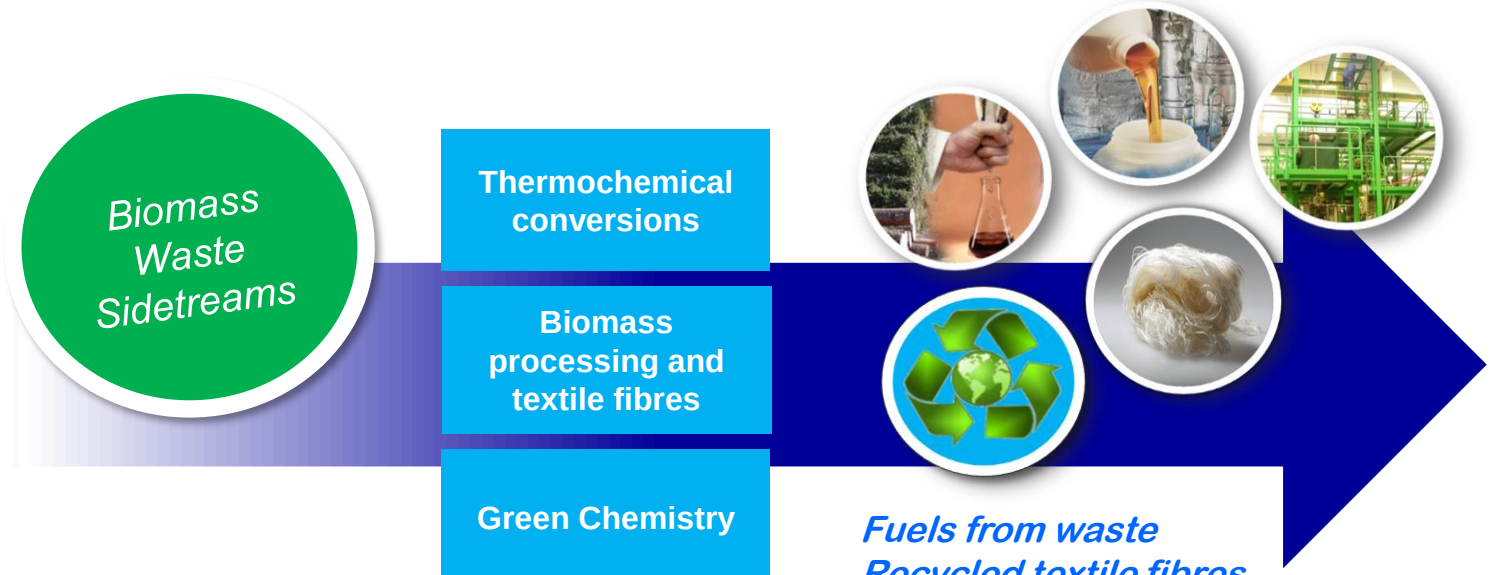
- Developing VTT's own competitiveness and acquiring knowledge and expertise to meet future customer needs

Bioruukki Pilot Centre - efficiency, speed and lower risks to development with piloting and demonstrations

- **A new piloting ecosystem** for process industry scale-up and demonstrations.
- A former printing plant transformed to world scale R&D centre.
- Located close to Otaniemi campus.

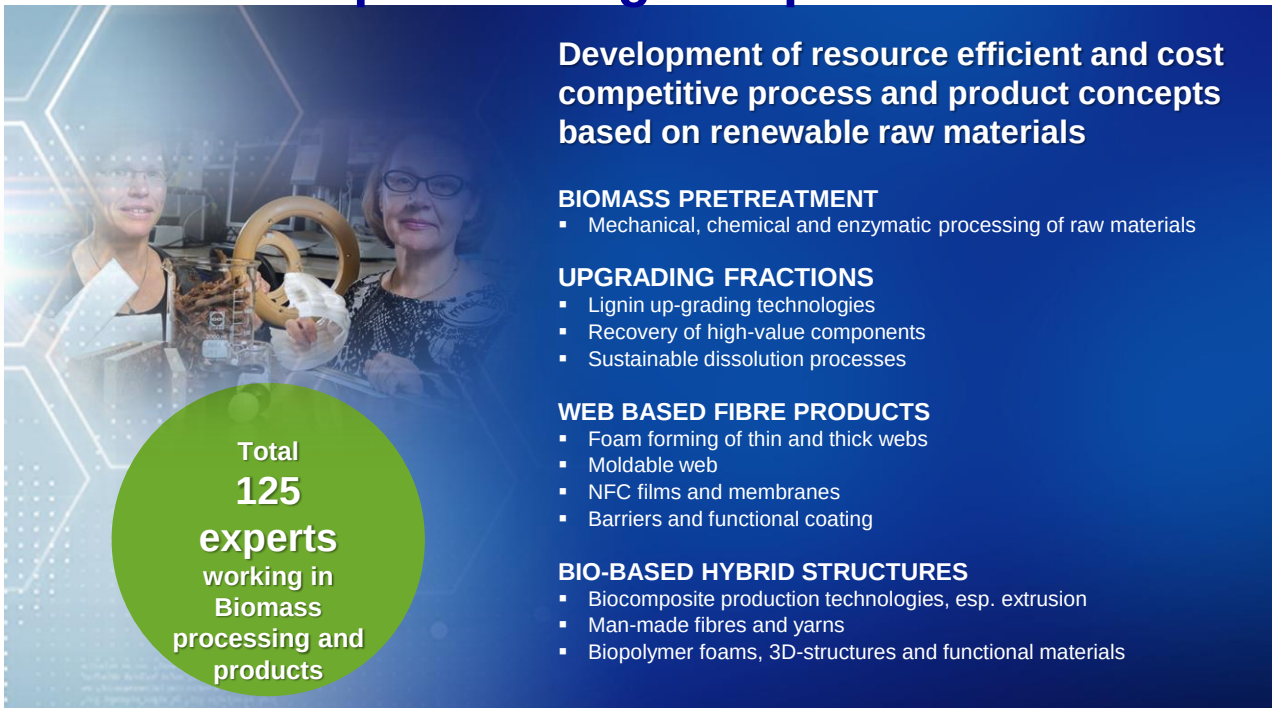
Bioruukki is the largest open pilot facility in bioeconomy in Northern Europe

Bioruukki pilot ecosystem – An integrated enabler to accelerate higher value business in bio and circular economy



Fuels from waste
Recycled textile fibres
Chemicals from cellulose
Bio-oil from forest residues
Solar energy stored as liquid fuel
Design of new sustainable processes

Biomass processing and products



Biomaterial products

Expertise from
idea generation to
market-ready applications

Our competence areas are

- Biopolymer and fibre foams
- High-performance fibre composites
- Tailoring of fibres and biopolymers
- Biomaterial process development
- Bio- and circular economy materials

Bioeconomy – From R&D to Commericalization

- Innovative Fibre Yarn - Spinnova (a VTT spin-off)
  - Uses virgin pulp fibres as yarn building blocks to replace cotton fibres
  - Pilot scale production ongoing since 2018 – Full commericialization ongoing

- Replacing Fossil Feedstock – Paptic (a VTT spin-off)
  - Uses renewable, cellulose based raw materials

- New BTL concept proven: From biomass to biofuels
  - **Production of biofuel by gasification of biomass residues was successfully validated. The process performance was verified with bark in an 80 hour-long test run at VTT.**

Bioeconomy – VTT Packaging Solutions

Cellulose-based multilayer packaging films

- Outer layer: Modified cellulose as moisture barrier
- Inner layer: Fibrillated cellulose as O2-barrier

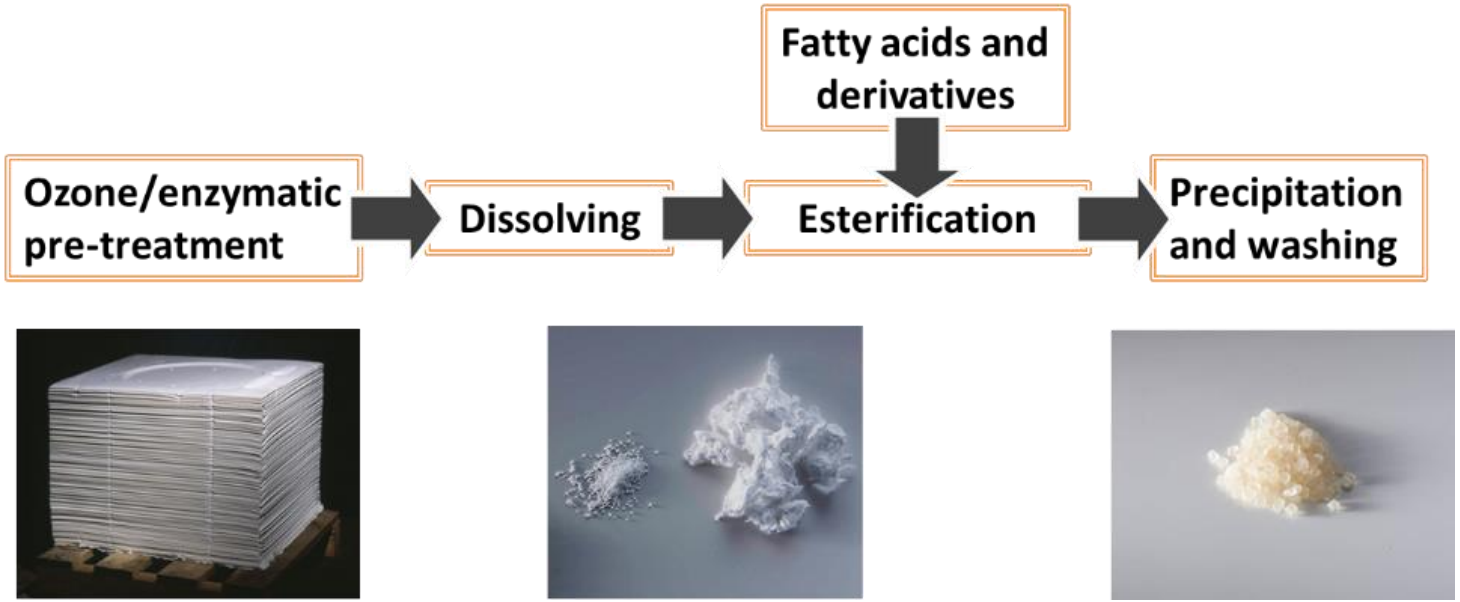
Paper like pouches

- Aesthetic layer
- Support
- Barrier
- Hot melt adhesive

Moldable board trays

- Aesthetic layer
- Support
- Barrier
- Hot melt adhesive

ThermoCell technology



Recent Headlines from Finnish R&D

- An optical fibre made from cellulose

https://www.vttresearch.com/media/news/vtt-developed-an-optical-fibre-made-of-cellulose

- Wood-based yarn captures hormones from waste water

https://www.vttresearch.com/media/news/wood-based-yarn-captures-hormones-from-wastewater

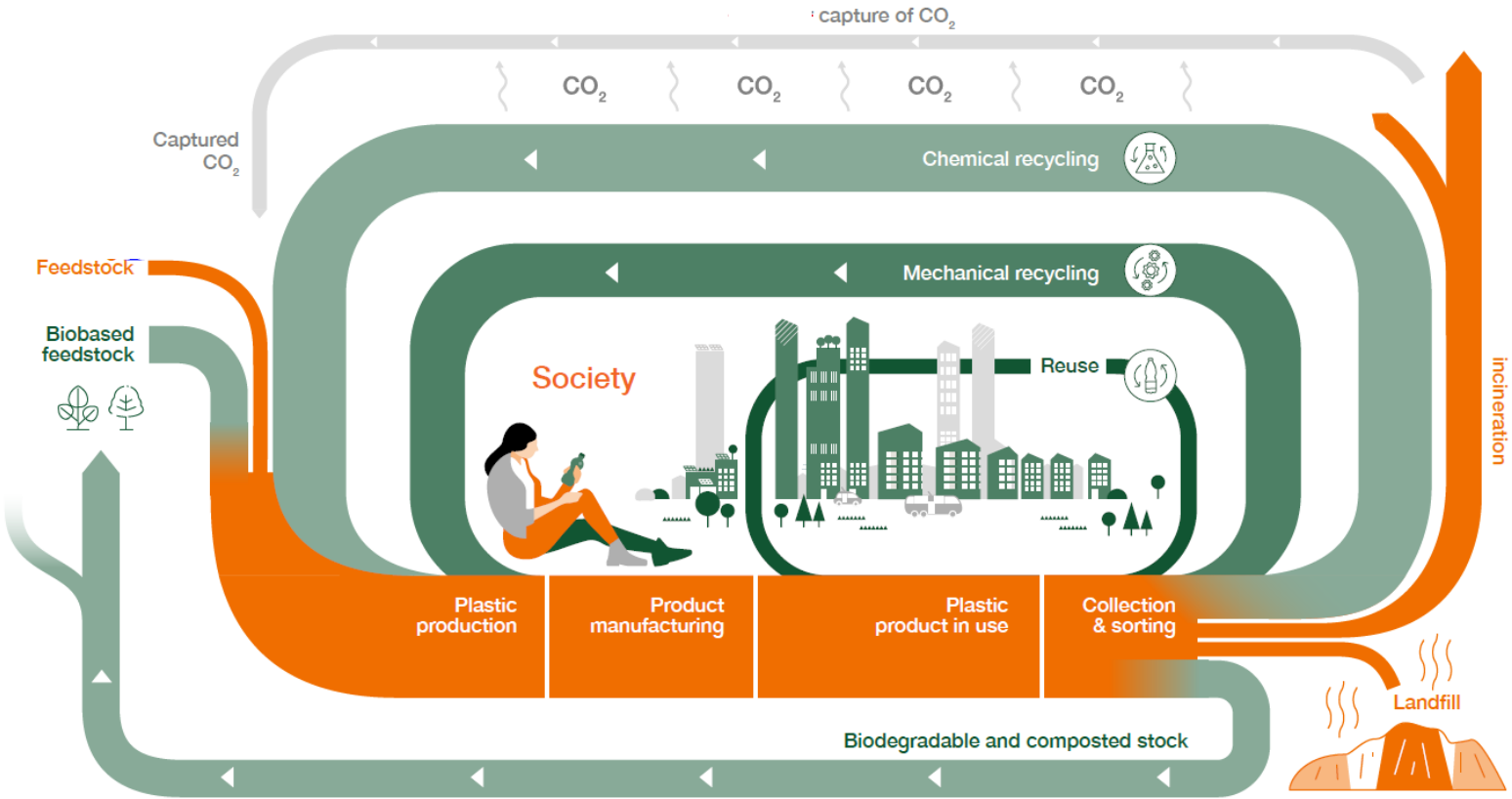
- Combination of wood fibres and spider silk could rival plastic

https://www.vttresearch.com/media/news/combination-of-wood-fibres-and-spider-silk-could-rival-plastic

Circular Plastics

Plastics – Good or Evil?

- We are living in a world, where plastics are everywhere
  - They keep our food fresh
  - They protect us from injuries in traffic or sports
  - They ensure a quality life through many medical applications
- At the same time, plastic waste is ending up in the environment and doing harm to it
- What are we going to do about it?
- **We must abandon the “make-use-dispose” approach**


capture of CO_2
CO_2
CO_2
CO_2
CO_2
Captured CO_2
Chemical recycling
Feedstock
Mechanical recycling
Biobased feedstock
Society
Reuse
incineration
Plastic production
Product manufacturing
Plastic product in use
Collection & sorting
Landfill
Biodegradable and composted stock

Driving a Circular Economy of Plastics

- **Ecodesign: Achieve Circularity in Every Step of the Value Chain**
  - Develop reuse opportunities supported by refurbishment and molecular repair technologies
  - Redesign and/or replace materials that are difficult to recycle
  - Develop materials for controlled degradation
- **Development of sorting and mechanical recycling technologies to improve recyclate quality and increase recycle rates**
- **Develop renewable bio- and CO2-based polymers and reduce fossil feedstock to a minimum**
- **Develop Thermochemical Recycling and Depolymerization towards monomers and oligomers**

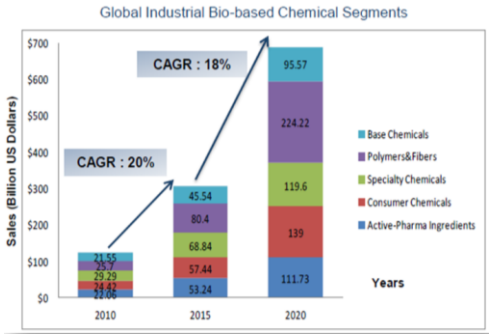
The Link Between Bio-economy and Circular Plastics

Why bio-based plastic?

- **VTT is looking to replace crude oil as the only source of the world's plastic and move to renewable feedstock**

- Every year the world consumes over 4 billion tons crude oil*, with 8% used for plastics and chemicals**

- Bio-based plastics manufacturing require only 25% of the CO2 needed for fossil-based plastics



* Statista, 2017. ** British Plastics Federation, 2017
Sources: Emerging Trends in Biochemicals; Frost & Sullivan, June 2013

From Food Waste to Food Packaging

- From sugar beet or citrus peels we can produce either FDCA or muconic acid which is then made into a plastic

Citrus peel

Sugar beet

Oxidized C6 sugar (aldaric acid)

FDCA

Muconic acid

PEF polymer

Nylon polymer

PEF

Nylon

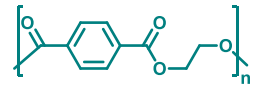
PEF Properties

- VTT's patented* technology with FDCA allows us to exploit a unique synthesis which overcomes the problems of alternative routes

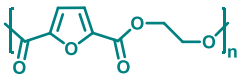
- Targeted applications
  - Select replacement for PET, Polyamides, Plasticizers

Better barrier properties than PET

- **O_2 BARRIER** = **10 times** better
- **CO_2 BARRIER** = **4 times** better
- **H_2O BARRIER** = **2 times** better



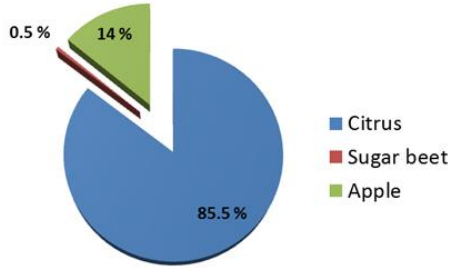
Polyethylene terephthalate (PET)



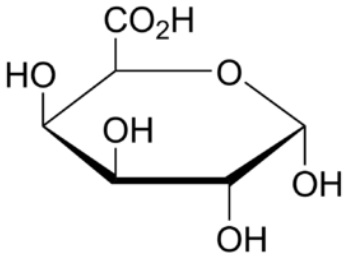
Polyethylene furanoate (PEF)

Raw materials - Availability

- Second generation source of sugars
  - Sugar beet pulp (European)
    - 50, 000 kT (21 % dry content)
    - Pectin content 2300 kT
    - Common usage: Animal feed
    - Extraction: Biotech / enzyme or acidic
  - Citrus peel (European)
    - 800 kT (25 % dry content)
    - Pectin content 90 – 116 kT
    - Common usage: Animal feed
    - Extraction: Biotech / Fungal



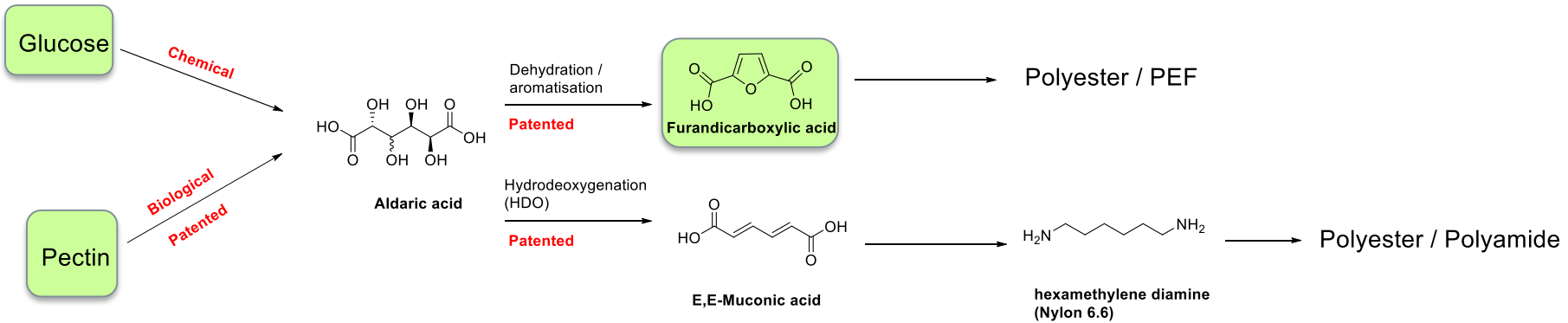
World-wide pectin sources



(% dry weight)	Citrus peel[+]	Sugar beet pulp[++]
Galacturonic acid	33	21.1
Arabinose	8.4	20.9
Galactose	6.4	5.1
Rhamnose	0.9	2.4
Xylose	3.7	1.7
Mannose	3.0	1.1
Glucose	25.8	21.1

VTT and bio-based platform chemicals

- Our FDCA development* comes from the conversion of oxidized sugars into aldaric acids, which are versatile precursors.



* patents: WO 2015189481A1, US20120045804A1, US9340809B2, WO2010072902A1,WO2017207875A1, US20180086728A1, FI127844, PF17238, PF17100

Conclusion

- Bio-based plastics from sugars is a hot topic with investment by significant players, and room to join in!
- VTT FDCA is currently on a kilo scale and still up-scaling
- Technology Readiness Level (TRL) = 4 – 5
- We see the potential for a commercially attractive solution in this technology

beyond
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