Ionic liquid based extraction of lipids from micro-algae

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IONIC LIQUID BASED EXTRACTION OF LIPIDS FROM MICRO-ALGAE

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Microalgae

- High lipid content
- Possible sources for biodiesel
- Can grow on CO$_2$
- Lipids inside the cell
- Cell disruption and lipid recovery necessary
Ionic Liquid Based Biomass Fractionation

• Ionic liquids: Liquids made entirely of ions
• For room temperature ILs typically bulky cation
• ‘Interesting’ solvent properties
  – Some can dissolve biomass
  – Some dissolve cellulose
  – Some dissolve lignin
  – Some destroy enzymes
Ionic Liquids - Structures

Cations

\[ \begin{align*}
&\text{N}^+ \\
&\text{N}^+ \\
&\text{N}^+ \\
&\text{N}^+ \\
&\text{N}^+ \\
&\text{N}^+ \\
&\text{N}^+ \\
&\text{N}^+ \end{align*} \]

Anions

\[ \begin{align*}
&\text{Cl}^- \\
&\text{Br}^- \\
&\text{NO}_3^- \\
&\text{SO}_4^{2-} \\
&\text{F}^- \\
&\text{SO}_3^{2-} \\
&\text{SO}_3^{2-} \\
&\text{SO}_3^{2-} \end{align*} \]
Enzyme Stability in Ionic Liquids

Green Chem., 2012, 14, 725–733
Ionic Liquids and Microalgae?

- Screen for ionic liquid to dissolve carbohydrates and no lipids
- Dissolve cell-wall of algae in ionic liquid
- Recover lipids as separate liquid phase
- Recover proteins as insolubles
- Recover carbohydrates after addition of anti-solvent (water)
Ionic Liquid Based Lipid Extraction

1. Ultrasonic pretreatment
2. Mixing by vortex, no pretreatment
3. Cooling down
4. Water batch at 95°C for 3hrs
5. Evaporation and concentration
6. Lipids for esterification
7. Organic layer
8. Water-induced precipitation
9. Solid layer
10. Proteins and cell-wall residuals for enzymatic hydrolysis
Heterotrophic Algae Growth

![Graph showing the change in OD, CO2, and pO2 over cultivation time.]

- OD Probe [AU]
- CO2 [%]
- pO2 [%]
Heterotrophic Algae Growth
Speed

Training, genetic makeup + human growth hormone...
Effect of Plant Hormones on the Growth of Microalgae

• Epibrassinolide
  – Enhance growth rate
# Lipid Extraction

<table>
<thead>
<tr>
<th>OESs</th>
<th>AMIMCl</th>
<th>70%AMIMCl+30%DMSO (w/w)</th>
<th>50%AMIMCl+50%DMSO (w/w)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-treatment</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Ultrasonic pre-treatment</td>
<td>RUN 1</td>
<td>RUN 3</td>
<td>RUN 5</td>
</tr>
<tr>
<td>Non pre-treatment</td>
<td>RUN 2</td>
<td>RUN 4</td>
<td>RUN 6</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Fraction</th>
<th>RUN1</th>
<th>RUN2</th>
<th>RUN3</th>
<th>RUN4</th>
<th>RUN5</th>
<th>RUN6</th>
<th>Folch</th>
<th>Algae</th>
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</thead>
<tbody>
<tr>
<td>Lipid (%)</td>
<td>2.91</td>
<td>10.93</td>
<td>7.11</td>
<td>7.98</td>
<td>5.18</td>
<td>6.76</td>
<td>4.04</td>
<td>-</td>
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<tr>
<td>Glucose (%)</td>
<td>-</td>
<td>1.29</td>
<td>1.05</td>
<td>1.17</td>
<td>1.07</td>
<td>2.20</td>
<td>2.00</td>
<td>13.49</td>
</tr>
<tr>
<td>FAME</td>
<td>RUN1 %</td>
<td>RUN2 %</td>
<td>RUN3 %</td>
<td>RUN4 %</td>
<td>RUN5 %</td>
<td>RUN6 %</td>
<td>Folch %</td>
<td></td>
</tr>
<tr>
<td>--------------</td>
<td>--------</td>
<td>--------</td>
<td>--------</td>
<td>--------</td>
<td>--------</td>
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<tr>
<td>C4:0</td>
<td>1.34</td>
<td>2.35</td>
<td>5.32</td>
<td>5.77</td>
<td>6.33</td>
<td>6.47</td>
<td>4.66</td>
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<tr>
<td>C16:0</td>
<td>17.92</td>
<td>29.35</td>
<td>28.11</td>
<td>27.84</td>
<td>27.5</td>
<td>28.04</td>
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<tr>
<td>C18:2n6c</td>
<td>15.63</td>
<td>24.64</td>
<td>24.62</td>
<td>25.1</td>
<td>24.87</td>
<td>24.5</td>
<td>24.82</td>
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<tr>
<td>C18:1n9/C18:2n6t/C18:3n3</td>
<td>20.57</td>
<td>32.55</td>
<td>31.55</td>
<td>32.06</td>
<td>31.85</td>
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<td>3.38</td>
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<td>3.06</td>
<td>3.26</td>
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<tr>
<td>C22:6n3</td>
<td>7.87</td>
<td>2.82</td>
<td>1.63</td>
<td>1.71</td>
<td>1.63</td>
<td>1.54</td>
<td>1.07</td>
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<tr>
<td><strong>Total</strong></td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>
Conclusion

- Microalgae can be fractioned using ionic liquids
- Majority of lipids can be recovered
- Carbohydrates can be recovered and hydrolyzed
- Drying step is necessary
Ongoing and Future Work

- Developing process for wet biomass
- Recycling the ionic liquid
- Extracting lipids from different algae strains
- Evaluating different ionic liquids
- Converting carbohydrates to ethanol and butanol
Thank You!