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

Type of Report: Quarterly Progress Report #1
Reporting Period Start Date: May 1, 2001
Reporting Period End Date: September 1, 2001

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Date Report Was Issued: September 10, 2001

DOE Award Number: DE-FC26-01NT41132

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Abstract

Predictions of increasing levels of anthropogenic carbon dioxide (CO_2) 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 CO_2 from the environment through the growth of organisms such as coccolithophorids, which are capable of sequestering CO_2 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 CO_2 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 CO_2 emissions from power plants. Cultivation of coccolithophorids for calcium carbonate ($CaCO_3$) 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 CO_2 into the sea and ocean fertilization. Consequently, cultivation of coccolithophorids could be carried out immediately and the amount of carbon sequestered as $CaCO_3$ 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 CO_2 sequestration through coccolithophorid calcite production and to evaluate the costs/benefits of using coccolithophorid cultivation ponds to abate CO_2 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 $CaCO_3$. The initial task of the research, which has been initiated, 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. Different coccolithophorid species (including the bloom-forming species, *Emiliania huxleyi* and *Gephyracapsa oceanica*, and large-celled and low salinity tolerant *Pleurochrysis carterae*) will be tested to determine which species and, if appropriate, cell line, has the maximum growth rate under specified conditions.

Experimental

We have obtained four cell lines of the coccolithophorid *Emiliania huxleyi,* one cell line of the coccolithophorid *Gephyracapsa oceanica*, and one cell line of the coccolithophorid *Pleurochrysis carterae.* All six cell lines calcify. We are trying to obtain additional cell lines of these species from laboratories in the United Kingdom and France. We are currently conducting experiments to determine which growth media yields the highest growth rate for each of the cell lines. These experiments involve using different nitrogen sources (nitrate alone, ammonia alone, or both nitrate and ammonia), different concentrations of nitrogen, and different concentrations of trace elements. In addition, we are using these cell lines to test the hypothesis that coccolithophorids have an absolute requirement for selenium, as reported in the literature (Danbara and Shiraiwa, 1999).

Results and Discussion

Our results to date are equivocal, with some cell lines showing dramatic increases in cell growth rates when selenium is added to the media and others displaying no difference. These results are preliminary, however, and require further investigation.

We are in the final stages of testing our methods to accurately measure calcification rates in coccolithophorids. Our data indicate that different methods must be used depending on 1) the population growth stage and concentration of discarded coccoliths in the water, 2) the cell density, and 3) the calcification rate of the cells.

Plans for the next six months include:

- Completion of experiments to test methodology for the accurate measurement of calcification rates;
- Continue experiments to determine if the addition of selenium enhances cell growth rates;

- Determine the nitrogen source and concentration in growth media that provides the highest rates of growth in the three species and various cell lines of *Emiliania huxleyi;*
- Initiate experiments to investigate the effects of different phosphorus loadings on coccolithophorid growth rates; and
- Try to obtain additional cell lines of coccolithophorids and conduct experiments with these strains to determine conditions for optimal growth.

Conclusion

During this initial period, we have acquired six cell lines of three different species of coccolithophorids. All six cell lines consist of calcifying cells. We have begun experiments to determine which growth media yields the fastest growth rate for each of the cell lines. We have focused on the effects of different nitrogen sources and total nitrogen concentrations and different concentrations of trace elements. A second thrust of our work has involved testing various methods to accurately measure calcification rates in coccolithophorids. In summary, the project is off to a good start and a plan of work for the next quarter has been developed.

References

Danbara, A. and Shiraiwa, Y. (1999) The requirement of selenium for the growth of marine coccolithophorids, *Emiliania huxleyi*, *Gephyrocapsa oceanica* and *Helladosphaera* sp. (Prymnesiophyceae). Plant Cell Physiol. 40(7): 762-766.