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Algae-Derived Biofuel Studies

Rowan Hall Room 304 Monday – 12:15-3:00 PM

Energy is critical for the development of poor nations, especially those that do not have resources such as fossil fuel and coal. For poor countries such as Bangladesh, Nepal, and Myanmar, wind and solar power are expensive alternatives. As such, the challenge for this generation of scientists and engineers is to develop cost effective, environmentally-friendly sources of energy. Biofuels have received wide attention in recent years, especially algae-derived biofuels. Algae reproduce quickly, produce oils more efficiently than crop plants, and require relatively few nutrients for growth. These nutrients can potentially be derived from inexpensive waste sources such as flue gas and wastewater, which provides a mutual benefit in helping to mitigate carbon dioxide waste. Algae can also be grown on land unsuitable for agricultural purposes, thereby eliminating competition with food sources. One of the main factors impeding the ability of algae-derived biodiesel to become widely used is its high cost relative to current petroleum-sourced fuels. In order to reduce cost, ways to optimize the growth and lipid productivity of algae species have been explored. The optimization of algae growth is a key step in increasing lipid yield and making algae-derived biodiesel an economically viable alternative to traditional fuels. While research using monocultures of algae looks extremely promising, there is a dire need for simple, cheap technology for alternate fuel for poor and developing countries such as Bangladesh, rural India, Myanmar, and Nepal. While the climate in these countries is conducive for algae-derived biofuel, monoculture sources will be difficult to implement. It will be impossible to maintain clean, pristine conditions for pure culture algae growth reactors in such countries. As such, **this project will investigate the use of commonly occurring algae in a mixed culture setting**. If the results from mixed culture studies are comparable to the monoculture results that have been widely reported, this will open the doors for new, simpler methods of algae-derived biofuels, especially in developing or poor countries.

An experimental study with mixed algae cultures is being proposed to complement our monoculture studies. Three algae species will be used in this study: *Chlorella vulgaris*, *Nanochloropsis oculata*, and *Scenedesmus dimorphus*. These species were chosen due to their common occurrence around the world, easy growth characteristics, and significant lipid content. Each species has a distinct morphology and high lipid content, as shown in Table 1. They can also be grown readily under a variety of environmental conditions. The images of the select algae are presented in Figure 1 below:

Table 1: Algae Species with Lipid Content (Becker, 1994)

Name	**% Lipid Content** *Based on dry weight*
Chlorella Vulgaris,	14-22
Nanochloropsis Oculata	31-68
Scenedesmus Dimorphus	16-40

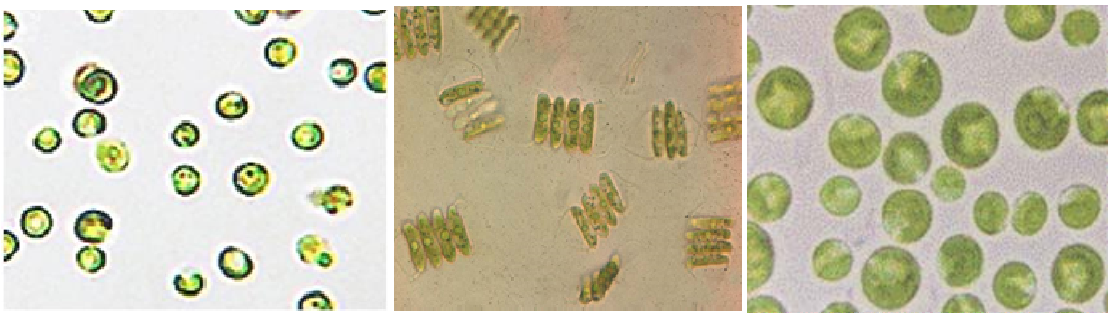

Figure 1: Images of a) *Nanochloropsis, b Scenedesmus,* and *c) Chlorella* cells (Mohan et al. 2010)

Project Goals: The overall goal of this project is to test the feasibility of mixed algae cultures as a source of biofuel. While there is an abundance of results from monoculture studies, this will be a novel study as there is very little literature on mixed cultures. Specific goals of the project are to:

a) Determine the growth kinetics of *Scenedesmus Dimorphus*
b) Measure the growth rate of monoculture or mixed culture populations
c) Compare results of the mixed culture studies with the results obtained from monoculture studies
d) Extract lipid from algae

Team Assignments

Team #	**Type of Study in Duplicate (Teams rely on data obtained by entire class)**
1	Monoculture Study with *Chlorella vulgaris*
2	Monoculture Study with *Scenedesmus Dimorphus*
3	Monoculture Study with *Nanochloropsis Oculata*
4	Mixed Culture Study with *Scenedesmus Dimorphus and Nanochloropsis Oculata*
5	Mixed Culture Study with *Scenedesmus Dimorphus and Chlorella vulgaris*

References:

Becker, E.W. (1984) "Biotechnology and exploitation of the green alga *Scenedesmus obliquus* in India", *Biomass, Volume 4, Issue 1, Pages 1-19.*

Mohan, S.V., M. Prathima Devi, G. Mohanakrishna, N. Amarnath, M. Lenin Babu, P.N. Sarma (2010) "Potential of mixed microalgae to harness biodiesel from ecological water-bodies with simultaneous treatment" *Bioresource Technology, In Press.*

Tentative Schedule

Date	Topic	5 Minute Presentation Topic	Assignments/ Quizzes
Jan 24	Course Introduction in Auditorium Introductory meeting with assigned faculty		Assignment #1: (Due 1/31/11) Read the assigned paper on *Scenedesmus D.* and be prepared for a quiz
Jan 31	Learn Lab Protocol Start Algae Growth Studies	Present 5 slides on: Intro/Background	Quiz on the paper from Assignment #1
Feb 7	Workshop on Technical Writing and Presentations Continue Algae Growth Studies	Present 1-2 slides on: How does a Spectrophotometer work?	Assignment #2: (Due 2/14/11) Writing Style and References
Feb 14	Data Analysis Workshop		Assignment #3: (Due 2/21/11) Data analysis
Feb 21	Measurement of Suspended Solids for Determining Algae Growth	Present Literature Review	
Feb 28	**Outside Speaker Presentation- Biofuels (1 hour)**	Present on Algae growth specific to the species assigned	
Mar 7	**Midterm Exam**		
Mar 21	Gas Transfer Fundamentals –CO_2 transfer	Present Algae Growth Data	Assignment #4: (Due 3/28/11) Gas Transfer
Mar 28	Midterm Presentations – All Teams		Quiz on gas transfer
Apr 4	**Field Trip to LSA**		
Apr 11	Modeling Studies using POLYMATH		Assignment #5: (Due 4/18/11) Modeling
Apr 18	Measure Lipid and calculate Yield (g lipid/g algae)		
Apr 25	Finalize results and presentation Course Evaluations		
May 2	Presentations by student teams		Final Report Due – Final Exam Week

Grading:

Engineering Laboratory	15%
Individual Homework Assignments	10%
Individual Quizzes and Exam	15%
Presentations	35%
Final Report	25%

Engineering Laboratory:
Students are expected to attend all laboratory periods, as described on the course syllabus. Proper conduct and attire is expected at all times in the laboratory. Students will not be allowed entry into the laboratory without proper attire. Algae growth measurements that are taken outside of specified class times are subject to the same regulations.

Each student group will be expected to maintain a laboratory notebook. The carbon copy pages from the laboratory notebook must be submitted as an appendix to the final report. Recall that your laboratory notebook should be thorough enough that an educated person can determine who, what, when, why, and how experiments in the lab were conducted.

Presentations:
As indicated on the schedule, student groups must prepare short presentations several times throughout the semester. For these presentations, each group must prepare and submit slides. Groups will be randomly selected to present each week.

Teamwork:
Students are expected to work collaboratively on team assignments. Each team member will be evaluated by every member of the team including him/herself. The raw score will be adjusted based on these evaluations, and the adjusted score will be used in the calculation of course grades. Thus, the student who consistently demonstrates a higher lever of effort may be rewarded, whereas the student who contributes less than average effort to the team assignments will be penalized.

Important Dates:

January 18-24: Drop/Add Period
March 14-18: Spring Break (no classes)
May 3-7: Final Exam Week – Exam schedule TBA for all classes

Change of Major:
A change of major form may be obtained in the Dean's Office (1st Floor Administrative Suite in Rowan Hall). A decision will be deferred if there are courses in progress that are needed for transfer evaluation.

- Fall transfer application deadline: March 1
- Spring transfer application deadline: November 1

Withdrawing From a Course:
Forms for withdrawal are available from the Office of the Registrar's website:
http://www.rowan.edu/provost/registrar/forms.html

- Withdraw Form A (for W only) – Due on or before March 7, 2011 with the professor's signature.
- Withdraw Form B (for WP/WF) – Due on or before April 4, 2011 with the professor's signature and the Department Chairperson's signature.
- The Registrar's Office will not distribute this form **after April 4, 2011**; **it will only be available from the Dean of the College in which the course is offered**. During this time, withdrawal must be considered exceptional and may occur only with the approval of the professor, department chairperson, and college dean, and only for acceptable and sufficient reasons that are beyond the control of the student. (WP/WF remains in effect.)