

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

Type of Report: Quarterly Progress Report #4

Reporting Period Start Date: April 1, 2002

Reporting Period End Date: June 30, 2002

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Date Report Was Issued: July 9, 2002

DOE Award Number: DE-FC26-01NT41132

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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.

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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 . This project will identify the parameters necessary to produce coccolithophorid blooms and the factors required to for maximum calcification rates. The information gained in this study can be incorporated into the design and construction of future algal ponds or bioreactors in follow-up research (not a part of this project) on CO_2 sequestration by coccolithophorids. 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 continue to maintain and conduct experiments with 5 cell lines of the coccolithophorid *Emiliania huxleyi*, one cell line of *Gephyrocapsa oceanica*, and one cell line of *Pleurochrysis carterae*. Our results indicate that growth rates and degree of calcification vary widely among cell lines and species.

Previously conducted experiments investigating the effects of selenium enrichment on cell growth rate produced mixed results, with some species and/or cell lines showing marked increases in growth rates and others exhibiting no response. These experiments are currently being repeated.

Results and Discussion

Cell growth experiments in different media. Owing to the variability among cell lines and species, we are trying to obtain additional cell lines from laboratories in the United Kingdom and France. In the weeks/months ahead, we hope to receive some additional cultures. We will determine growth rates of any new cultures in the growth media (i.e., media K (Keller et al., 1987), which contains nitrogen in the form of nitrate and ammonium, high concentrations of chelator, and organic phosphate). This combination of nutrients and trace metals yielded the highest growth rate for CCMP 371.

Selenium addition experiments. Results to date indicate that the addition of selenium increases the cell growth rate and significantly increases the maximum cell density achievable in batch cultures by 0.5 to 1 order of magnitude. Additional experiments are currently in progress to determine whether selenium-enrichment also optimizes calcification and/or enhances the output of calcified coccoliths.

Methods development. Methods development for the accurate measurement of calcification at different population growth stages and over a range of cell densities has

been completed. In addition, we designed and fabricated an experimental vessel that will be used to monitor the CO₂ system parameters in a suite of experiments investigating the net removal of CO₂ by coccolithophorids as a function of various environmental conditions (different nutrient loadings, levels of dissolved inorganic carbon, and bioavailability of calcium from weathered, waste concrete).

Conclusion

Because of the wide variability in different cell strains of the same species, we are working to obtain other cell lines in addition to the 6 calcifying lines that we already maintain. Selenium enhancement experiments indicate that, in some cell lines, the addition of selenium increases the cell growth rate and the maximum cell density obtained in batch cultures. Future work is needed to determine whether the addition of selenium also increases calcification. In preparation for experimental work described in Task 2.0, we have completed methods development for the accurate measurement of calcification at different population growth stages and over a range of cell densities.

References

Keller, M. D., Selvin, R. C., Claus, W. and Guillard, R. R. I. (1987) Journal of Phycology. 23: 633-638.