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Carbon Dioxide Sequestration

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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 obtain maximum calcification rates. 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. The second task of the project is to quantify the amount of CO_2 sequestration by coccolithophorids when cells are grown under high-calcifying conditions in a custom-manufactured experimental vessel. We began Task 2 and described our preliminary results in the last report. Herein we present the remainder of the analyses including the total dissolved inorganic carbon and total alkalinity data.

Experimental

We have completed analysis of samples taken from our first closed vessel experiment that was described in the last quarterly report. In the experiment, we inoculated 7 liters of F/50 media with a small volume of *Emiliana huxleyi* cell strain CCMP 371. The culture was stirred continuously to keep cells uniformly suspended. This vessel was placed in a temperature- and light-controlled environmental chamber. The temperature during the experiment was 18.5 °C and the light/dark cycle was 16 hours light/8hours dark.

Previously, we reported on the changes in ambient seawater pH as a function of cell density over the 26-day experiment. We now have the all the data from this experiment which investigates the impacts of coccolithophorid growth on the CO_2 system parameters. Total alkalinity (TA) was determined using our own software. Total dissolved inorganic carbon in duplicate samples was measured using coulometry (Dickson and Goyet, 1995). Cell densities were determined daily by direct count.

During this report period, we also modified our artificial seawater formula and media preparation technique to increase the initial total alkalinity and available dissolved inorganic carbon.

Results and Discussion

Results of the first 19 days of the experiment are graphically illustrated in Figure 1. Population cell growth showed the expected exponential growth curve including logarithmic and stationary phases. Total alkalinity (TA) and total dissolved inorganic carbon (DIC) changed with population growth of *E. huxleyi*. As shown in Figure 1, the DIC steadily declines with increasing cell numbers. The TA decreases with increased cell density until about Day 8. This decrease is due to the precipitation of calcium

carbonate by the growing population of *E. huxleyi* cells. The increase in TA on and after Day 8 is likely due to dissolution of coccoliths in the preserved subsamples prior to analysis and is not thought to have occurred in the experimental vessel. Sampling and preserving protocols have been modified to reduce or eliminate this effect.

Conclusion

All data from our first closed-vessel experiment with *E. huxleyi* has now been analyzed. The data acquisition programs that we developed for this project worked well and enabled us to continuously monitor temperature and electromotive force (EMF in mV). In addition, subsamples were taken for total alkalinity and total dissolved inorganic carbon analyses. This first run of our equipment, software, and methods was successful and enables us to move forward to conduct the suite of experiments described in Task 2.

References

Dickson, A. G. and Goyet, C. (1994) *Handbook of Methods for the Analysis of the Various Parameters of the Carbon Dioxide System in Sea Water*. U.S. Department of Energy.

Fig. 1. Changes in cell density (pink line), total alkalinity (blue line), and total dissolved inorganic carbon (orange line) over the first 19 days of a closed vessel experiment.