DIVERSIFIED TECHNOLOGIES, INC.®

PRODUCT BRIEF

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PowerMod™

Pulsed Electric Field Pre-Treatment of Algae for Oil Extraction

Algae provide a very efficient factory for the production of a range of chemicals and compounds, but extracting these products from within the algae cells can be complex and expensive. Pulsed Electric Field (PEF) technology is a low cost, low energy process that applies high voltage electric pulses to an algal slurry. These very short, high intensity pulses rupture the algal cells, increasing the availability of intracellular materials such as lipids, proteins, pigments, etc., for downstream separation from the supernatant. The process is in-line, low energy, scalable, and can be performed on concentrated slurries.

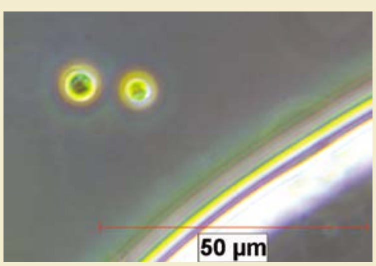
Technology

In DTI's patented process, PEF treatment is applied to algal material (or other biomass) as it 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.

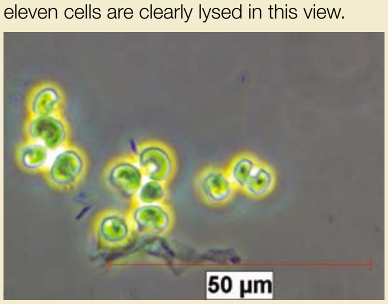
A typical PEF system consists of (1) a power supply to convert utility power to high voltage DC power, (2) a high voltage pulse modulator to transform the DC power into short pulses for electroporation of the cells in the slurry, and (3) a treatment chamber through which the slurry flows, and where the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

PEF can significantly reduce the costs of the extraction of lipids, proteins, and other valuable intra-cellular compounds from algal cells. Lipids are conventionally liberated from algal cells through drying and the use of solvents (such as hexane or methanol). Drying alone accounts for as much as 75% of the total energy used in the extraction process. The amount of energy within the biofuel produced is only slightly greater than the amount of energy used by the drying process itself. These expensive extraction processes contribute significantly to the high overall cost of producing biofuels. We estimate the cost of PEF treatment to be 1/10th the cost of drying microalgae using conventional methods, allowing wet extraction techniques to be applied. Alternative approaches using wet extraction, such as presses, bead mills, or ultrasonic lysing are significantly more energy intensive than PEF.

System in Action



Isocrysis algae PEF treated at DTI in 2009. Top: Control (live) cells captured near a bubble (bottom-right of photo). Bottom: PEF-treated electroporated cells. Nine of eleven cells are clearly lysed in this view.

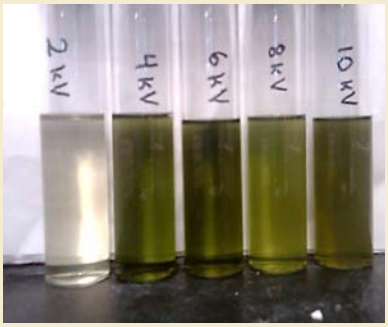


Pulsed Electric Field Systems

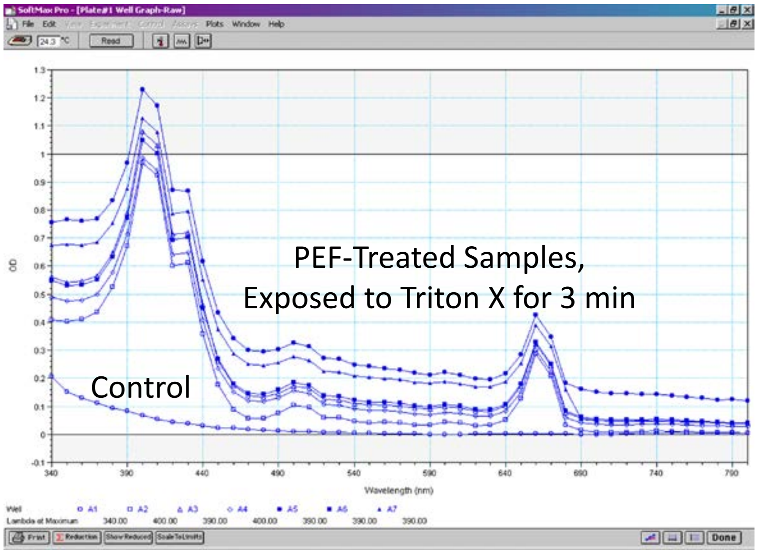
Status

The basic effectiveness of PEF pretreatment for algal biofuels has been demonstrated, but not yet quantified. Initial experiments have clearly shown that PEF lyses algal cells. DTI is currently working with Arizona State University's Arizona Center for Algae Technology and Innovation (AzCATI) to determine the effectiveness of PEF across a range of algal species and potential products. The objective of these efforts is to determine optimal PEF processing protocols, and how best to integrate them with downstream extraction processes, to achieve the highest performance at the lowest cost.

In related applications, PEF processing has been implemented for commercial-scale processes in food processing and wastewater treatment. The same hardware, and controls used in these related applications can be directly applied to algal product extraction.

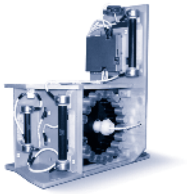
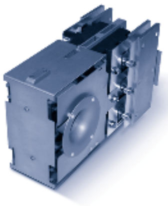
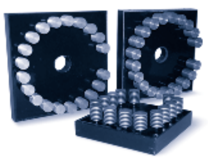


Chlorella vulgaris samples after PEF treatment at different field strengths and centrifugation. Spectrophotometric scans for pigment liberation showed clear differentiation as a function of PEF treatment, indicating that increased lysing of the algal cell membranes occurred at higher field strengths and pulse durations, releasing intracellular components into the supernatant.**



Spectrophotometric wavelength scans illustrate the release of multiple pigments in Chlorella vulgaris after PEF treatment at different intensities. **

**Images and data courtesy of Arizona Center for Algae Technology and Innovation (AzCATI), Arizona State University, Mesa, Arizona, USA.

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35 Wiggins Avenue,
Bedford, MA 01730-2345 USA
Tel: 1.781.275.9444