Calciﬁcation and transparent exopolymer particles (TEP) production in batch cultures of Emiliania huxleyi exposed to different pCO2

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INTRODUCTION

Coccolithophores, among which Emiliania huxleyi (Ehux) (Figure 1), is the most abundant and widespread species, are considered to be the most productive calcifying organism on Earth. They play a key role in the marine carbon cycle because of their calcite production (in the form of coccoliths) and their subsequent sinking to the ocean floor. Like other phytoplanktonic species, the coccolithophores produce transparent exopolymer particles (TEP) (Figure 2) that promote the aggregation of biogenic particles produced in surface oceans, and therefore contribute to the export of carbon to deep waters.

RESULTS

Phytoplankton growth

The evolution in chlorophyll a (chl a) concentrations, indicative of Ehux growth, during the culture experiments is shown in Figure 3. The pH drop observed lead to a higher biomass. The time lag observed for the onset of the Ehux growth may be partially related to the time necessary for the initial pCO2 to equilibrate with the ambient pCO2. The cells were not pre-adapted to the initial pCO2 conditions.

Calcification

The accumulation of calcite was calculated using the alkalinity anomaly technique (Figure 4). The initial pCO2 decreases due to the consumption of CO32- ions by calcification. Near the end of the experiment, the net calcification slows down; when ωcalcite falls below 1, dissolution can take place. For the first and the second experiments, the calcification kicks off when ωcalcite is around 3 close to initial value, which slows down when it falls below 2. For the third culture, ωcalcite increases first until 3, due to degassing and primary production, before the onset of calcification. It appears that 3 is a key value below which the calcification is hampered in this species.

CONCLUSIONS

Ehux growth, calcification and related processes are sensitive to changes in initial pCO2. Our results show that the development of the Ehux cultures is delayed with increasing initial pCO2. TEP accumulate until the end of the experiment and are enhanced after nutrient exhaustion. TEP contribute significantly to POC and calcite production during the exponential growth phase. The very good correlation between TEP and calcite concentrations suggests that the calcification acts as a potential source of TEP in coccolithophore blooms. Finally, an ωcalcite of 3 seems to be necessary for Ehux to calcify.

MATERIAL AND METHODS

Three laboratory batch experiments (each in duplicate) were conducted with monospeciﬁc cultures of Ehux exposed to different initial pCO2 at a temperature of 13°C. The pCO2 was not controlled and was let to evolve in these experiments. Cultures were grown in sterilized ﬁltered seawater enriched with nitrate and phosphate (Table 1). Incident irradiance was 150 µmol m-2 s-1. A dark/light cycle was 14h/10h for the three cultures. Various parameters related to primary production and calcification (Fluorescence and turbidity, chlorophyll a, particulate inorganic carbon, particulate organic carbon) were followed.

Table 1: Initial parameters for the 3 batch culture experiments.

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<thead>
<tr>
<th>Initial parameters</th>
<th>Culture 1</th>
<th>Culture 2</th>
<th>Culture 3</th>
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<tr>
<td>pCO2 (µatm)</td>
<td>490</td>
<td>630</td>
<td>930</td>
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<tr>
<td>Initial volume</td>
<td>2</td>
<td>8</td>
<td>8</td>
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<tr>
<td>NO3 (µM)</td>
<td>92/µg L-1</td>
<td>92/µg L-1</td>
<td>92/µg L-1</td>
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<td>P04 (µM)</td>
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REFERENCES


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Figure 1: SEM images of Ehux for the second experiments at an initial pCO2 of 630 µatm. (Courtesy of N. Van Oostende, UNIV LIBRE DE BRUXELLES, Laboratoire d’Océanographie Chimique et Géochimie des Eaux)

Figure 2: Microscopic view of a large web-like TEP stained with Alcan Blue.

Figure 3: Evolution of the chl a concentrations.

Figure 4: Evolution of the calcite concentrations.

Figure 5: Evolution of the TEP concentrations.

Figure 6: POC in relation to TEP concentrations after nutrient exhaustion. (Initial pCO2 of 630 µatm.)

Figure 7: TEP concentrations in relation to POC for the second experiment at an initial pCO2 of 630 µatm, solid squares and ωcalcite=1, open squares.

Figure 8: Calcification in relation to calcite saturation state for each experiment. Initial pCO2 of 490 ppmV (solid squares), 630 ppmV (open squares) and 930 ppmV (solid triangles).

Figure 9: Evolution of the calcite concentrations.

Figure 10: TEP production

Figure 11: Calcification and the saturation state with respect to calcite (ωcalcite).