Oxygen and the photodissolution of shallow coastal suspended sediments and phytoplankton detritus

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Background

- River delta sediments account for ~44% of organic carbon (OC) buried in marine sediments, globally. (Hedges and Keil 1995). (A, upper right)
- However, deltaic sediments have lower surface-area normalized OC loadings than suspended riverine and non-deltaic shelf sediments (Keil et al 1997). (B, middle right)
- "Photodissolution" of POC from resuspended deltaic sediments is one hypothesis consistent with their relatively lower OC loadings (Mayer et al 2006). (C, lower right)
- 25-40% of POC is dissolved during laboratory irradiations. Typically, 5% is not detected as DOC.

Questions

- Is photodissolution reversible, once particles settle out of the surface water (right side of schematic, below)?
- Is photodissolved POC photooxidized, as is dissolved organic carbon (left side of schematic)?

What are impacts on O2 and nitrogen forms during photodissolution?

Results and Discussion

- Sediments at reasonable field levels after 24 h of irradiation were depletions of O2. For suspensions with the highest initial POC concentrations (algae, 100 mg/L), O2 levels after 24 h of irradiation were below detection.
- For both algal membrane and Atchafalaya Bay bottom sediments, the photodissolution of POC consumed O2 at a molar ratio (C:O2) of about 3:1. This is consistent with the remobilization of 5% of total organic carbon not accounted for after irradiation.
- The EHAA fraction of THAA decreased during pre-irradiation algal decay. Irradiation then increased access of enzymes to THAA, suggesting that the initial drop was due to protein "encapsulation" by protective material or cross-linking that is especially sensitive to irradiation under O2.

Conclusions

- O2 is involved, when present, in the photodissolution of POC from suspended sediments.
- O2 is likely required for the photodissolution of fresh algal phytoplankton.
- The C:O2 molar loss ratio is about 3:1, consistent with photo-oxidation of the fraction of photodissolved POC not detected as DOC.
- Irradiation may accelerate N cycling, via enhanced hydrolysis and photoammonification.

Study Area and Experimental Design

- Suspensions of Atchafalaya bottom sediments and freeze-dried algae (Tetraselmis spp., membrane fraction) made up in carbon-free artificial seawater.
- Replicate suspensions were irradiated in a solar simulator or kept in the dark as non-irradiated controls, all at room temperature.
- Suspensions were analyzed for POC, DOC, and dissolved O2 before and after irradiation.
- To test for effects of microbial degradation followed by irradiation, additional Tetraselmis membrane samples were allowed to decay for periods of 2 weeks and 2 months prior to irradiation and analysis as described above. Additional analyses for DON, PN, total acid- and enzymatically-hydrolyzable amino acids (THAA and EHAA, NOx, and NH4) were carried out on these samples.

References


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