Extraction by spark generated shockwaves

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EXTRACTION BY SPARK GENERATED SHOCKWAVES

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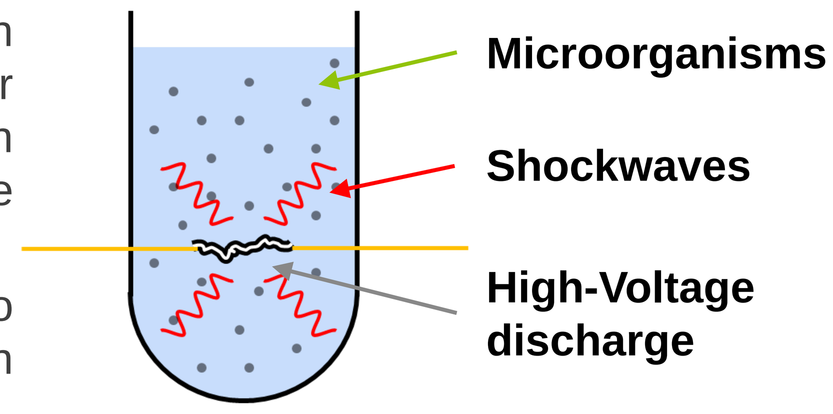
Abstract

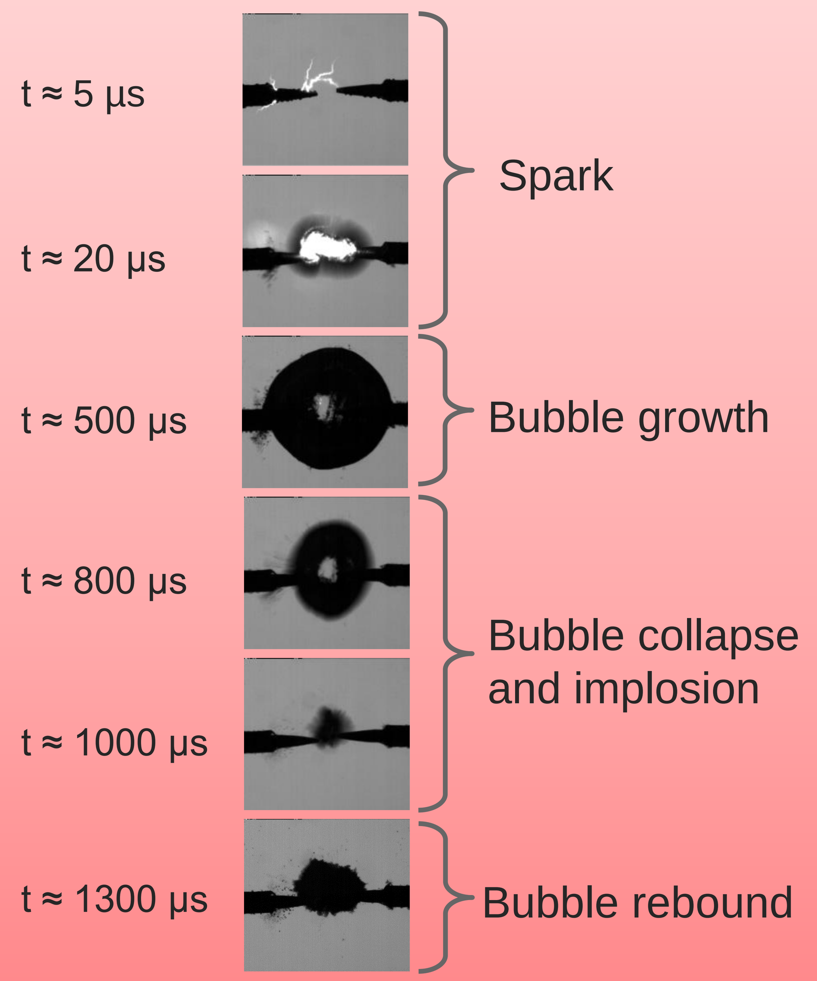
The production of lipids using oleaginous microorganisms is widely studied to develop the next generation of renewable fuels. Now, the extraction of intracellular lipids has been identified as one of the crucial elements that have the largest impact on the cost of microalgal bio-refinery process. In this context, a new electric field based technique is studied to disrupt cell membranes and to extract their content. High voltage electrical pulses are used without any transducer to create underwater spark discharges that produce a high-pressure plasma/vapor bubble whose expansion, collapse and rebounds generate shockwaves. The high induced variations of pressure produce a cloud cavitation above the electrode; bubbles collapses are known to destroy mechanically cells membranes. Moreover, the pressure rise induced by the process can be used to renew the solution containing destroyed cells at each pulse.

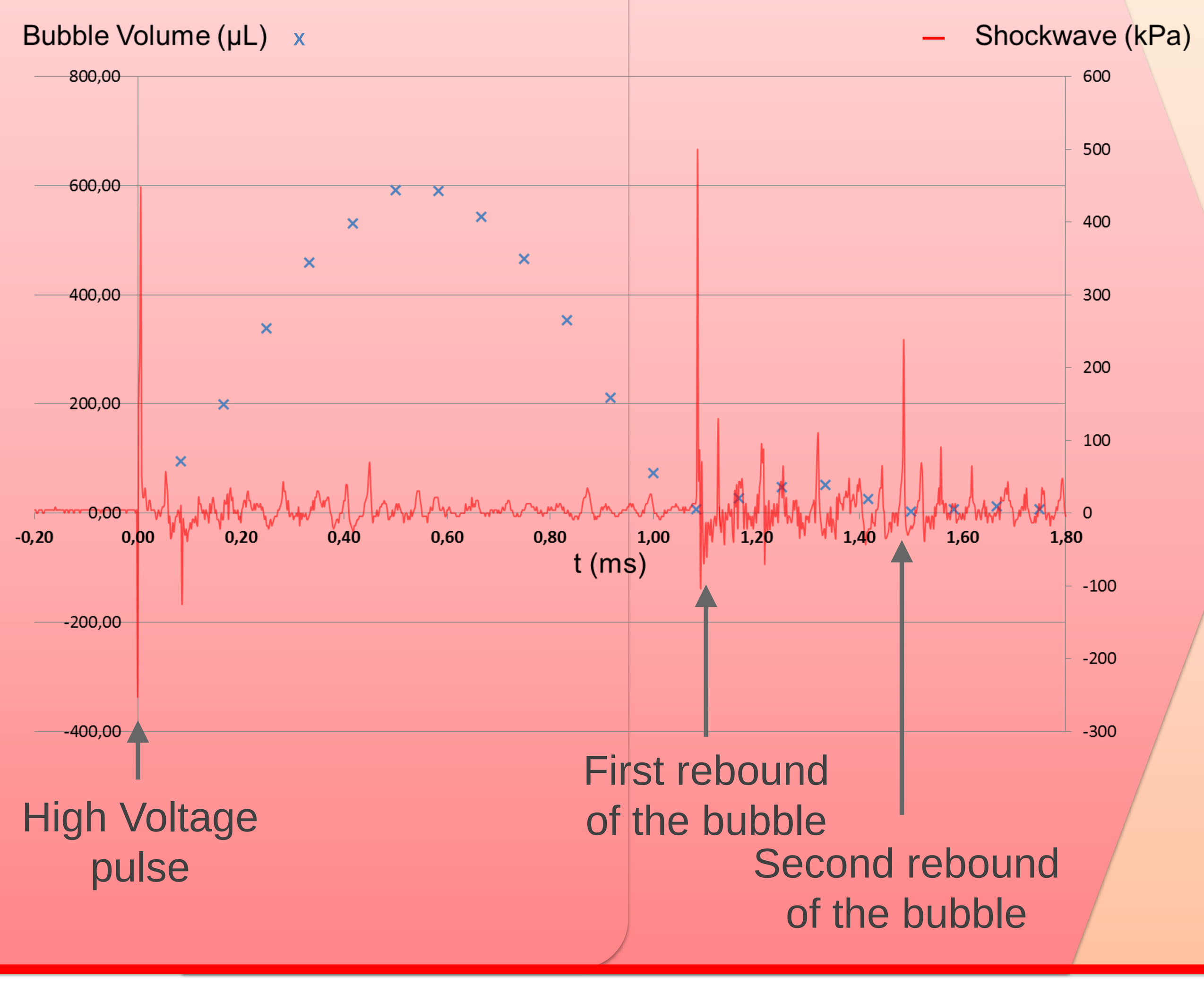
Underwater spark discharges can extract chlorophyll and lipids from *Phaeodactylum tricornutum* and *Nannochloropsis gaditana* and also DNA from bacteria such as *Bacillus subtilis*. The present communication presents results of a parametric study of the process. It is shown that efficiencies depends on the microorganisms' concentration and the water height above the electrodes.



Following an underwater discharge of a 45 nF capacitor at 10 kV

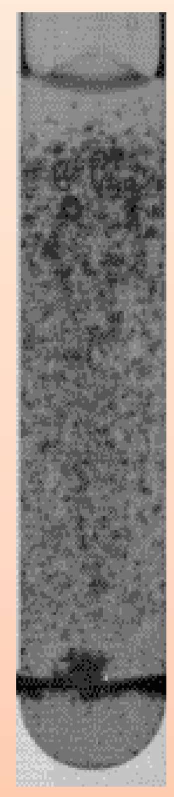
Shockwaves generation





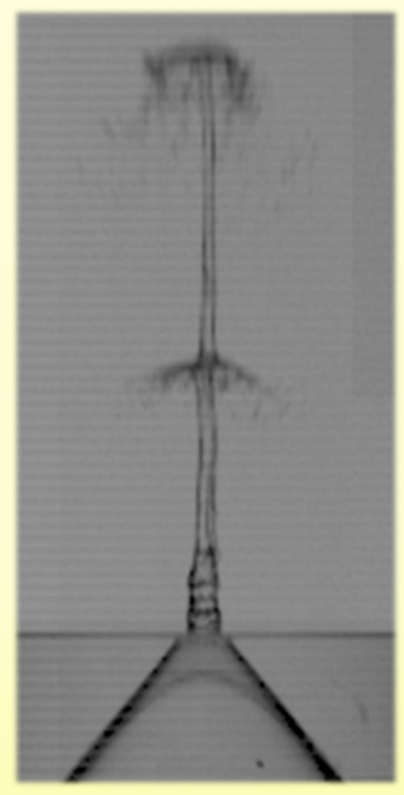
Cloud cavitation

Shockwaves induce pressure changes that lead to the formation of cloud cavitation.



Picture of the cavitation bubbles taken 150 µs after the electric discharge.

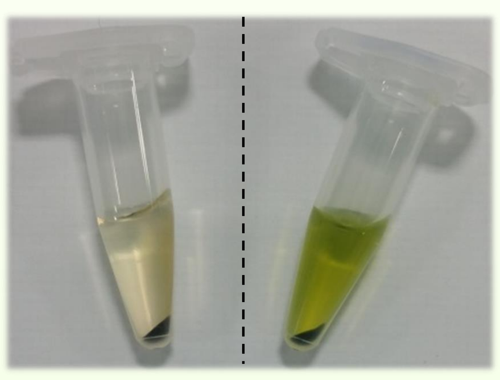
Water ejection



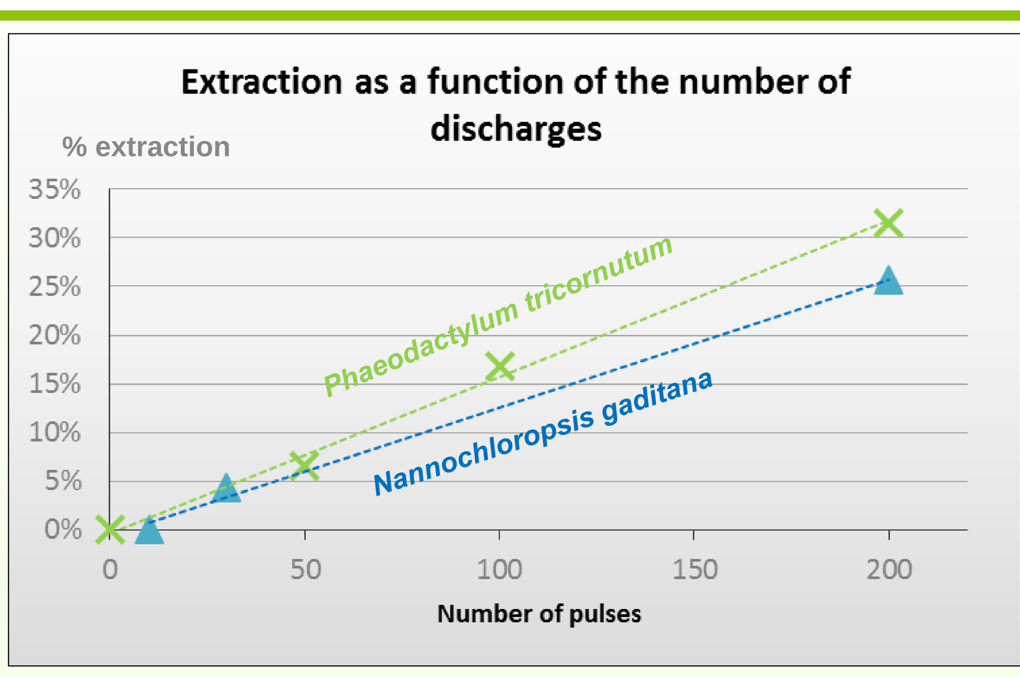
The pressure rise and the bubble growth can expel water from the treatment unit.

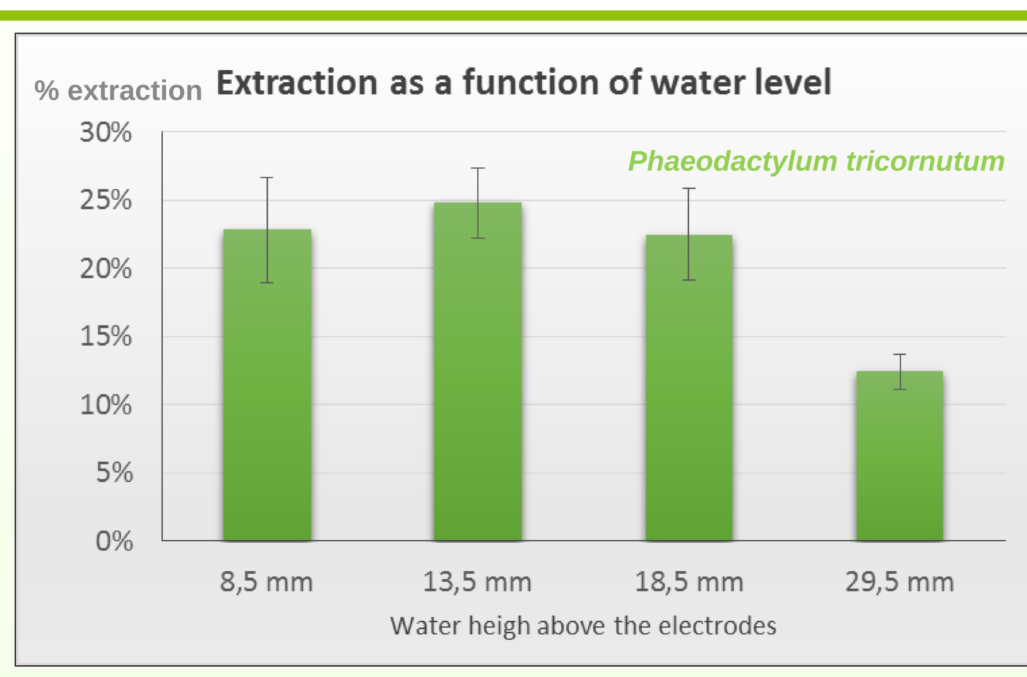
Two applications

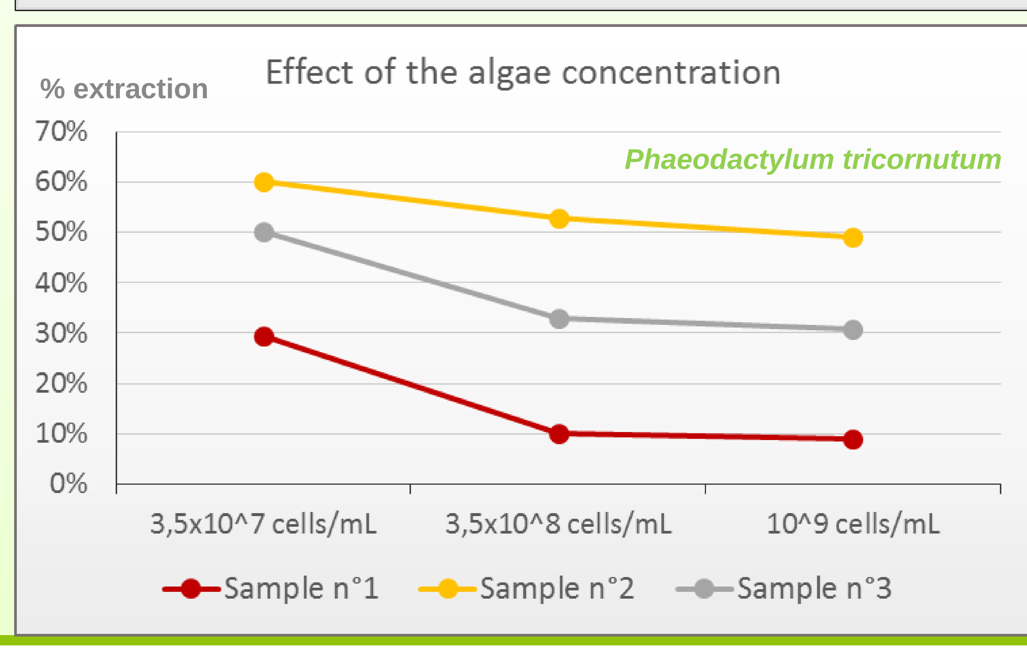
Chlorophyll release



Untreated Treated





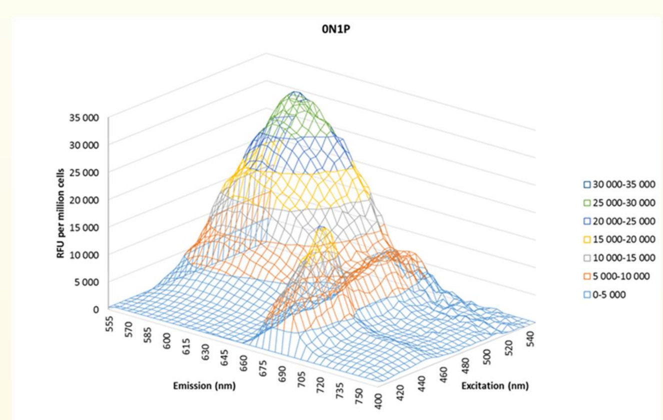


Underwater discharges produce heat and free radicals that combine to create very reactive molecules such a hydrogen peroxyde. But *Phaeodactylum tricornutum* does not release pigments when heated up to 90°C. Also 1 mM of hydrogen peroxyde does not seem to make the algae release pigment. **Release of intracellular molecules seem to be therefore due to the mechanical effect of cloud cavitation.**

- About 25-35% of chlorophyll are released by 200 electric pulses
- A water height of about 13,5mm above the electrodes seems to be optimal
- Dilution seems to improve the treatment efficiency

Triglyceride release

Studied on cultures (nitrogen starvation)



➢ Extraction of about 6%

Perspective : recover the same amount as chlorophyll

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