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PUREVISION TECHNOLOGY, INC.

The PureVision Technology Platform For Producing Pulps and Sugars from Hemp Biomass

Presentation to the Pennsylvania Hemp Engine

April 2, 2024

PureVision Technology LLC 511 McKinley Ave. Fort Lupton, Colorado 80621 *www.PureVisionTechnology.com*

PureVision Founders and Managers

Ed Lehrburger, Founder, CEO. Biotech and hemp industry pioneer & leader, program manager

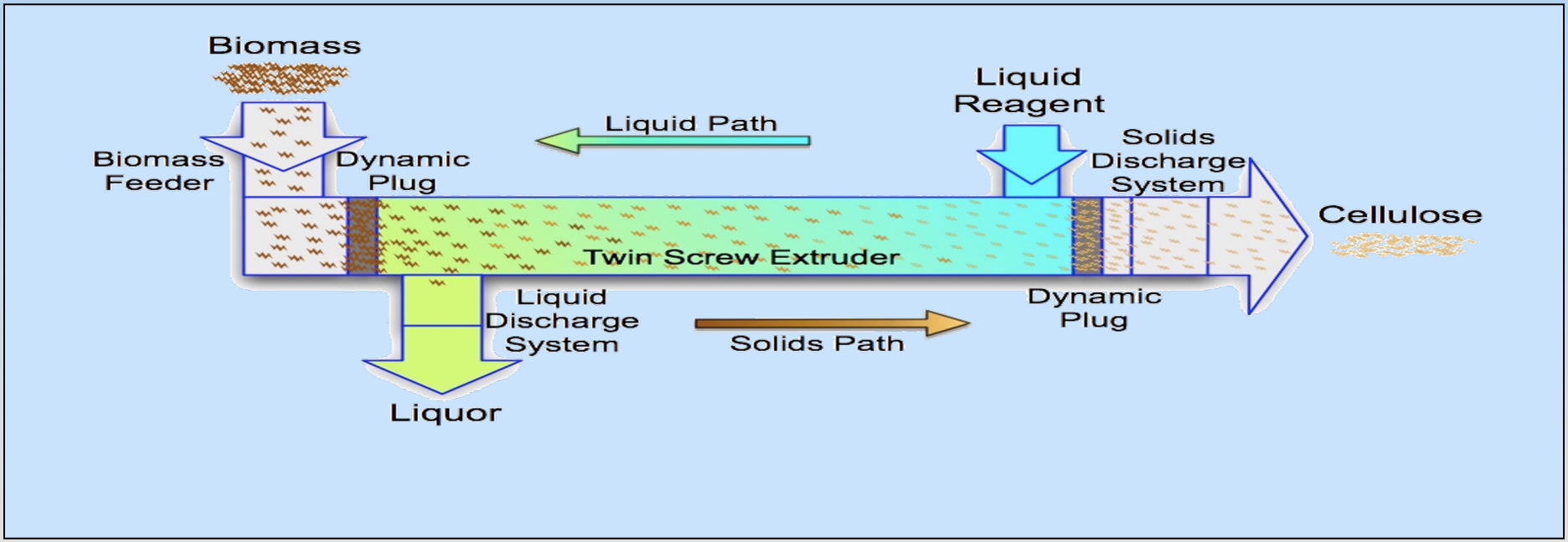
Carl Lehrburger, Founder, COO. Manager, analyst, recycling professional, historian and author

What We Do

Operating at pilot scale since 2008 PureVision is advancing the **continuous countercurrent reactor (CCR) technology**

- CCRs are feedstock agnostic
- CCRs produced pulp, lignin, sugars from hemp stalks and other biomass
- CCRs produce pulps for **paper and fiber molded products** in 4 minutes!
- CCR hemicellulose sugars can be economically converted into **xylitol**
- CCR **lignin** is low in molecular weight
- CCR has proven platform to produce sugar-based **chemicals & plastics**
- CCRs can economically reduce carbon footprints for major industries

The Continuous Countercurrent Reactor (CCR)



1. 4-minute pulping process vs the 2-hour Kraft pulping process
2. Removes lignin continuously while producing high-quality pulp (cellulose)
3. Continuous *In situ* solid and liquid separations and mixing
4. Countercurrent flow decreases water, energy and chemical usage
5. Environmentally sound, carbon neutral process with emphasis on sustainability.

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½-Ton/Day CCR Pilot Plant at PureVision HQ

½-Ton/Day CCR Front End at PureVision HQ

Primary Products from a PureVision Biorefinery

Liquid Reagent

Liquid Path

Stalks and Other Ag Residues

Continuous Countercurrent Reactor

Solids Path

Lignin

C-5 Sugars

Pulps

- Numerous grades of cellulose
- Packaging applications
- Pulp to sugars for plastics, chemicals and fuels
- Pulp for molded fiber applications (clam shells, egg cartons, trays, etc.
- Pulp for fillers and 3-D printing applications

Lignin

- Binders
- Adhesives
- Plastics
- Advanced Materials

Xylose

- Xylose (commodity)
- Xylitol
- Nutraceuticals
- Chemicals

CCR Primary Products

Pulp

Lignin

Xylose-Rich Sugar

Full utilization of biomass is a significant advantage of CCRs.

The cellulose is used as pulp for papermaking or as an intermediate to produce sugars. The low-molecular weight lignin and xylose sugars are value-added co-products.

PureVision Business Model

- Historically an R&D company.
- Now proven at pilot scale, the next step is to scale-up and commercialize the CCR technology
- Work with 3rd parties to secure grants and private capital to scale up the CCR technology
- PVT to sublicense its CCR technologies and work with biorefinery developers under royalty-based agreements to manufacture eco-friendly products from local biomass sources

CCRs can reduce global reliance on petroleum and trees by providing industrial quantities of fiber-derived products

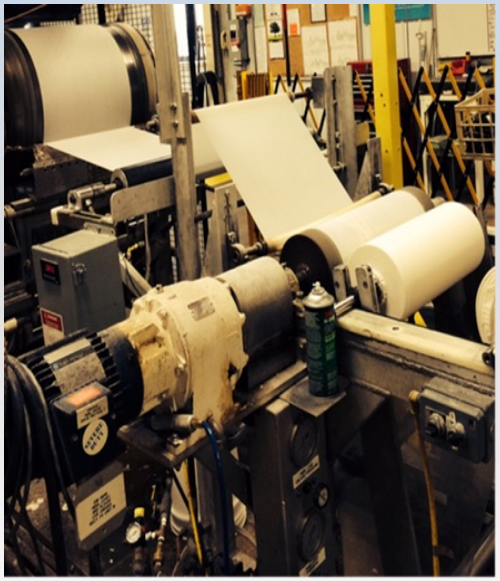
CCR Key Differentiators

Faster processing, lower environmental impacts over conventional biorefining and value-added co-products

- ❑ CCR produces high quality pulp in ~4 minutes
- ❑ "Bolt-on" deployment to existing infrastructures
- ❑ Feedstock agnostic
- ❑ Lower water, energy and chemicals
- ❑ Value-added co-products. Target to convert ag residues into:
  - **Pulp & paper products** including tissue, specialty papers & molded fiber for packaging (CCR P&P Platform)
  - **Biochemicals and bioplastics** including lactic acid, poly lactic acid, ethanol, polyethylene (CCR Sugar Platform)

CCR Pulp & Paper Platform

PureVision has processed wheat straw and hemp stalks into pulps for papermaking including wheat straw paper towels and TP and molded fiber products from hemp stalks.



CCR Wheat Straw Pulp Being Converted into High-Quality Tissue Paper at client's Pilot Paper Mill

CCR pulp is suitable for making Molded Fiber Products using 75%-100% CCR hemp pulp.

CCR Cellulose Derived Products

Agricultural Pulps

- Mechanical pulp
- Market pulp
- Blended pulps

Applications

- Hemp paper products
- Composites, plastics
- concrete additive, insulation, etc.

Paper Products

- Molded fiber products
- toilet paper, paper towels, napkins and
- packaging

Pulp & Paper

α-Cellulose, NFC

- **High purity alpha cellulose pulps**
- **Separation/filtration applications** (batteries, capacitors)
- **Films and packaging**

Specialty and Fine Chemicals

- **Specialty chemicals** include cellulose esters, micro celluloses
- **Emulsion stabilizer** in paints & coatings

Chemicals

- **Chemicals** include lactic acid, acetic acid, ethylene, ethanol

CCR Pulping vs Kraft Pulping

Vital Statistics	
Category	**CCR to Kraft Comparison**
Water Usage	**8 times Less**
Effluent Stream	**8 times Less**
Chemical Consumption	**25% Less**
Energy Usage	**55% Less**
Pulp Cost with Co-product Credits (at =>55-t/d scale)	**Competitive with Kraft Pulp**
Project Development Time	**18 months vs. 4-plus years**

- Mini bolt-on CCR pulp mills represents a significantly more advanced, continuous pulping process compared to traditional technologies.
- CCRs utilize existing infrastructure, reducing costs and construction time.
- Significant environmental & cost benefits

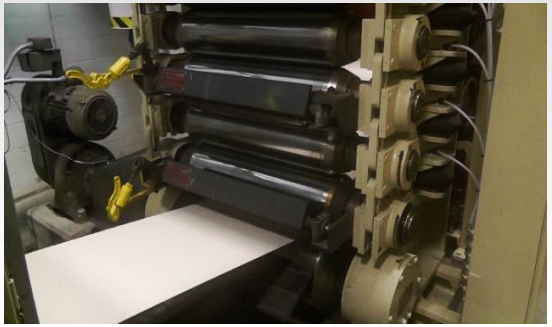
Producing Hemp Pulp and Paper

CCR hemp pulp made in Colorado and shipped to paper mill

Hemp and wood Pulp blended at paper mill

Pulp at the head box of the paper mill

Hemp paper being manufactured at mill



Hemp paper prior to being made into rolls of paper

Hemp paper being rolled up as final step

CCR Lignin Will Add Value Biorefineries

A sustainable feedstock for formulating into higher value products

- CCRs produce high-quality, low molecular weight lignin
- CCR derived lignin can replace petroleum-based ingredients
- CCR lignin, unlike Kraft lignin, is suitable for creating bio-based adhesives, glues, binders, coatings, sealers, inks & 3-D printing media, phenols, polyurethanes, and other chemicals
- Highly reactive molecule
- Lignin = ~20% of all hemp stalks
- Lignin = ~25% of all soft wood trees

CCR Co-Product - C-5 Sugars

The targeted product is **xylitol,** the "healthy" sugar.

C-5 Sugar Pathways

Consumer Products and Nutraceuticals → **Xylitol for supplements, table sugar, foods & beverages**

Chemicals → **Furfural, furan dicarboxylic-acid, and other chemicals**

Crude xylose-rich liquor

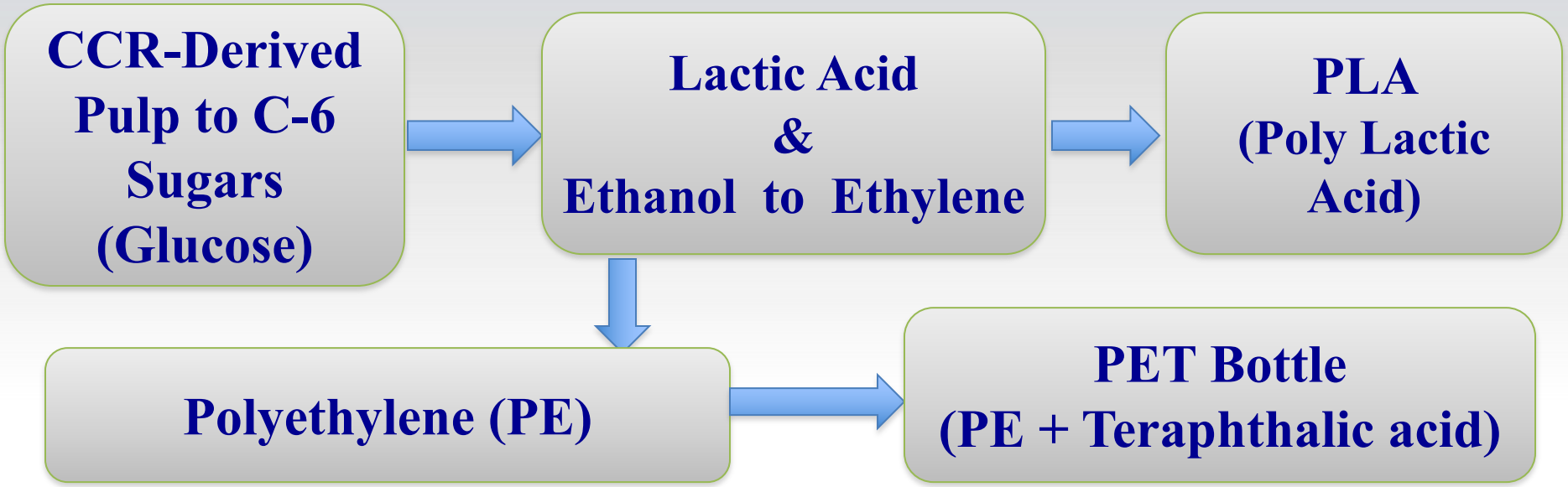
Xylitol is used as ingredients in many products, including

✓ Toothpaste	✓ Mouthwash	✓ Chewing
✓ Nutraceuticals	✓ Beverages and foods	✓ Nasal Spays

CCR Sugar Platform for Green Chemicals/Bioplastics

The CCR-Derived Glucose Sugar Pathway

1. CCR pulp is converted into glucose sugar with enzymes
2. The enzymes are made on site using CCR-derived glucose sugar
3. Glucose is then fermented into diverse bio-plastic intermediates



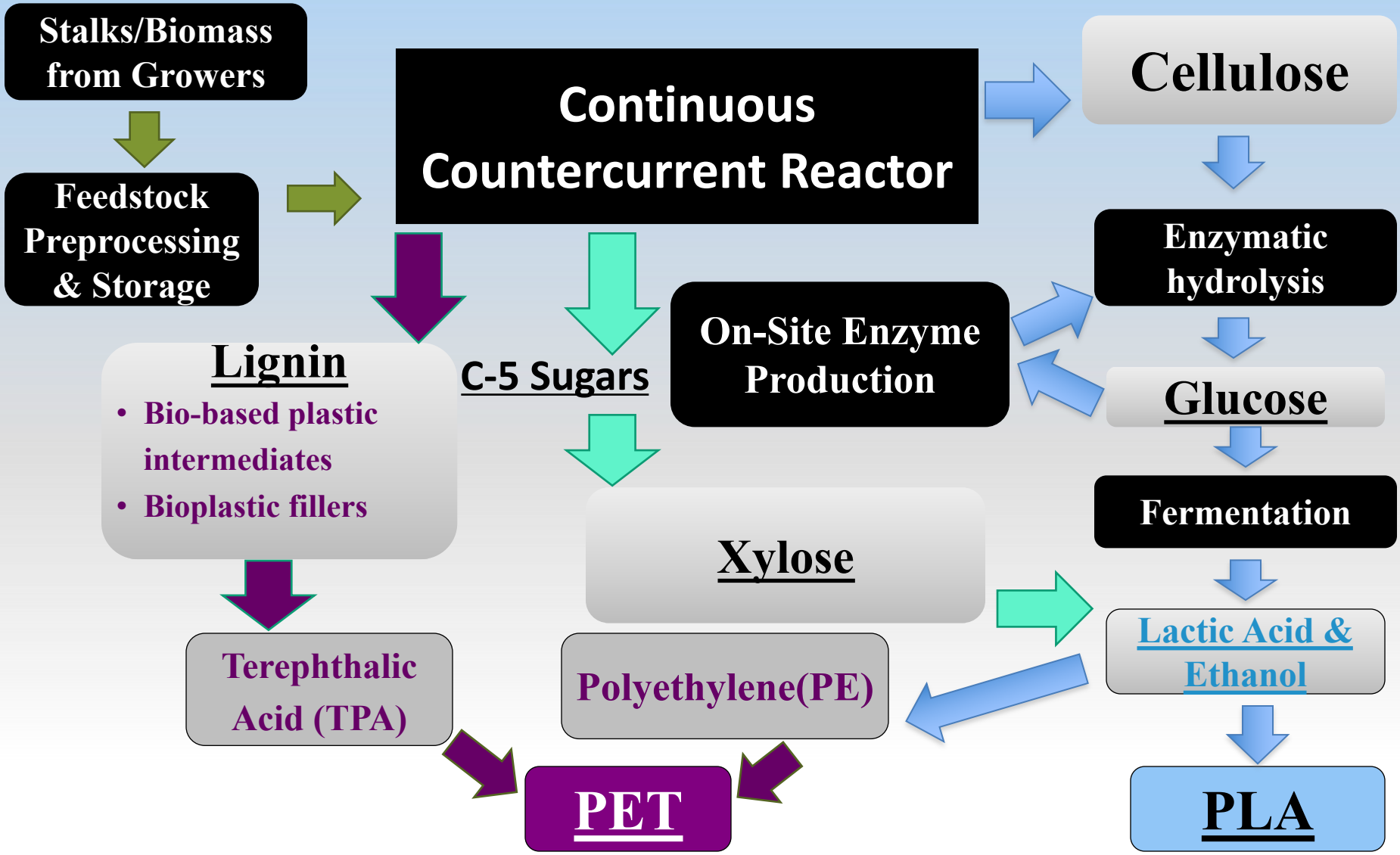
CCR Biorefineries

CCR Sugar Platform to Bioplastics

- Each of the CCR outputs – cellulose, hemicellulose, lignin - can be converted into biobased chemicals and bioplastics.
- Multiple pathways to different types of bioplastics.
- Integrated, on-site enzyme operations reduce overall costs.
- Present focus is hemp stalks-to-lactic acid as an intermediate for making bio-based poly lactic acid.
- Collaboration partners include Auburn University

CCR Sugar Platform to Bioplastics

CCR-Based Bioplastics – Main Unit Operations



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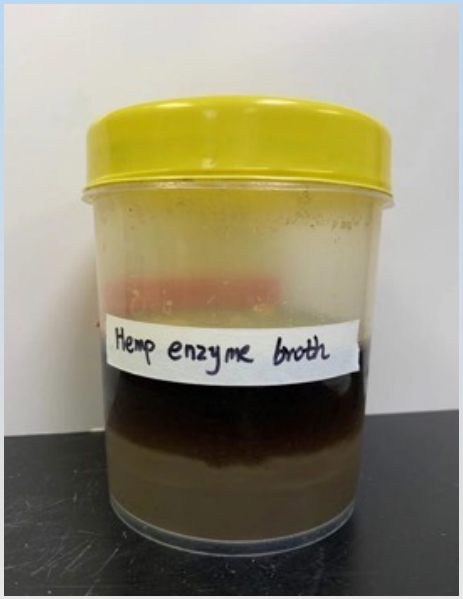
Lab and Bench Scale Equipment Used To Produce Lactic Acid



CCR pulp and sugars used to manufacture on-site cellulase enzymes

Lactic acid fermentation using sugar-rich hemp enzyme broth

500-liter hydrolysis reactor to convert pulp into lactic acid

Pilot lignin cart to separate lignin from the CCR liquid fraction

PureVision has significant data showing well-defined pathways to produce 100% biodegradable, reusable and recyclable PLA from biomass

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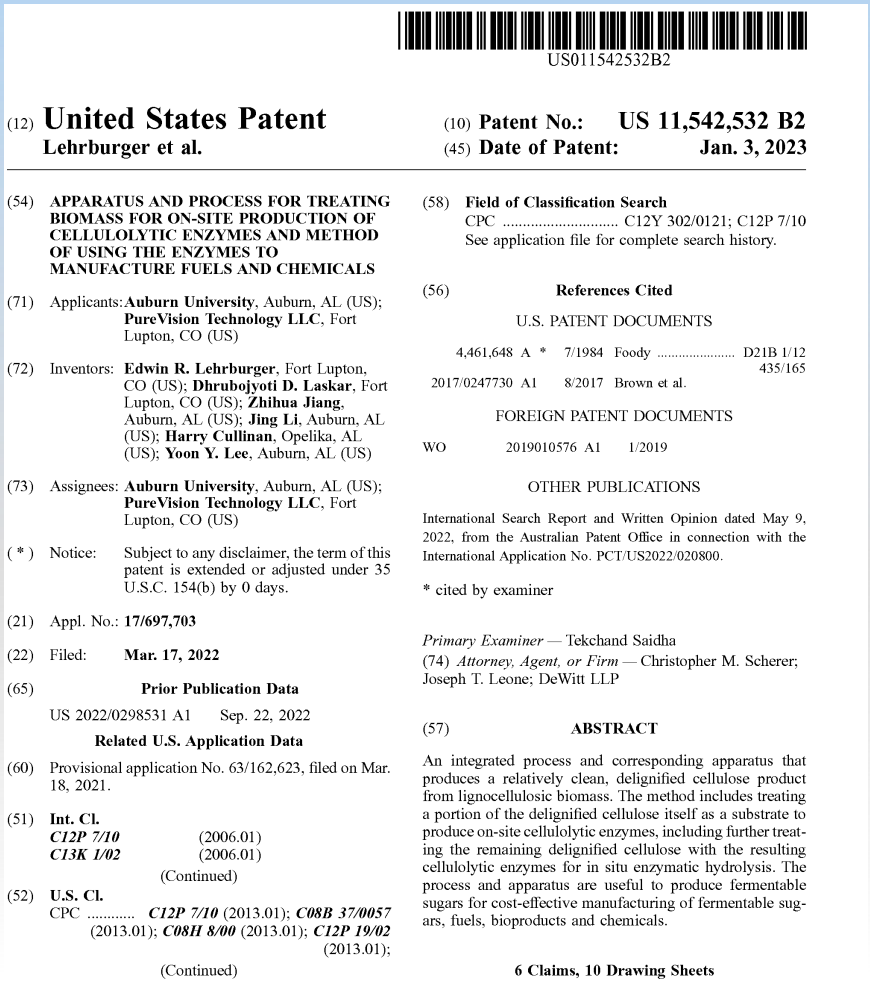
Intellectual Property Portfolio



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(12) **United States Patent**
Lehrburger et al.

(10) **Patent No.: US 11,542,532 B2**
(45) **Date of Patent: Jan. 3, 2023**

(54) **APPARATUS AND PROCESS FOR TREATING BIOMASS FOR ON-SITE PRODUCTION OF CELLULOLYTIC ENZYMES AND METHOD OF USING THE ENZYMES TO MANUFACTURE FUELS AND CHEMICALS**

(71) Applicants: **Auburn University**, Auburn, AL (US); **PureVision Technology LLC**, Fort Lupton, CO (US)

(72) Inventors: **Edwin R. Lehrburger**, Fort Lupton, CO (US); **Dhrubojyoti D. Laskar**, Fort Lupton, CO (US); **Zhihua Jiang**, Auburn, AL (US); **Jing Li**, Auburn, AL (US); **Harry Cullinan**, Opelika, AL (US); **Yoon Y. Lee**, Auburn, AL (US)

(73) Assignees: **Auburn University**, Auburn, AL (US); **PureVision Technology LLC**, Fort Lupton, CO (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

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(51) **Int. Cl.**
C12P 7/10 (2006.01)
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(Continued)

(52) **U.S. Cl.**
CPC ***C12P 7/10*** (2013.01); ***C08B 37/0057*** (2013.01); ***C08H 8/00*** (2013.01); ***C12P 19/02*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC C12Y 302/0121; C12P 7/10
See application file for complete search history.

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Primary Examiner — Tekchand Saidha
(74) *Attorney, Agent, or Firm* — Christopher M. Scherer; Joseph T. Leone; DeWitt LLP

(57) **ABSTRACT**

An integrated process and corresponding apparatus that produces a relatively clean, delignified cellulose product from lignocellulosic biomass. The method includes treating a portion of the delignified cellulose itself as a substrate to produce on-site cellulolytic enzymes, including further treating the remaining delignified cellulose with the resulting cellulolytic enzymes for in situ enzymatic hydrolysis. The process and apparatus are useful to produce fermentable sugars for cost-effective manufacturing of fermentable sugars, fuels, bioproducts and chemicals.

6 Claims, 10 Drawing Sheets

US Patent 11,542,532 B2

- Since 2000, PureVision has been expanding its CCR IP portfolio.
- Six U.S. patents have been filed and obtained since 2000.
- Most of the art relating to the CCR involves many trade secrets.
- Since 2016, Auburn University and PureHemp have converted hemp stalks into fermentable sugars and lactic acid.
- In 2023 a comprehensive patent was issued.
- PureHemp has an exclusive technology license to produce xylitol from crude hemp xylose sugars.
- Many opportunities for new IP related to CCR outputs, equipment and processes.

Business Opportunities

- Strategic partnerships and joint ventures based on CCR technology licensing targeting scaleup and deployment
  - Supply chain partnerships with a focus on pulp & paper, chemical, and bioplastic processes via joint venture and/or equity participation in technology scale-up and commercialization.
- Project development engagements: target is to co-locate near local feedstocks and existing industrial sites with infrastructure
- Bioplastic product development engagements with target companies
- Equity participation: PureVision subsidiary companies PureHemp and Pure BioPlastics, Inc., offer corporate structures for technology deployment based on a technology licensing business model

Hemp Engine Focus
CCR Technology Scaleup and Deployment In Pennsylvania

- Stage 0 Pre-program includes establishing contractual arrangements, business structure and IP rights with PA partners and stakeholders for NSF II proposal
- **Stage I Process refinement** at ½-ton/day pilot, develop Stage II program including PA site determination (12 months)
- **Stage II Scale up pilot CCR to an 8-ton/day** – via the Hemp Engine, to a small commercial biorefinery (18 months)
- **Stage III – Scale up to a 60-ton/day biorefinery** – site in PA to be determined (24 months)
- Stage IV – Scale up to any size biorefinery, anywhere

PureVision Stage I Program

Process refinement at pilot scale, develop Stage II scale-up program including site determination

- Stage I: $2.5 Million, 12-month program at pilot-scale
- Move existing ½-ton/day pilot plant to PA for feedstock-specific testing
- Process optimization at pilot scale targeting pulp specifications
- Provide pulp samples for analytical tests, initial product testing
- Undertake scale-up engineering for Stage II
- Perform Total Energy Analysis (TSA), complete target end-product economic analyses
- Undertake site assessments and select a host for Stage II
- Proceed to develop Stage II, 8-ton/day small commercial PA biorefinery.
  - Stage II for CCR Pulp & Paper platform (~$12.5 M, 18-months).
  - Stage II for CCR Chemical platform (~$20, 24-months)

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Next Steps

We will be scaling up, sublicensing and deploying advanced biorefining technologies to produce sustainable bio-products from hemp stalks and other non-food biomass.

Let’s explore opportunities in Pennsylvania!

Carl@ PureVisionTechnology.com
Ed@PureVisionTechnology.com