

annikki

CHEMICALS FROM BIOMASS



Experienced Industry Team

Management	Ortwin Ertl <i>CEO & founder</i>	Former CEO & founder, IEP GmbH
	Dr. Heikki Hassi <i>CTO & investor</i>	Former Senior VP and Group Director Technology, Alstrom Paper Group, former Senior VP UPM-Kymmene Corp.
Investors	Prof. Dr. Ernst Günter Afting	Former CEO, Pharma Division Hoechst AG; former CEO Roussel Uclaf
	John Bump	Former Member, Chicago Board of Trade
	Prof. Dr. K. Messner	Professor, Vienna University of Technology; former President, International Research Group on Wood Protection
	Dr. Antonius Schuh	CEO GSV, former CEO, Sequenom Inc.
	Dr. Wolfgang Meindl	Former owner and CEO, Loba Feinchemie AG
	Dr. Christopher Prince	Former CSO and founder, Phytion Inc.
	Dr. Peter Hemken	Former VP and General Manager, DuPont Biobased Materials

Changing completely the Chemical Markets

*We aim to broadly replace petroleum-based chemicals
by **bio-chemicals and bio-materials**
made at significantly lower cost than petro-chemicals*

Chemical Process Integration Made to Work

- Serial reaction processes with up to 5 enzyme-reactions in one pot commercial
- Serial reaction process with 10 enzyme-reactions in one pot under development
- Piloting highly integrated biomass fractionation process with US-multinational company since 2016
- Full technology industrialization for large scale commodity chemicals by 2021

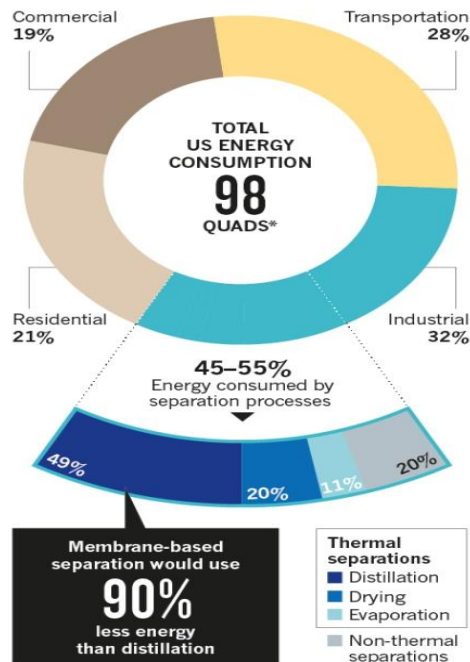
High Cost of Petro-Chemicals from....

- Product losses
- Waste separation
- Waste disposal
- Intermediate isolation
- Intermediate transportation

Chemical Separations use 16 % of US Energy

CUTTING COSTS

Chemical separations account for about half of US industrial energy use and 10–15% of the nation's total energy consumption. Developing alternatives that don't use heat could make 80% of these separations 10 times more energy efficient.



*A quad is a unit of energy equal to 10^{15} British Thermal Units (1 BTU is about 0.0003 kilowatt-hours).

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- Chemical separations use 16 % of US energy
- Membranes-idea to lower separation energy
 - Needs years of R&D
 - In-between reaction steps transportation still needed
 - Chemicals still from oil

Current Bio-Solutions do not Bring Cost Down

Standard industry practice fermentation combines several steps into one living microorganism, which needs to be fed and does not tolerate too high product yields.

Therefore, high microbial loading and low product yield makes fermentation and product isolation expensive.

The Power of the Annikki Solution

- Start from agricultural residues
- Mild, non-destructive conditions for high purity chemicals
- Combine separate (enzymatic) reactions into one vessel
→ *No in-between separations needed*
- Fermentation for enzymes only → 1/100 of classical volume
- High yields, no byproducts
- Cost-savings by between 50 % and 80 % even over petroleum-based chemicals

Market Need Addressed

- PEF as a replacement for PET bottles and fibers (\$ 100 Billion)
- Next-generation sweetener xylitol (\$ 1 Billion + high growth)
- (Chemical) cellulose, paper, rayon for fabrics (\$ 200 Billion)
- Lignin-based resins, glues (\$ 40 Billion)
- Green PU foam (\$ 40 Billion),
- Carbon fibers (\$ 4 Billion + replacement of steel in cars)
- Polyamides (\$ 50 Billion)
- Many more products from chemicals market

Company Overview

Three streams – their combination results in major cost cuts

Overview

Redox Biocatalysis

One-Pot, Serial Step Processes

Biomass Fractionation

Pure Products

**Fructose to FDCA
JV with Microinnova**

Microreactor Technology

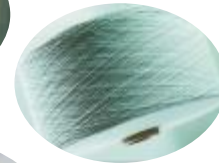
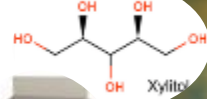
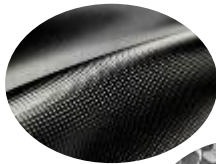
State

First Process Commercial

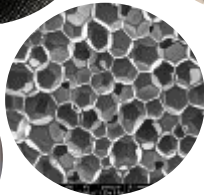
Pilot

Lab-Pilot

From Straw/Stover to Pure & High-Value Products

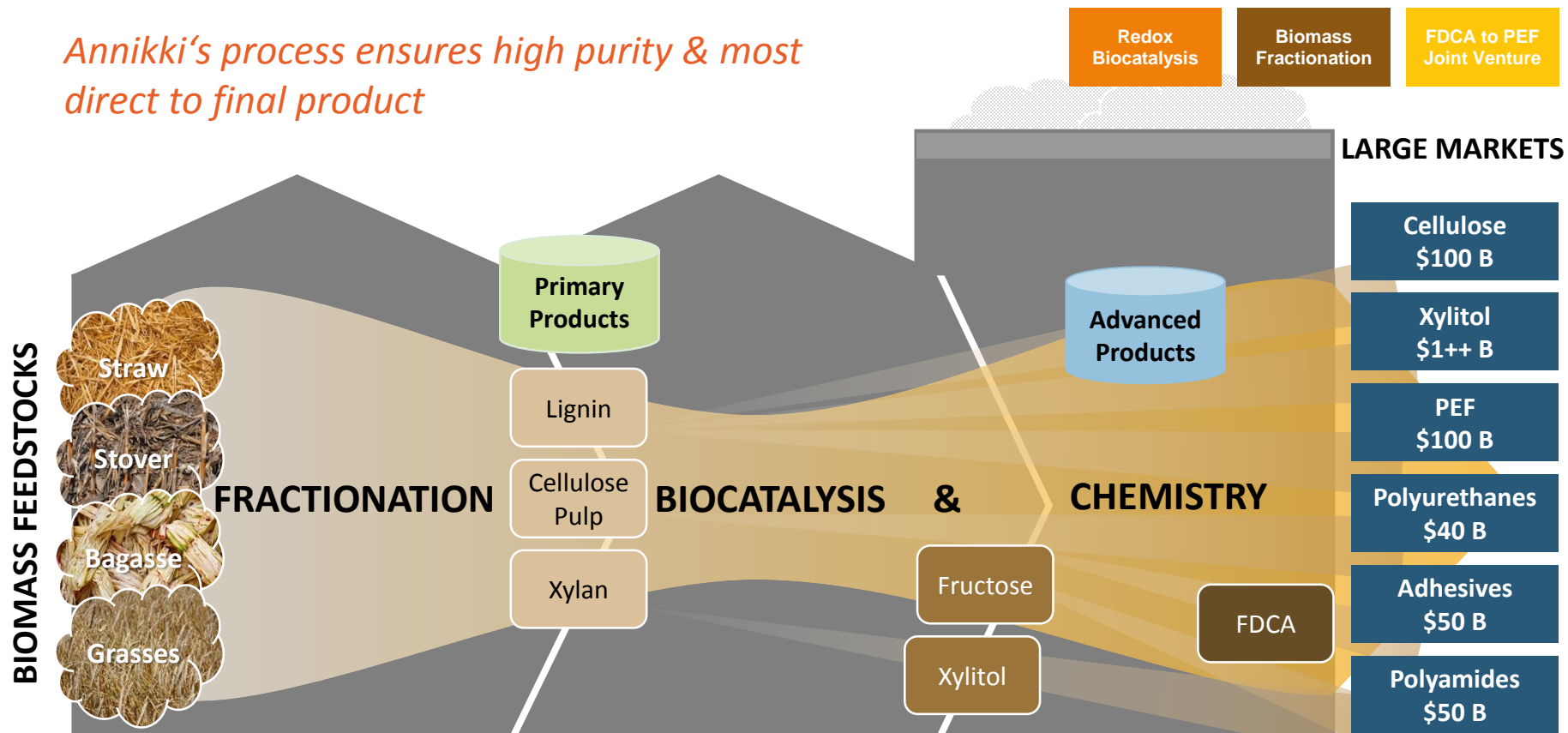


CMC



Integrated Processes Overview

Annikki's process ensures high purity & most direct to final product



Conventional Biomass Fractionation (1930 - 2010)

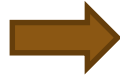
Redox
Biocatalysis

Biomass
Fractionation

FDCA to PEF
Joint Venture



Biomass



Product scope

Main Product

Cellulose
Pulp

Yield 40-50%

Fuel

Lignin

Product value

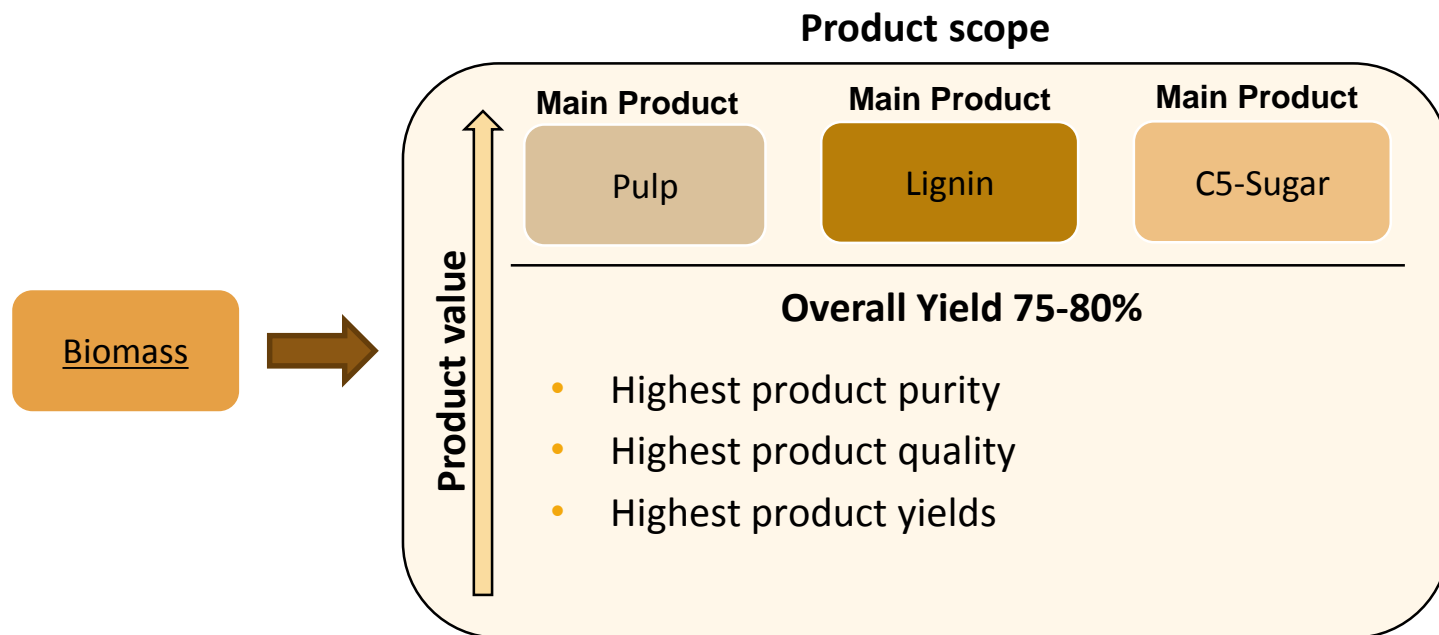


Annikki Biomass Fractionation (as of now)

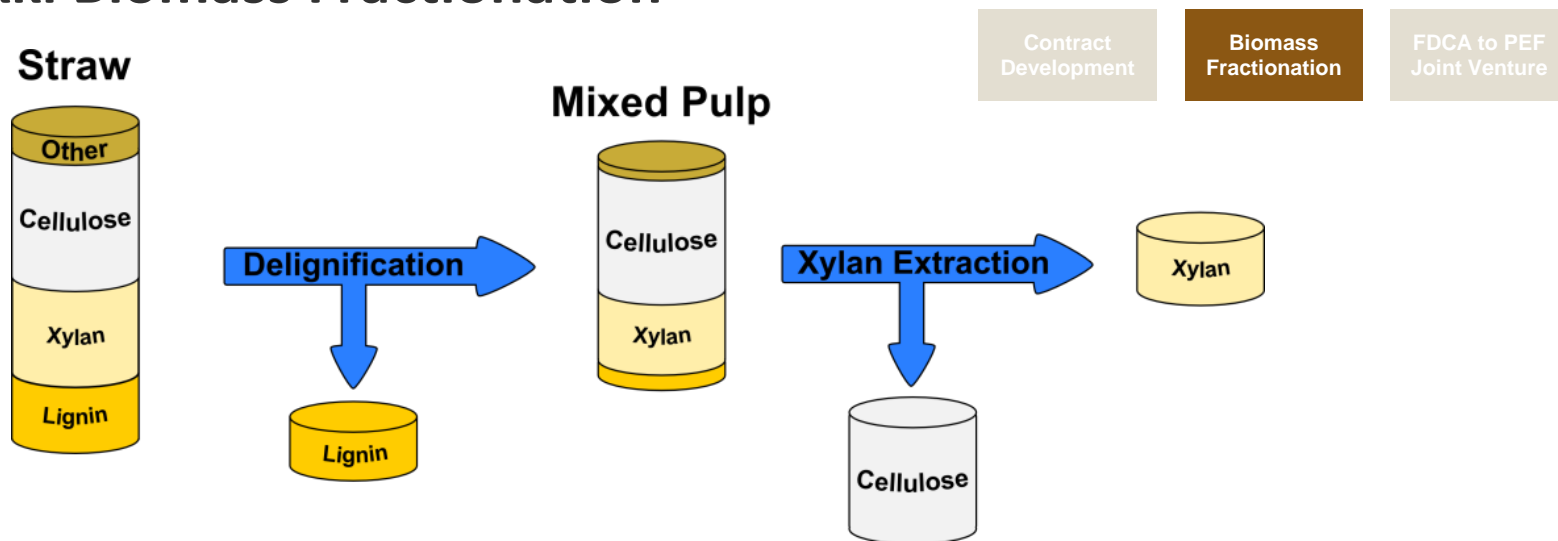
Contract
Development

Biomass
Fractionation

FDCA to PEF
Joint Venture



I. Annikki Biomass Fractionation



Yields pure primary product streams

→ Which allow direct conversion to secondary products

II. Direct Biocatalytic Conversion

Redox
Biocatalysis

Biomass
Fractionation

FDCA to PEF
Joint Venture

No isolation of intermediates (reduces cost by 70 %)

- Traditional: „Dirty“ xylan → purify xylose → Xylitol (sweetener)
- vs. **Annikki**: **Direct conversion** of pure Xylan → Xylitol

Product Case: Quality Xylitol, Reduced Cost

The Next Great Sweetener Opportunity

Redox
Biocatalysis

Biomass
Fractionation

FDCA to PEF
Joint Venture

- As Sweet as Sucrose
- Equal Weight Basis (replacement in recipes simple)
- High Volume Applications (ice cream, jams etc.)
- Appealing Flavor Profile
- Low Glycemic Index => Recommended for diabetic diets
- Fewer calories
- Prevents dental caries

Biocatalysis Processes

Highly Integrated, at Lower Cost

Redox
Biocatalysis

Biomass
Fractionation

FDCA to PEF
Joint Venture

- Multi-reactions, „one pot“ (no intermediate isolation)
- Industrially proven
- 10 x higher concentration of product in reactor volume vs. fermentation
- Up to 1000 times less biomass than in classical fermentation

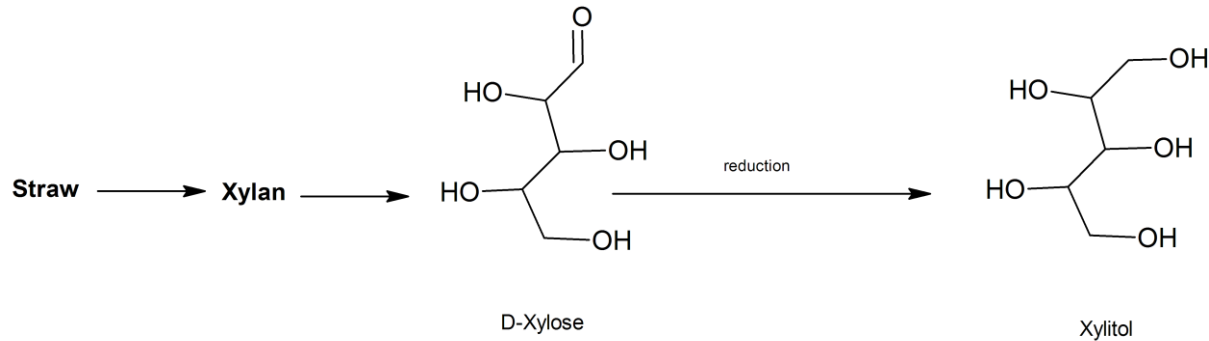
Straight from Xylan to Xylitol

Huge Energy Savings

Redox
Biocatalysis

Biomass
Fractionation

FDCA to PEF
Joint Venture



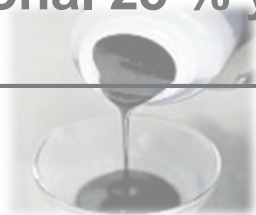
Combined Reactions in One Pot

Redox
Biocatalysis

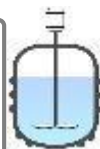
Biomass
Fractionation

FDCA to PEF
Joint Venture

Xylitol: Traditional 25 % yield



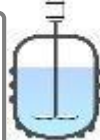
Black liquor



Xylose isolation / big losses



Harsh catalytic conversion



Final purification to Xylitol



ANNIKKI 95 % yield

Xylan



Multiple enzymes - conversions



Easy separation

Xylitol
(purity > 99.5 %)



Annikki Fractionation – Pilot Trials (kg-scale)

Conceptual engineering for industrial plants



Annikki Fractionation – Pilot Trials, ca 100 kg

German pilot facility



**Currently making
100 kg cellulose
sample to prepare
upscale to
300.000 tons p.a.
for multinational
customer**



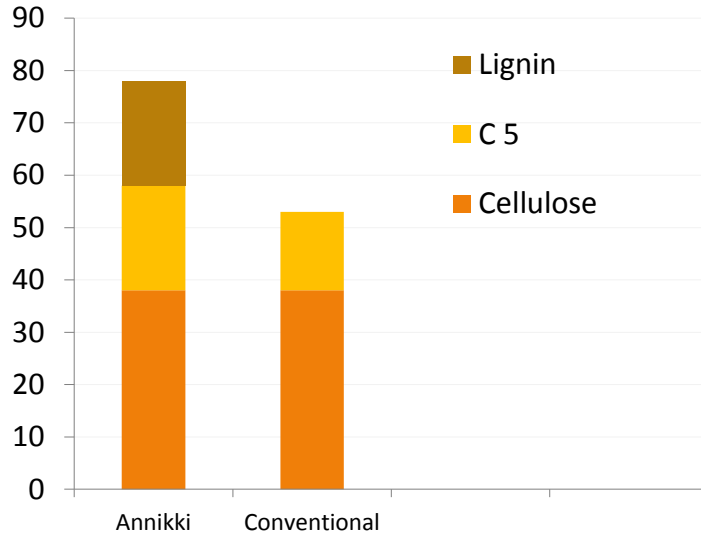
Comparison: Output & Joint Products from Biomass

Redox
Biocatalysis

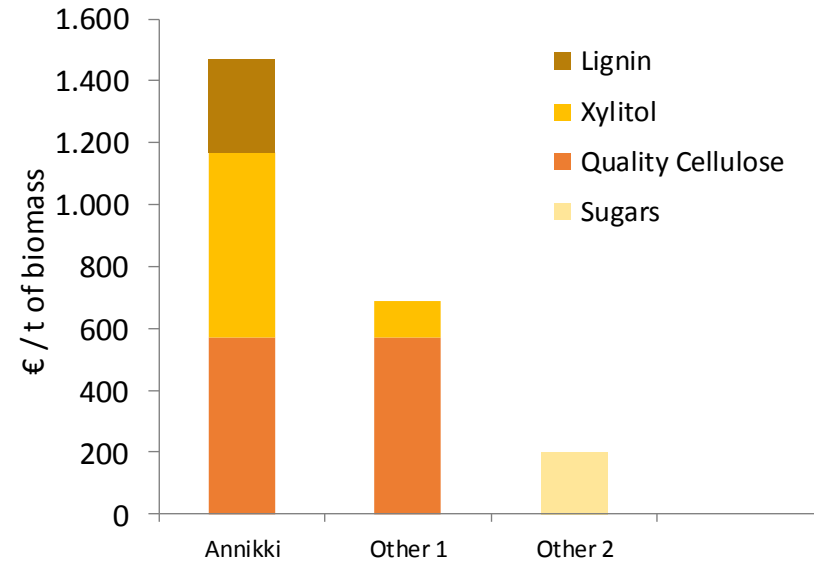
Biomass
Fractionation

FDCA to PEF
Joint Venture

Yield in %



Products and Sales from 1 ton of straw



FCDA Overview

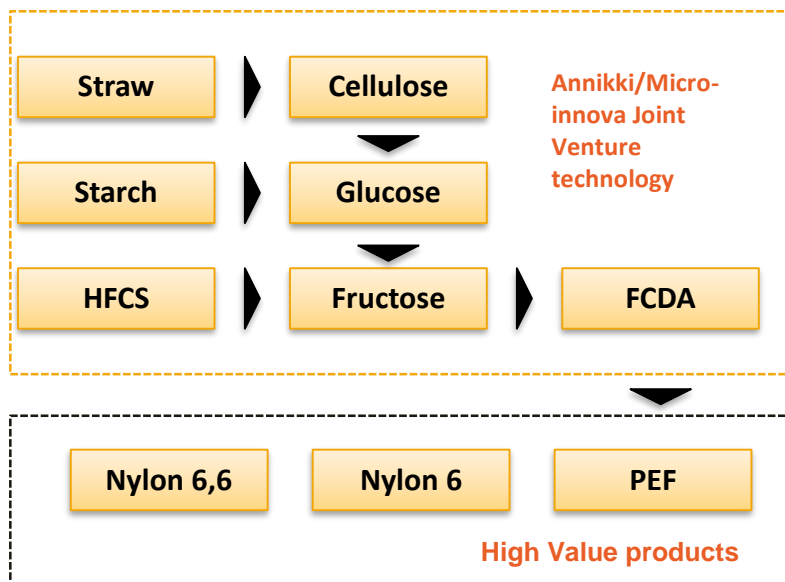
Chemical
Development

Biomass
Fractionation

FDCA
process

PEF is superior to PET and will largely replace it

PEF Process Overview



PEF advantages vs. PET

- **10x** better oxygen barrier
- **2x** better water barrier
- **4x** better carbon dioxide barrier
- **1.6x** stronger material

Contact

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