Biomanufactured Porous Carbon: A New Bioproduct

Justin Whiteley, PhD - Co-founder & CTO, Emergy Labs
Bioproducts

Fuels

Energy

Materials
Biomaterials
Biomanufacturing

Microorganisms:
- Yeast
- Bacteria

- Enzymes
- Protein
- Chemical
Pre-revenue - materials company
Bottom-up approach for manufacturing porous carbon materials
Diverse application set with same manufacturing process
Activated Carbons

Coal

Wood

Coconut Shell

OLD

NEW
Inspiration from Nature

Biosynthesis of Materials

Highly sophisticated structures

Neutral pH - non-toxic

Abundant
Waste Sources as Carbons

Bamboo

Algae

Mushrooms

Repeatable Feedstock

Proximity

Value
“Biological 3D Printer”

Filamentous Fungi

Controlled Cultivation

Thermal Conversion

Chemical Properties

Mutant 1

Mutant 2

Physical Properties

Patent Pending Process
Increased Material Performance

Improved
• Surface area
• Purity
• Hardness

Benefit to industry
• Less amount of material
• Less capital and O&M costs

Competitor
“Surface usage”

Emergy
“Full volume usage”
## Product Comparison

<table>
<thead>
<tr>
<th>Monolith</th>
<th>Nanotube</th>
<th>Carbon Aerogel</th>
<th>Coconut GAC (High Purity)</th>
<th>Emergy Bio-carbons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Integrate metals upfront</td>
<td>X</td>
<td>✓</td>
<td>X</td>
<td>✓</td>
</tr>
<tr>
<td>Zero-cost Feedstock</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>✓</td>
</tr>
<tr>
<td>Industrial scalable</td>
<td>X</td>
<td>X</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Porosity (m²/g)</td>
<td>1500</td>
<td>1000</td>
<td>900</td>
<td>&gt;2000</td>
</tr>
<tr>
<td>Price ($/kg)</td>
<td>~100</td>
<td>~300</td>
<td>10</td>
<td>8</td>
</tr>
</tbody>
</table>
Tunable Material Properties

- Fully tunable
- Customized for application
- Increased performance

<table>
<thead>
<tr>
<th>Carbon Material</th>
<th>Density (g cm(^{-3}))</th>
<th>(V_{\text{total}}) (cm(^3))</th>
<th>(V_{\text{micro}}) (cm(^3))</th>
<th>Specific BET Surface Area (m(^2) g(^{-1}))</th>
<th>Volumetric BET Surface Area (m(^2) cm(^{-3}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wild-3st</td>
<td>0.0765</td>
<td>0.0765</td>
<td>20.5</td>
<td>1870</td>
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<tr>
<td>4530-3st</td>
<td>0.0938</td>
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<td>23.1</td>
<td>1866</td>
<td>175</td>
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<tr>
<td>1372-3st</td>
<td>0.0846</td>
<td>0.0846</td>
<td>25.5</td>
<td>1990</td>
<td>168</td>
</tr>
</tbody>
</table>
Product Applications
Sustainably Manufactured

- Carbon sequestration
- Waste utilization
- Low energy/resources

Benefit to industry
- Lower carbon footprint
- Reduced materials cost
- Good PR

\[
\text{Kg CO}_2\text{e} / \text{kg product}
\]

- Coal GAC: 8.7
- Coconut GAC: 2

Emergy Bio-carbon: -15
On-Site Production

- On-demand
- Reduced supply logistics
- Reduced transportation

Benefit to industry
- Lower material costs
- No production delays
Brewery Wastewater Nutrient Source

24 hours
Distribution of Coconut Feedstock
Distribution of Wastewater Feedstock
Integration into Bioeconomy

Waste utilization

Biology for Physical Properties

High Performance
Co-founders

Tyler Huggins, PhD  
Chief Executive Officer  
Biologist, Environmental Engineer

Justin Whiteley, PhD  
Chief Technology Officer  
Materials Scientist, Electrochemist

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