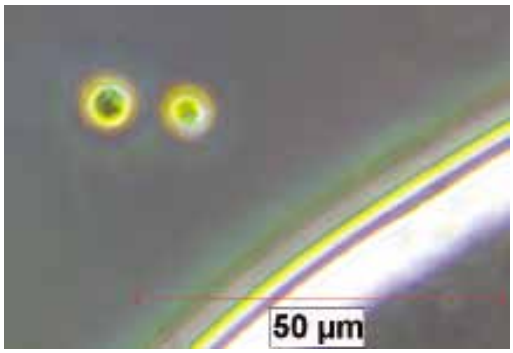
DIVERSIFIED TECHNOLOGIES, INC.®

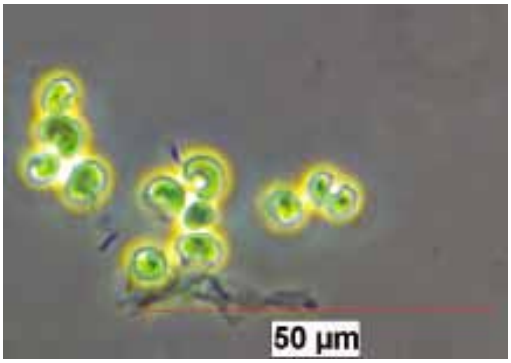
PRODUCT BRIEF

PowerMod Technology Breakthrough Brings High Availability to High Power Electronics

PowerMod™

Pulsed Electric Field Pre-Treatment of Algae for Oil Extraction





Isocrysis algae PEF treated at DTI on 28 Aug 09. Top: control (live) cells. These cells are motile, and easier to capture near a bubble (bottom right of photo). Bottom: PEF-treated electroporated cells, clumped and all dead (non-motile). Nine of eleven cells are clearly lysed in this view. Analysis found clear evidence of released biodiesel compounds, such as methyl hexadecanoate. .

Pulsed Electric Field (PEF) technology is a low cost, low energy process that applies high voltage electric pulses to an algal slurry. These pulses rupture the algal cell walls, increasing the availability of intracellular materials for downstream separation and extraction. The process is in-line, and scalable to high volumes.

Using PEF treatment would help biorefiners simplify the processing algae for biofuels and accelerate downstream extraction processes. We calculate that PEF treatment would account for about 0.10 $/gal. of the price of algae-derived biofuel, compared to about $1.75/gal. for conventional drying.

Technology

Streamlining the extraction of oils from algal cells early in the biofuel manufacturing process could yield substantial production cost savings. Presently, oil is liberated from algae/plankton cells through drying and the use of solvents (such as hexane or methanol), or through freeze drying and the use of supercritical CO_2.for separation. These expensive extraction processes contribute significantly to the high overall cost of producing biofuels.

Conventionally, after cultivating and harvesting, the algae is processed through a filter press, then dried and extruded. According to Gieskes*, drying accounts for as much as 75% of the total energy used in the extraction process. We calculate that the amount of energy within the biofuel produced is only slightly greater than the amount of energy used by drying in the extraction process. Thus, the net energy is just barely positive (15%)*. PEF processing applied after filter pressing, where algae is 50% of the total flow, will likely eliminate the need for drying, increasing the net energy yield five-fold or more.

Using PEF treatment, algal material (or other biomass) is pumped in a slurry through a treatment chamber, where the material is subjected to short, high-voltage pulses, typically 1 – 10 microseconds in length. The electric field from these pulses “electroporates” the cell wall, rupturing it and causing the cell’s contents to flow into the surrounding solution. PEF processing requires very short in-chamber treatment times, enabling very large throughputs in a continuous-flow process. The PEF process has been proven in food disinfection and wastewater processing, where it is in commercial use.

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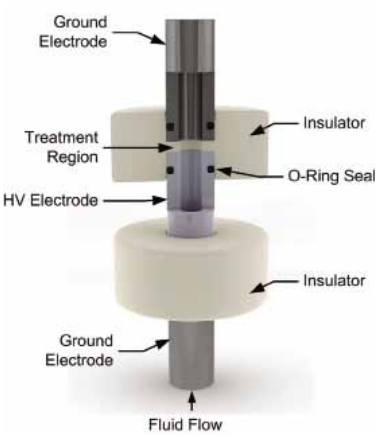
*Gieskes, Thomas E. Algae Oil Extraction (Powerpoint Presentation), Organic Fuels Holding, Inc., March 2008

A typical PEF system consists of (1) a power supply to convert utility power to high-voltage DC power; (2) a high voltage pulse modulator to transform the DC power into short pulses for electroporation of the cells in the slurry; and (3) a treatment chamber through which the slurry flows, and where the high-voltage pulses are applied.

Status

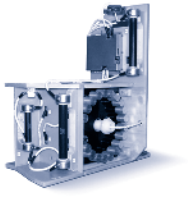
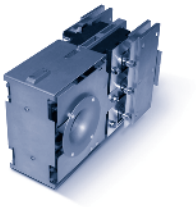
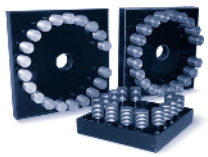
PEF pretreatment for algal biofuels is presently at a Technology Readiness Level (TRL) of 3, meaning its basic effectiveness has been demonstrated, but not yet quantified. Initial experiments have clearly shown that PEF lyses algal cells. In related applications, PEF processing has already achieved a TRL of 8, proof that it can be implemented on a large scale, with consistent and predictable results. Furthermore, the commercial-scale processes, hardware, and controls used in these related applications can be applied to algal oil extraction.

The objective of current development efforts is to determine optimal PEF processing protocols, and how best to integrate them with downstream extraction processes, so as to achieve the highest improvement in extraction at the lowest PEF cost. The value of the PEF process in lowering the cost of an existing process, or significantly increasing a process yield, will be evaluated against the overall reduction in cost-per-gallon of biofuel.



Cutaway view of one-half of a PEF treatment chamber, showing a single treatment zone. The pulsed electric field is applied to the fluid as it flows through the treatment zone.

PEF treatment system for wastewater treatment (pre-digestion). This system is rated at 150 kW average power, and produces pulses up to 40 kV, 500 A. It processes 10,000 liters/hour of wastewater sludge prior to anaerobic digestion.

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