EXCELLENCE IN SCIENCE

THE ROYAL SOCIETY

Applications of Energy Efficient Microbubbles

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2010 Royal Society Brian Mercer Innovation Award Winner

Microbubble fluidic oscillator

Fluidic oscillator is one approach that promises minimal power losses and low power consumption with desirable bubble size properties and nearly uniform spacing to oppose coalescence.

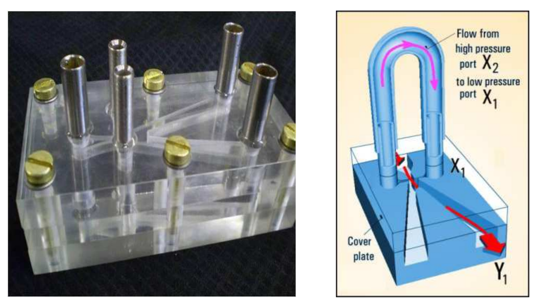


Fig. 1: Fluidic oscillator

Advantages:

- 18% less electricity;
- 3-4 fold better aeration rates;
- very low shear mixing.

a b c

Fig. 2: Microbubbles with membrane only (a) and with membrane and oscillator (b). Comparative size of bubbles (c).

Microbubbles' transport behaviour –mass, momentum, and heat transport at the interface of microbubbles is fluenced by the interfacial surface area: smaller bubbles lead to greater transfer.

Ozone for breakdown of complex organics / disinfection

Our low power ozone plasma microreactor can be inserted into the microporous diffusers to arrange for ozone dosing on demand for sterilization or other uses.

- Low power - a ten-fold reduction over conventional ozone generators.
- High conversion. The selectivity is double that of conventional reactors (30% rather than 15% single pass).
- Strong irradiation in UV.
- "killing zone" of ~300 nm.
- Operation at atmospheric pressure, at room temperature,and at low voltage (170V, can be mains powered).

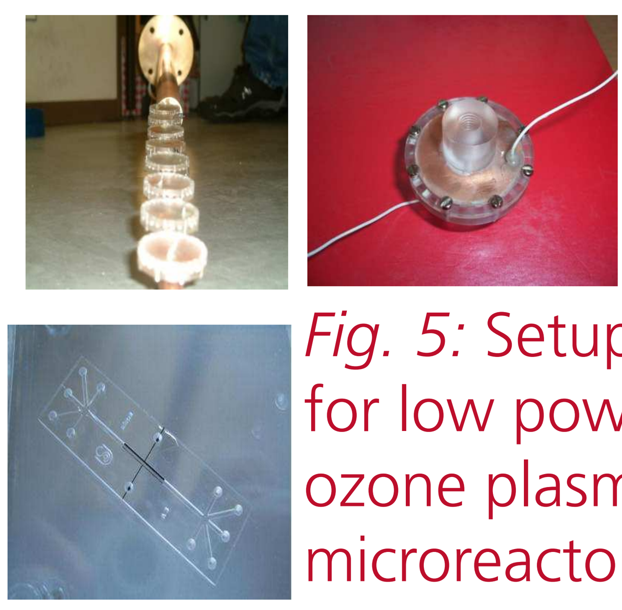
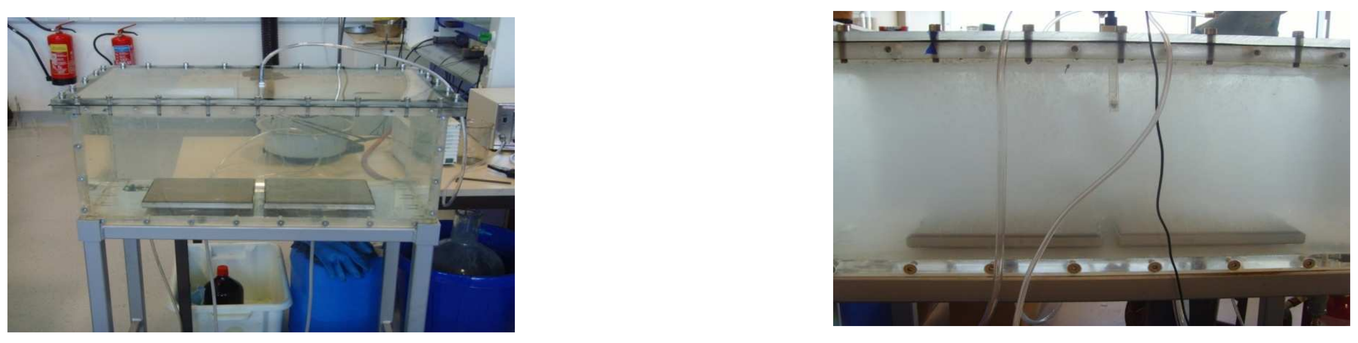


Fig. 5: Setups for low power ozone plasma microreactor

Biogas Sweetening

An artificial biogas mixture (60% CH_4; 40% CO_2) was bubbled through an alkaline-rich solution with the aim of increasing the methane content in the gas. During the experiment the solution turned cloudy indicating that the CO_2 had reacted with metal hydroxides in the solution to form mineral salts. After 10 minutes the methane content in the gas stream was 97%.



Before After

Fig. 8:Biogas sweetening with a fluidic oscillator

PERLEMAX

Microflotation

Microflotation applies the traditional physical chemistry of dissolved air flotation – dosing with flocculants and coagulants to form microbubble flocs of algae for harvesting and dewatering. This is the single most important problem precluding economic algal biofuel production. We have achieved 99% separation performance with 2-3 orders of magnitude lower energy cost.

Fig. 3: Microflotation stages of clarification: (a) Flocculated algae; (b) blanket formation; (c) completed separation.

Algae recovery efficiency increased as a function of pH as coagulant concentration increased (Fig. 4).

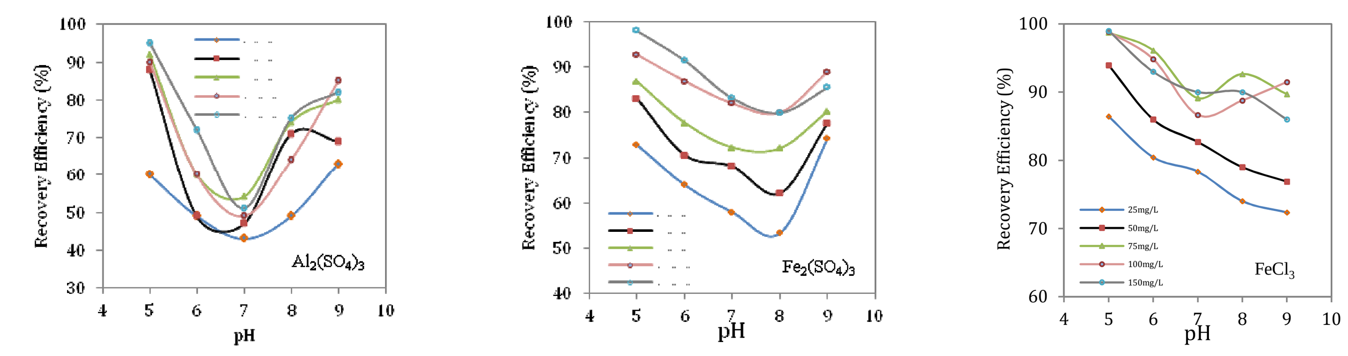


Fig. 4: Plots of algae recovery efficiency as a function of pH at different coagulant concentrations.

Algal growth in an air lift loop bioreactor

- Microbubbles dissolve CO2 faster and therefore increase algal growth.
- Microbubbles extract the inhibitor O2 produced by the algae from the liquid.
- Algal culture had supra-exponential growth (Fig 7.).
- Bioenergy could become a more attractive option in the recycling of the high concentration of CO2 emissions.

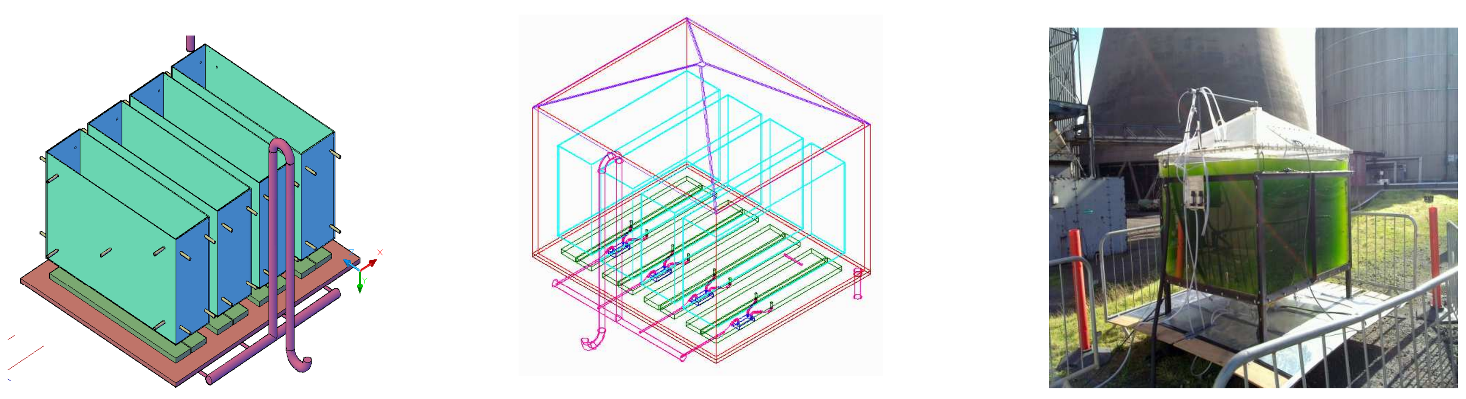


Fig. 6: Air lift loop bioreactor

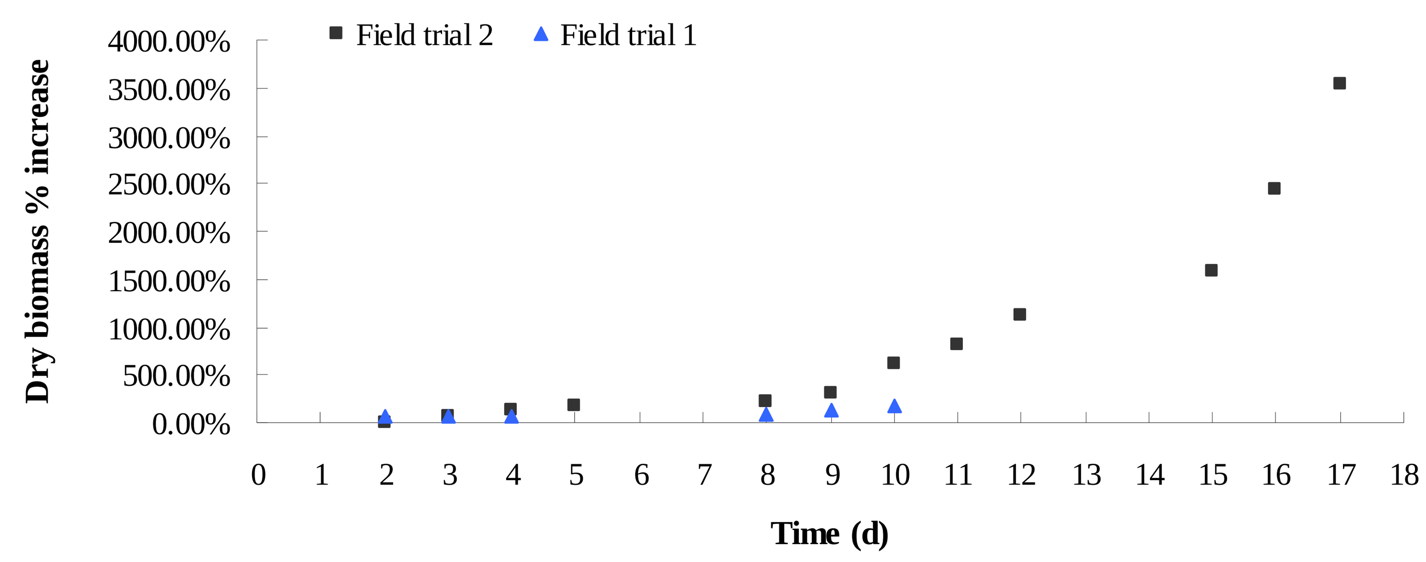


Fig. 7: Algal biomass / bioenergy production