Project title: Calcium Carbonate Production by Coccolithophorid Algae in Long Term,
Carbon Dioxide Sequestration

Type of Report: Quarterly Progress Report #3
Reporting Period Start Date: January 1, 2002
Reporting Period End Date: March 31, 2002

Principal Author: V. J. Fabry, Ph.D.

Date Report Was Issued: April 5, 2002

DOE Award Number: DE-FC26-01NT41132

Name and Address of Submitting Organization:

Dr. V. J. Fabry
Department of Biological Sciences
California State University San Marcos
San Marcos, CA 92096-0001

Disclaimer:

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

Abstract

Predictions of increasing levels of anthropogenic carbon dioxide (CO₂) and the specter of global warming have intensified research efforts to identify ways to sequester carbon. A number of novel avenues of research are being considered, including bioprocessing methods to promote and accelerate biosequestration of CO₂ from the environment through the growth of organisms such as coccolithophorids, which are capable of sequestering CO₂ relatively permanently.

Calcium and magnesium carbonates are currently the only proven, long-term storage reservoirs for carbon. Whereas organic carbon is readily oxidized and releases CO₂ through microbial decomposition on land and in the sea, carbonates can sequester carbon over geologic time scales. This proposal investigates the use of coccolithophorids — single-celled, marine algae that are the major global producers of calcium carbonate — to sequester CO₂ emissions from power plants. Cultivation of coccolithophorids for calcium carbonate (CaCO₃) precipitation is environmentally benign and results in a stable product with potential commercial value. Because this method of carbon sequestration does not impact natural ecosystem dynamics, it avoids controversial issues of public acceptability and legality associated with other options such as direct injection of CO₂ into the sea and ocean fertilization. Consequently, cultivation of coccolithophorids could be carried out immediately and the amount of carbon sequestered as CaCO₃ could be readily quantified. The significant advantages of this approach warrant its serious investigation. The major goals of the proposed research are to identify the growth conditions that will result in the maximum amount of CO₂ sequestration through coccolithophorid calcite production and to evaluate the costs/benefits of using coccolithophorid cultivation ponds to abate CO₂ emissions from power plants.

Table of Contents

	Page Number
Title Page	1
Disclaimer	2
Abstract	3
Table of Contents	4
Introduction	5
Experimental	5
Results and Discussion	5
Conclusion	6
References	6

Introduction

The objective of this project is to determine the efficacy of using coccolithophorid CaCO_3 production in CO_2 removal technology. This project will determine the methods and biological and chemical conditions needed to optimize the native ability of coccolithophorid algae to sequester CO_2 in the form of CaCO_3 . The initial task of the research is to identify the species, cell strain and the specific growth conditions (e.g., temperature, light intensity, nutrient concentrations) that maximize population growth rates and rates of calcification.

Experimental

We have now measured the growth rates of 5 cell lines of the coccolithophorid *Emiliana huxleyi*, one cell line of coccolithophorid *Gephyrocapsa oceanica*, and one cell line of *Pleurochrysis carterae* in 4 to 6 different growth media with various chemical forms and concentrations of nitrogen, phosphorus, trace metal, and chelator enrichments. In other experiments, we measured the effects of selenium enrichment on cell growth rate.

In preparation of Phase II of the project in which we quantify the amount of dissolved CO_2 sequestered through coccolithophorid calcification, we have started the manufacture of a custom-made experimental vessel and have begun to develop the data acquisition program needed to measure the effects of coccolithophorid calcification on the CO_2 system parameters.

Results and Discussion

We identified one cell line of *Emiliana huxleyi* (CCMP371) that grows rapidly and calcifies well in media with both ammonia and nitrate as nitrogen sources, organic phosphate (as opposed to inorganic phosphate), and high concentrations of chelator which likely increases the bioavailability of the trace metals. When grown under these conditions, cells typically exhibit multiple layers of calcified coccoliths and reach stationary phase in 8-10 days. Thus, the experimental results on cell line CCMP371 indicate that this cell line of *Emiliana huxleyi* has a higher cell growth rate and greater calcification in K medium (Keller *et al.*, 1987) compared with F/50 growth medium (Guillard, 1975). Our next task is to determine the light intensity which optimizes calcification in CCMP371.

Our results to date indicate that, in some cell lines, the addition of selenium significantly increases cell growth rate. However, in contrast to the results reported by Danbara and Shiraiwa (1999), not all cell lines appear to respond in the same manner. Further experiments are currently in progress to determine whether selenium-enrichment can be used to optimize cell growth and/or calcification.

Conclusion

We continue to make progress on determining the specific growth conditions that maximize cell growth and calcification in selected cell lines of different species of coccolithophorids. We have identified one cell line of *Emiliana huxleyi* as a good candidate for carbon sequestration technologies, and have determined the growth media which maximizes its growth and calcification. We continue to investigate the hypothesis that selenium is required for cell growth of coccolithophorids as suggested by Danbara and Shiraiwa (1999). Finally, we have initiated tasks in preparation for work in Phase II of the project.

References

- Danbara, A. and Shiraiwa, Y. (1999) The requirement of selenium for the growth of marine coccolithophorids, *Emiliana huxleyi*, *Gephyrocapsa oceanica* and *Helladosphaera* sp. (Prymnesiophyceae). *Plant Cell Physiol.* 40(7): 762-766.
- Guillard, R.R. I. (1975) In: Smith, W. H., and Chanley, M. H., eds. *Culture of Marine Invertebrate Animals*. Plenum Press: New York. 726 pp.
- Keller, M. D., Selvin, R. C., Claus, W. and Guillard, R. R. I. (1987) *Journal of Phycology*. 23: 633-638.