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Formation and Distribution of Marine Biogenic Halocarbons with Emphasis on Polar Regions

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Akademisk avhandling för filosofie doktorsexamen i kemi, som med tillstånd från Naturvetenskapliga fakulteten kommer att offentligt försvaras fredagen den 9:e november 2012 kl. 10.15 i föreläsningssal KB, Institutionen för kemi och molekylärbiologi, Kemigården 4, Göteborg.

ISBN: 978-91-628-8545-8

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Abstract

It is well-established that marine micro- and macroalgae form volatile halogenated compounds (halocarbons). Production occurs throughout the world ocean with strong regional sources in coastal areas. In the atmosphere, these compounds are converted to reactive inorganic halogen compounds, which degrade ozone. Biogenic halocarbons typically contain iodine or bromine, which have higher ozone depletion potentials than chlorine.

The main pathway of halocarbon formation involves haloperoxidases, which reduce hydrogen peroxide, formed during photosynthesis, by oxidation of halide ions. Therefore, this is a universal process in the oceans, but there are large spatial and temporal variations. Estimations of the oceanic source of these compounds rely on accurate assessments of production and degradation rates, as well as on air-sea flux calculations.

In this work, the distribution of biogenic halocarbons in the ice-covered central Arctic Ocean, and in the Pacific sector of the Southern Ocean, was investigated. Elevated concentrations were found under the sea ice, and even higher concentration in the ice. The production, attributed to sea ice algae, was highly variable. Degradation was also observed with half-lives of as short as 1 day. Production was also found in snow, which could be attributed to biological activity. The studies were performed in a period when the sea ice was melting, and low nutrient levels indicated that a previous bloom had now been followed by heterotrophic activity. The fast degradation, presumably biotic since known abiotic reactions are much slower, showed the importance of this parameter when studying natural populations, as compared to culture studies.

The highest concentrations in surface water and sea ice brine in the Arctic Ocean coincided with high concentrations of dissolved organic matter (DOM) carried by river water from the Russian rivers. It was hypothesized that this is a key parameter for the production of halocarbons in this region, as an organic substrate is needed for halocarbon production.

In the Southern Ocean it was found that large regions may act as a sink for bromoform. This was highly dependent on the wind direction. When air was transported from coastal regions, under-saturation was measured in open ocean regimes. This has implications for the estimation of local sources to the atmosphere in the Southern Ocean, as the net air-sea flux may be lower due to these nearby sinks.

Keywords: volatile biogenic halocarbons, Arctic Ocean, Southern Ocean, sea-ice, snow, air-sea exchange, cyanobacteria

ISBN: 978-91-628-8545-8