Microalgae Preconcentration by Sedimentation and by Addition of Montmorillonite Clay Coagulant

Elizabeth Murray • Dept. of Chemical Engineering, Columbia University, New York, NY • etm2116@columbia.edu

Dr. Belinda Sturm, Marie-Odile Fortier, Griffin Roberts
University of Kansas
Dept. of Environmental Engineering
Lawrence, Kansas 66045
785-864-2907

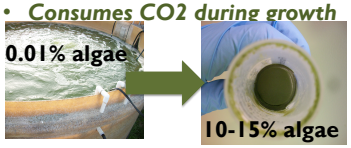
KU BIOFUELS Feedstock to Tailpipe© Initiative

This material is based on work supported by the National Science Foundation under grant number EEC-1063097.

Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

Algae is promising as a source of lipids for "green" fuels

- Easy to grow, purifies water
- High yield per acre
- Consumes CO_2 during growth



Current harvesting methods are too energy intensive

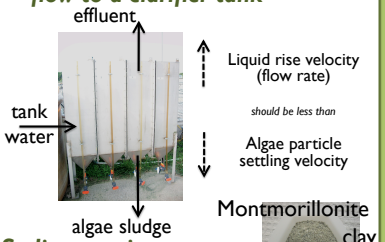

Filtration


Centrifugation


Dissolved Air Flotation

Using gravity sedimentation for "preconcentration" before centrifugation lowers energy cost

Sedimentation can be accomplished via continuous flow to a clarifier tank



Sedimentation can also occur in a batch process

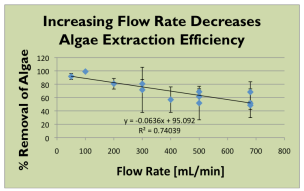
Montmorillonite clay

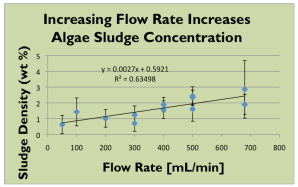
A coagulant can be used to neutralize surface charge on algae particles

Examine continuous and batch process & coagulant to maximize:

- Efficiency (% algae harvested from water)
- Algae concentration in "sludge"

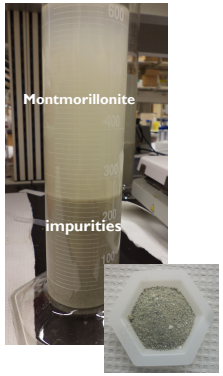
In the continuous process, testing flow rates of 50-680 mL/min reveals a trade-off between efficiency and sludge concentration.

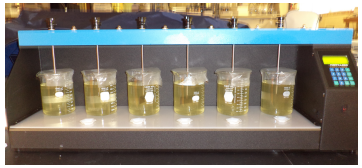




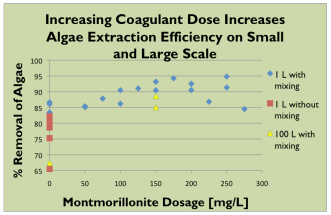
Examine the batch process on a small scale, with and without clay coagulant

Clay is dissolved to allow feldspar, quartz, etc. to settle out

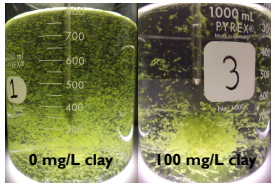




1 min rapid mix (to disperse clay)
60 min slow mix (to bring particles into contact)
30 min settling



Mixing makes a difference!
150 mg/L is selected as the optimum coagulant dosage

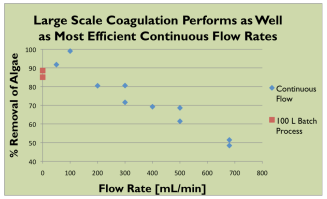


Neutralizing negative surface charge allows particles to clump together and settle more effectively

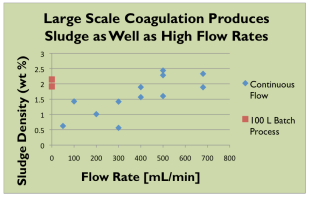
Scaling up the batch process with 150 mg/L coagulant gives good results

50 L water

5 min rapid mix
60 min slow mix
30 min settling



Large-scale batch coagulation at this dose has an efficiency of 85-88%



Large-scale batch coagulation at this dose produces 2% concentrated sludge, although measurements vary

Average particle settling velocity is calculated from the continuous flow data

$$v_0 = \frac{\text{flow rate}}{\text{area}} = \frac{100\ \text{mL/min}}{0.1452\ \text{m}^2} = 0.00069\ \text{m/min} = 4.13\ \text{cm/hr}$$

Continuous

•Even the highest flow rate processes only 65% of the volume that can be processed in a large scale batch during the same time frame.

•No mixing costs
•Easier to collect sludge

Batch

•Higher efficiency and sludge density

•Energy cost of dissolving, dosing, mixing clay

Future work: add Montmorillonite to continuous process at high flow rate

Effects of Montmorillonite on fuel properties?

What to do with settled clay waste product?

References

Davis, Mackenzie L. and David A. Cornwell. "Water Treatment." *Introduction to Environmental Engineering*. 4th ed. St. Louis: McGraw-Hill Companies, 2008. 187-352. Print.

Salim, S., M. H. Vermuë, and R. H. Wijffels. "Ratio between Autoflocculating and Target Microalgae Affects the Energy-efficient Harvesting by Bio-flocculation." *Bioresource Technology* 118 (2012): 49-55.

Westemeyer, Brandon. "A Comparison of Dewatering Techniques for Algae Cultivated at a Wastewater Treatment Plant." Unpublished. 2010.