Biodegradable Polymer from Biomass

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Partner/VP Business Development
Biodegradable Polymer from a Biofuel Waste

- TDA has a new invention - PDHDO
- Poly(2,5-dihydroxy-1,4-dioxane)
- New polymer from renewable, non-food source plant feedstock (lignocellulose)
  - Compostable
    - Reduces landfill volume
    - Degrades rapidly
  - LDPE Replacement
    - Films (wrappers, plastic bags)
    - Coatings
    - Pellets, fibers
    - Fibers

Patent issued for composition of matter and process
US 9040635 – valid until 2034
Invention

Disruptive Technology

Valuable co-products

Biomass

PYROLYSIS REACTOR

Heat

Char

Ashes as fertilizer

condenser

Gas

Bio-oil

Bio-Diesel

Acetic Acid

Aqueous Phase (Currently Waste)

TDA’s Polymerization Process

Glycolaldehyde

PDHDO Bioplastic

Water

TDA RESEARCH
How Our Product is Made

US Patent # 9,040,635
“Renewable Polymer and Method of Making”

1st Stage
Biomass → fast pyrolysis → Aqueous concentrate

2nd Stage
TDA’s catalytic polymerization

| Glycolaldehyde | DHDO | PDHDO |

3rd Stage
Consumer disposable products → Plastics
Benefits - “Waste” Source Degradable Polymer

**Biodegradable polymers**
- PLA: Polymers that break down into non-toxic, non-persistent byproducts

**Renewable polymers**
- Bio-PE
- Bio-PP
- Bio-PET
- Sustainable, compostable polymers
- Polymers made from non-food renewable feedstock

**Solvent-less process** reduces energy use and waste products

- **Original process** involved solvents and exotic catalysts
- **Current process** uses **NO** solvents and readily-available catalyst

TDA’s Bioplastic

5
Degradation time of plastic shopping bags decreased by **up to 96%**

**Estimate of Years to Degrade**

- Polyethylene – **500 years**
- PDHDO
  - 14 years (pH 7)
  - 5 years (pH 2)

**Biodegradable polymers...**

*Reduce degradation time,*

*Environmentally friendly...*
Global LDPE Market

- $33 B (2013)
- $37 B (2021)

Our product is a novel, renewable, and compostable replacement LDPE thermoplastic.
Where Are We?

In-Lab production of PDHDO

TRL = 4

In-lab R&D results show promise for technology and profitable economics

Original process involved more expensive solvent and exotic catalyst

Simpler polymerization route to make PDHDO was successful with low-cost catalyst
Next?

Regulation and Certification Approvals

- EPA Approval - Toxic Substance Control Act (TSCA)

- Biodegradability testing and certification – ASTM D6400

- Characterization and certification of properties to match LDPE as drop-in replacement

- Build relationships with end customers to tune characteristics for durability, manufacturability
  - Have interest from large consumer products company to test product
# Business Model and Timeline

**License** patent and know-how to polymer manufacturer

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<th>In-lab advancements</th>
<th>Y 1-2</th>
<th>Y 3-5</th>
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*Engagement with large polymer manufacturer to license technology*
Capital Need - Pilot Plant Demonstration

- Feedstock is available

- Pilot Plant demonstration cost estimate - $10 MM for design, CAPEX, OPEX

- TDA will seek to leverage with DOE/USDA/EPA funds

- TDA is looking for scale-up and development partners
Why Care?

• We are proposing a very **SIMPLE** business Model
  • Not capital intensive – no manufacturing plant
• Successful Pilot demonstration will lead to technology license
• Long-needed product (market pull)
• Spin-off a technology licensing company
• Payback estimated to start in **Year 5**
  • Revenues from licensing patent/know-how

**Growing renewable polymer market**
• $3.5B/year
• Potential first adopter has been identified
Why Invest?

- **Innovative Technology**
- **Strong Patent Position**
- **Growing Market**
- **Simple Business Model**
- **Strong Fundamentals**
- **Experienced Management**
TDA - Strong Fundamentals

- TDA has been in business for ~30 years
  - No external debt
  - Profitable every single year
- Has experience in licensing chemical/environmental technologies
- Spun-off a successful, ongoing business 4 years ago
Experienced Management

• Equity closely held – active managers
  • 80 employees
  • 27 Ph.D.'s - chemistry/engineering

• Facilities
  • Combined 50,000 ft² laboratory and office space near Denver, Colorado

• Management
  Girish Srinivas, Ph.D., MBA – VP Business Development
  Gokhan Alptekin, Ph.D. – VP Technology
  John Wright – President

Technical
  Bob Bolskar, Ph.D., Principal Scientist
  Jim Raebiger, Ph.D. – Senior Scientist

Each has 25 - 40 years of technology development and commercialization experience