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Second Generation Bioethanol - Advanced Biofuel

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Beijing, China
October 30-31, 2017
VUPC (PPRI) Bratislava
- established in 1947

Main activities:
1. Research and development
2. Process simulation in laboratory scale
3. Technology testing in pilot plant scale
4. Specialty paper and board production
5. Coating and laminating
6. Pulp, paper and board quality testing
7. Technical and economical information services
8. Instrument service, development and production
9. Research activities for Bio-based Industry
10. Smart biodegradable packaging
Well Equipped Laboratories

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Universal Pilot Plant Paper Machine with 3 headboxes and in-line sizing press
Pilot Plant Supercalender and Pilot Plant Couting, Laminating and Roll-Slitting Machine
Research and development activities are oriented to

- cooking technologies
- bleaching technologies
- recycling technologies
- papermaking
- surface treatment
- biofuel production technologies
- wood processing
- process & technology optimisation

More details about these activities you can find on the website www.vupc.sk
Research and development activities are oriented to

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Raw Material: Fast-growing Trees - Paulownia, Softwood, Hardwood, Bamboo ...
One-year Lignocellulosic Raw Materials: Sugar Cane, Hemp, Industrial Grasses, Arundo Donax...
1 different chemical bond
Starch vs. cellulose – molecular sight

- **Amylose**
  - Amorphous Structure

- **Amylopectin**
  - Symmetrical (Crystalline) Structure

- **Cellobiose**
  - Intermolecular Hydrogen Bonds
Starch vs. cellulose – molecular sight

Amylose
Amorphous Structure

Amylopectin

Cellobiose
(Crystalline) Structure

Molecular Hydrogen Bonds
The Main Goal is Optimisation

- of Lignocellulosic Biomass Pre-treatment
- of Hydrolysis of Lignocellulosic Biomass
Pretreatment procedures

- Cryolysis-cyclic freezing-thawing (patent)
- Frozen mechanical pretreatment (patent)
- Dry mechanical pretreatment (milling in Brabender)
- Wet mechanical pretreatment (milling in Sprout-Valdron)
- Steam explosion
- Extrusion (continuous steam explosion)
Pre-treatment – Cryolysis – Destruction of LCRM by Rapid Deep Freezing and Thawing

Patent application PP50076-2014 was submitted in 2014 „Increasing Accessibility of LC Materials for Hydrolytic Enzymes by Cryolysis During Biofuel Production“
Dry pretreatment of LCM in a laboratory rotary mill Brabender
Wet pretreatment of LCM with defibrator
Sprout-Valdron
Reactor for Discontinuous Steam Explosion of Impregnated LCRM
Extruder for Continuous Steam Explosion of Impregnated LCM
Comparison of enzyme accessibility of LCRM pretreated with mechanic, hydro-mechanic, thermo-hydro-mechanic procedures

(note: dry milling B, cyclic freezing and thawing ZR, wet milling SW, extrusion SE-Ex at 145°C, steam explosion SE at 215°C)
Structural changes in LCM after pretreatment

Cyclic freezing-thawing of LCM

Steam explosion treatment of LCM
Steam explosion treatment of LCM

Original LCM

LCM after SE
Influence of wood species on enzymatic hydrolysis efficiency of pretreated wood branches and roots

Conversion of cellulose and xylan to monosaccharides during hydrolysis of LCRM pretreated by steam explosion after mechanical pre-treatment

Conversion of Polysaccharides/%

Branches and Roots of Trees (Forest Waste)
Influence of steam explosion temperature on enzymatic hydrolysis efficiency of pretreated wood branches and roots

Conversion of Polysaccharides/ %

Temperature of Pretreatment (STEX)/ °C

- Spruce
- Pine
- Beech
- Paulownia
Enzymatic hydrolysis of short fibers from recycled paper treatment (VK) after de-ashing (OVK) and short fibers from pulp treatment (KV)

**Conversion of polysaccharides**

- **7.2 (KV)**: 80% Glucose, 72% Xylose
- **33.4 (OVK)**: 63.8% Glucose, 55% Xylose
- **62.4 (VK)**: 67.7% Glucose, 62.7% Xylose

**Yield of monosaccharides**

- **7.2 (KV)**: 80% 5% Cellic Ctec3, 69.4% 20% Cellic CTec3
- **33.4 (OVK)**: 31.5% 5% Cellic Ctec3, 33.2% 20% Cellic CTec3
- **62.4 (VK)**: 35.7% 5% Cellic Ctec3, 17.4% 20% Cellic CTec3

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Comparison of conversion of polysaccharides from wheat straw pretreated with various procedures

- SE 185°C + A-extraction + filtrate from SE: 64.0%
- SE 185°C + A-extrusion + filtrate from SE: 62.0%
- SE 185°C + A-extrusion 155°C + filtrate from SE after 24h: 55.8%
- A-extrusion 155°C + A-extraction: 56.7%
- SE 200°C: 54.0%
- SE 185°C: 53.0%

Conversion of polysaccharides (%) vs Glucose + xylose + arabinose
Yield of monosaccharides from original and washed samples of wheat straw and corn stover
Concentration of inhibitors of fermentation (v g/L) in hydrolysates of original corn stover samples
Pilot plant equipment for pretreatment of LCRM with steam explosion
Pilot mixing batch reactor for hydrolysis
Conclusions

Optimal Conditions of STEX Pretreatment of LCRM

- mass concentration 12.5 %
- temperature 210-230°C
- retention time 3-6 min
Conclusions

Optimal Conditions of Enzymatic Hydrolysis of Pretreated LCRM

- mass concentration 15 %
- temperature 49°C
- reaction time 72 h
- pH 4.9
- 3 - 6% dose of enzyme product Cellic CTec 3 per cellulose content in LCRM
The Optional Cooperation Areas

1. Pulping technologies
2. Pulp bleaching technologies
3. Recycling technologies
4. Papermaking technologies
5. Surface treatment
6. Coating and laminating
7. Biofuel production technologies
8. Process & technology optimisation
9. Process simulation in laboratory scale
10. Technology testing in pilot plant scale
11. Specialty paper and board production
12. Publication of research results in WOOD RESEARCH
13. Pulp, paper and board quality testing
14. Technical and economical information services
The Optional Cooperation Areas – Focused on Biofuels

1. Pulping technologies
2. Pulp bleaching technologies
3. Recycling technologies
4. Papermaking technologies
5. Surface treatment
6. Coating and laminating
7. **Biofuel production technologies**
8. **Process & technology optimisation**
9. **Process simulation in laboratory scale**
10. **Technology testing in pilot plant scale**
11. Specialty paper and board production
12. **Publication of research results in WOOD RESEARCH**
13. Pulp, paper and board quality testing
14. Technical and economical information services
Biofuel production technologies – Process simulation in laboratory scale
Biofuel production technologies – Technology testing in pilot plant scale
Biofuel production technologies – Process & technology optimisation

PAPSTAR

REPAY

RECOPT

OPTIMEN

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Publication of research results in Scientific Journal

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Thank You for Your attention!