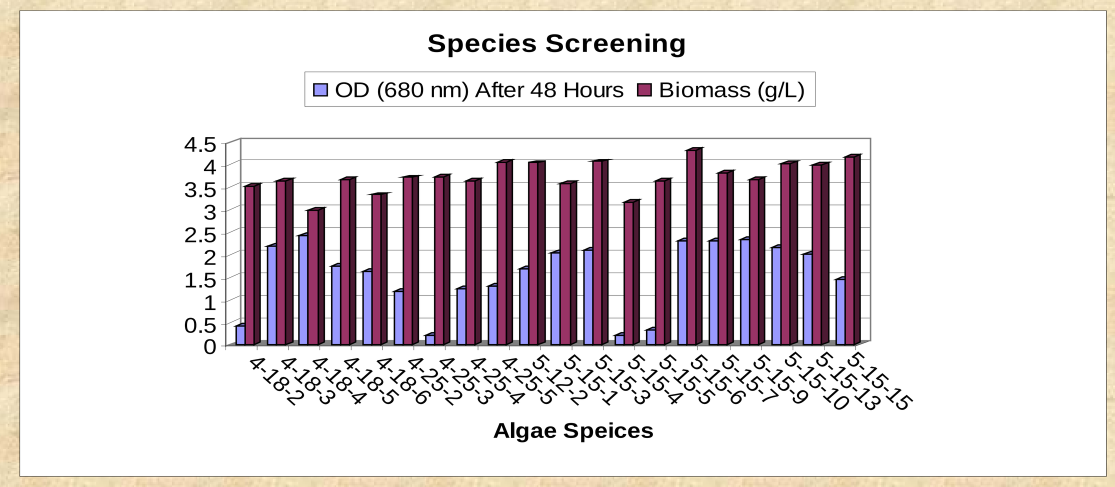
Mass Production of Algae to Make Biodiesel

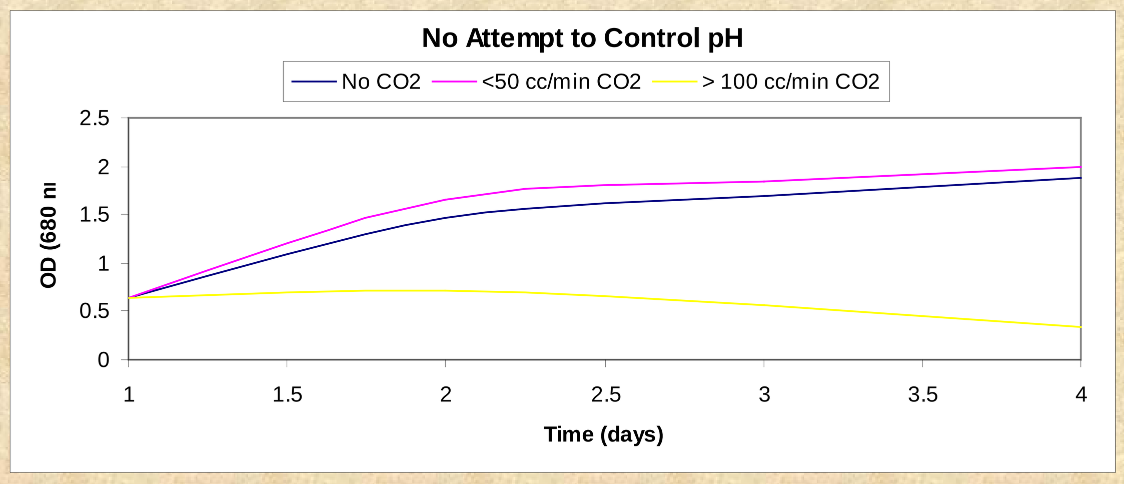
Steven A. Biorn
Faculty Mentor (Dr. Roger Ruan)
Bioproducts and Biosystems Engineering
University of Minnesota - Twin Cities

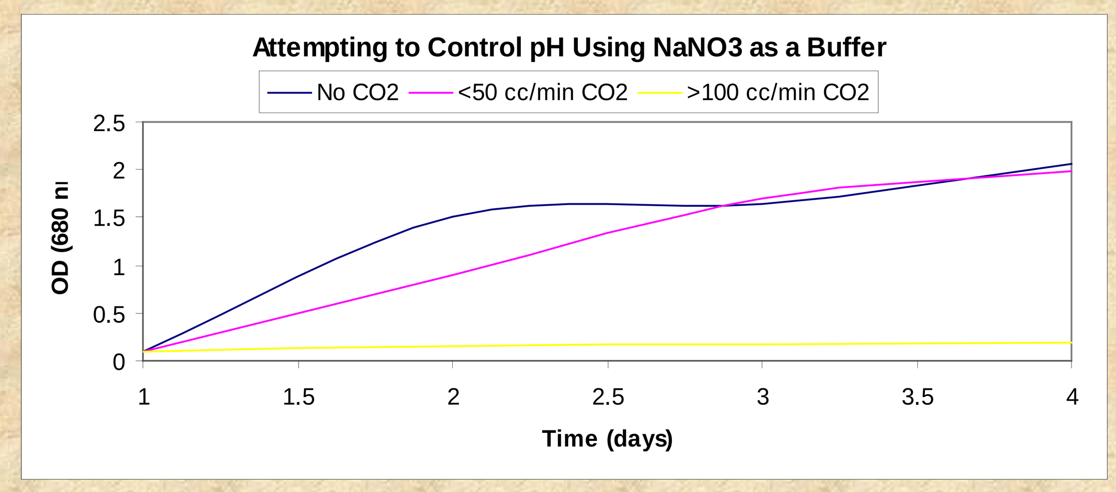
Objective: The purpose of the project is to isolate a species of algae with large quantities of triacylglycerides, starch and biomass. The Ruan Laboratory at the University of Minnesota has isolated several species of algae from Minnesota's ponds, rivers and lakes. Variations in CO_2 quantity, and how it affects algae growth were also investigated.

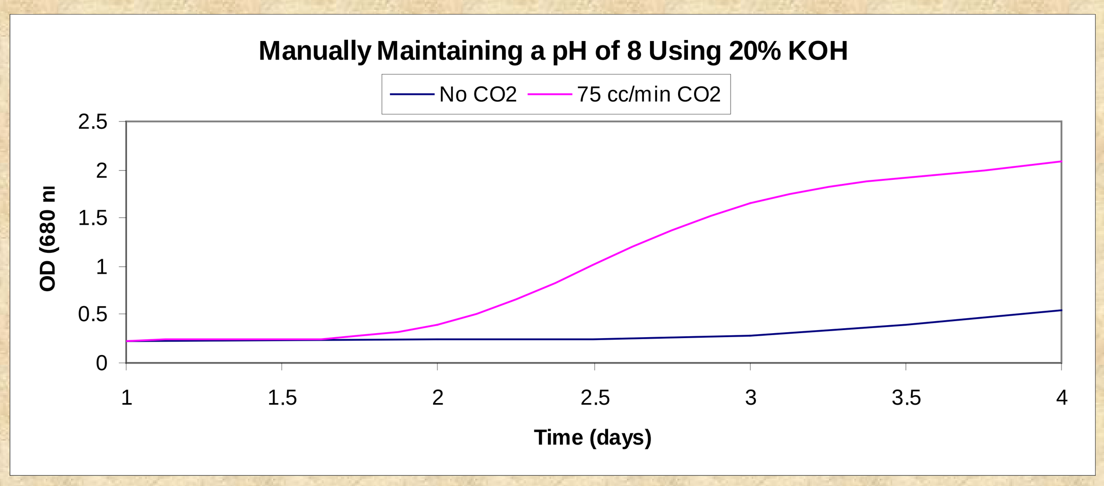
Why would algae make a good biofuel alternative?

Use up to 10 percent of solar energy to make cellular structure (1)
45 to 220 times the triacylglyceride production of terrestrial biomass (3)
7 to 60 percent dry weight is triacylglycerides (2)
Some species of algae can double their biomass every 24 hours (4)
Feasible to grow enough to meet U.S. fuel demand, using only 3-6 percent of total crop area (4)
Also produces methane from anaerobic digestion of biomass after triacylglyceride extraction (5)









Discussion and Future Work:

From what is known about the reaction of photosynthesis; $6CO_2 + 6H_2O$ (+ light energy) $C_6H_{12}O_6 + 6O_2$, it was expected that supplying algae with more CO_2 would increase its replication rates. This prediction was made based on La Chateliers Principle, where an addition of reactants in the equation will drive the reaction to the right, therefore forming more glucose ($C_6H_{12}O_6$) and O_2. The experiments discussed above support this hypothesis, and also suggest that growth rates are heavily dependent on pH levels. Systems could be developed where pH is measured and maintained using a computer, or even simpler yet, base could be slowly dripped into the algae bioreactors at a given pace to counteract the decrease in pH caused by the addition of CO_2.

Acknowledgements:

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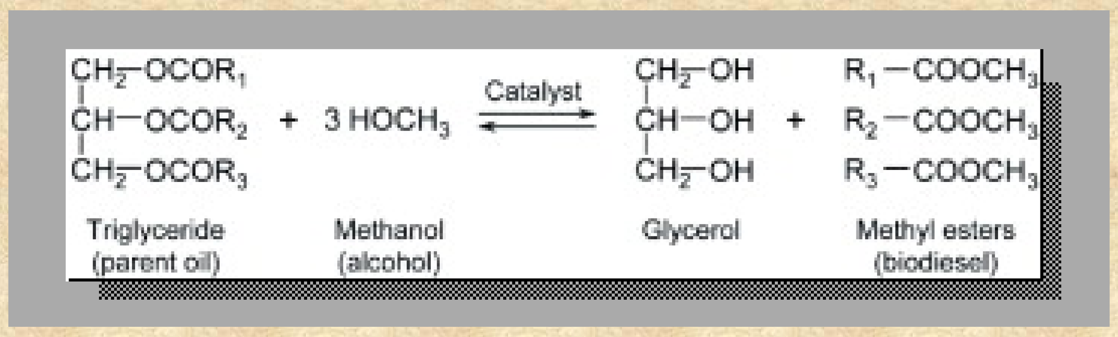
Biodiesel Chemical Reaction



The process of making biodiesel (methyl esters) is performed using methanol, heat and a catalyst to induce a transesterfication reaction.

Image from: www.rise.org.au/info/Tech/waste/index.html

Methods and Results:

Twenty different species previously isolated by the Ruan laboratory were scaled up from solid media in a test tube to 100 ml of liquid media in 250 ml Erlenmeyer flasks. Light intensity, media concentrations, temperature and aeration times were kept constant for all species. The algae concentrations were measured every twenty four hours using a spectrophotometer (Spectronic Genesys-5, 680 nm-visible light). After eight days, biomass (g/L) was determined for all twenty species. The two species with the fastest growth (based on OD) and highest biomass were selected for the CO_2 augmentation study. Both CO_2 and atmospheric air were supplied to the algae at varying concentrations, as determined by a gas flow meter. The initial study found that while some CO_2 increased algae growth, too much CO_2 lead to the formation of carbonic acid and thus a decrease in pH levels. pH levels were measured using a Accumel AB15 pH meter. These low pH levels inhibited and in some cases were fatal to the algae. Past studies performed by the Ruan Laboratory at the University of Minnesota have shown a homeostatic pH range near 8. A second study was conducted using sodium nitrate ($NaNO_3$) as a buffer in an attempt to maintain the pH within the desired range. This study yielded similar results, where a little CO_2 and a lack of CO_2 showed similar growth rates, but too much CO_2 caused a large decrease in pH. From here, a third study was derived where pH would be taken each day and twenty percent potassium hydroxide (KOH) would be added to adjust the pH back to 8 for those flasks receiving CO_2. Manually maintaining the pH has shown promising results, where one species has OD measurements nearly four times that of the control, which did not receive any CO_2.

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