Microalgal production and exploitation for biofuel

Ian Watson*, Mehmood Ali, Jonathan McMillan, Yasintinee Aimyuak, Stefano Giacalone, Weaam Jaafa

*ian.watson@glasgow.ac.uk
Microalgal production and exploitation for biofuel

Contents

Motivation
Microalgae
Processes
Real time detection
Scaling-up
Conclusions

Algae is one of the most important biofuel technologies of the twenty-first century. — Dennis Bushnell, Chief Scientist, NASA
Rising CO$_2$ levels
For the first time in human history
“Global CO$_2$ in atmosphere passes milestone level” – **400 ppm**

15 TW ~ 85% from fossil fuels

**Everyday:**
41M miles/day in planes (76M gals jet fuel)
30M miles/day cargo ships (30M gals of oil)
16Mt of coal to fuel electricity demand
700M cars travel

9B global population by 2050

Mauana Loa Observatory
www.esrl.noaa.gov
Reliance on Fossil Fuel
Opportunities:
clean coal technology,
carbon capture and storage,
mining Investment/nationalisation
Failure to cap global temperature rise to 2°C
Global temperature rise likely to be 4-6°C
Motivation

Microalgal production and exploitation for biofuel

Carbon Footprint

Image by Stanford Kay (stan@standfordkay.com)
Microalgal production and exploitation for biofuel

Nuclear
Wind
Tidal
Solar
Biofuels

Microalgae

Added value
CO₂ absorption
Water treatment
Syngas
Genetic engineering

ADVANTAGES/
DISADVANTAGE

microalgae

wood

Algae is one of the most important biofuel technologies of the twenty-first century.

Dennis Bushnell, Chief Scientist, NASA
Microalgal production and exploitation for biofuel

ADVANTAGES

Sustainable
Can be grown on brown sites
On-shore/off-shore
Closed/open systems
Not competing for land with food crops
High quality fuel
Plenty of potential for added value
Sequester CO2 gas
Clean water, remove impurities
Food
Drugs

“...crop-fuelled power stations will push up food prices by competing for land...”
Guardian, 2/10/10

DISADVANTAGES

Difficult to scale
Not competitive with petrochemical fuels
Complex processes

<table>
<thead>
<tr>
<th>Crop</th>
<th>Oil Yield Gallons/acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn</td>
<td>18</td>
</tr>
<tr>
<td>Cotton</td>
<td>35</td>
</tr>
<tr>
<td>Soybean</td>
<td>48</td>
</tr>
<tr>
<td>Mustard seed</td>
<td>61</td>
</tr>
<tr>
<td>Sunflower</td>
<td>102</td>
</tr>
<tr>
<td>Rapeseed/Canola</td>
<td>127</td>
</tr>
<tr>
<td>Jatropha</td>
<td>202</td>
</tr>
<tr>
<td>Oil palm</td>
<td>635</td>
</tr>
<tr>
<td>Algae (10 g/m²/day at 15% TAG)</td>
<td>1,200</td>
</tr>
<tr>
<td>Algae (50 g/m²/day at 50% TAG)</td>
<td>10,000</td>
</tr>
</tbody>
</table>

The potentials of Biofuels from algae", NREL (National renewable energy laboratory). 2007, TAG - Triacylglycerol)
Microalgal production and exploitation for biofuel

Processes

GROWTH → SOLID SEPARATION → DEWATERING → EXTRACTION → REFINE

Photobioreactors
Indoors/outdoors
Closed pond systems
Open raceways
Control/optimising growth
Geographically dependent
Microalgal production and exploitation for biofuel

Processes

- Growth
- Solid Separation
- Dewatering
- Extraction
- Refine
Microalgal production and exploitation for biofuel

Processes

GROWTH → SOLID SEPARATION → DEWATERING → EXTRACTION → REFINE

Lysing
(Poster - Laser, microwave, ultrasonics, blender, water bath)

Solvents

Alcohol yield (%)

- Isopropanol
- Ethanol
- Methanol

Powder

Advanced combustion processes
Need revenue streams that compliment the algae production process to make microalgae biofuel a reality
Real time detection

Microalgal production and exploitation for biofuel
Scaling-up
Microalgal production and exploitation for biofuel

Tree concept, urban deployment, indoors, outdoors, raceways...

Example of two Commercial Companies...
Solarzynme, USA, Valued at $636M, with $26.8M revenues pa
Euglena, Japan, Value x10 this year, worth >£1B, trades 335x current earnings
Microalgae oil production works well in the lab
Scaling-up difficult - compliment problems with processing line
Vigorous activity in the USA and around the world
Opportunities for
  • Biofuel
  • New processes
  • Developing technology
  • Genetic modification
  • Biorefining – new drugs and food

We are collaborating with partners from Angola, Brazil, India and China

For more information please email me ian.watson@glasgow.ac.uk