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Amino acids, carbohydrates and lipids in the tropical oligotrophic Atlantic Ocean: Sea-to-air transfer and atmospheric in situ formation

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Carbohydrates, amino acids, and lipids are important contributors to organic carbon (OC) in the marine environment. To study their sea-to-air transfer, including their enrichment in the sea surface microlayer (SML), potential atmospheric in situ formation or degradation, and their oceanic contribution to the ambient marine aerosol particles, we provide measurements from the tropical Atlantic Ocean at the Cape Verde Atmospheric Observatory (CVAO) where the above compounds were investigated in both surface seawater and in ambient submicron aerosol particles.

In bulk seawater and the SML, similar distributions among species were found for the lipids and carbohydrates with moderate SML enrichments (enrichment factor EF_{SML} = 1.3 ± 0.2 and 1.1 ± 0.5 respectively). In contrast, the amino acids exhibited a higher enrichment in the SML with an average EF_{SML} of 2.3 ± 0.4 although they are less surface-active than lipids. The same compounds studied in the seawater were found on the ambient submicron aerosol particles whereas the lipids were more pronounced enriched ($EF_{aer.}$ = $1.6x10^5$) compared to the amino acids and carbohydrates ($EF_{aer.}$ = $1.5x10^3$ and $1.3x10^3$ respectively), likely due to their high surface activity and/or the lipophilic character. Detailed molecular analysis of the seawater and aerosol particles revealed changes in the relative abundance of the individual organic compounds. They were most pronounced for the amino acids and are likely related to an in situ atmospheric processing by biotic and/or abiotic reactions.

On average 49% of the OC on the aerosol particles (97 ng m^{-3}) could be attributed to the specific components or component groups investigated in this study. The majority (43%) was composed of lipids. Amines, oxalic acid, and carbonyls, comprised an OC fraction of around 6%. Carbohydrates and amino acids made up less than 1% of the OC. This shows that carbohydrates, at least when resolved via molecular measurements of single sugars, do not comprise a very large fraction of OC on marine aerosol particles, in contrast to other studies. However, carbohydrate-like compounds are also present in the high lipid fraction (e.g., as glycolipids), but their chemical composition could not be revealed by the measurements performed here.

Since the identified compounds constituted about 50% of the OC and belong to the rather short-lived biogenic material probably originating from the surface ocean, a pronounced coupling between ocean and atmosphere was indicated for this oligotrophic region. The remaining, non-identified OC fraction might in part contain recalcitrant OC, however, this fraction does not constitute the vast majority of OC in the aerosol particles here investigated.

The study contributes to the international SOLAS program.

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