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Extracellular macromolecules in sea-ice: Effects on sea-ice structure and their implications

M. Ewert (1) and M. Bayer-Giraldi (2)

(1) School of Oceanography, University of Washington, Seattle, USA, (2) Alfred Wegener Institute (AWI), Bremerhaven, Germany (maddalena.bayer@awi.de)

Brine inclusions within sea-ice offer a favorable environment for certain marine microorganisms which live and thrive within the ice. These assemblages are a crucial element in the polar ecosystem. Partly entrained by ice platelets into the ice sheet, microorganisms closely interact with the liquid and solid phases of this porous environment (brine and ice), likely influencing their properties. Extracellular polysaccharide substances (EPS) and antifreeze proteins (AFP) have been identified as major elements with the potential to affect ice structure and processes, due to their capability to interact with ice crystals (selected planes in the case of AFPs) and with water molecules and salt ions present in the brine. EPS present in sea water can be selectively retained in the ice during ice formation, with implications for ice structure. Likewise, EPS and AFP released by sea-ice organisms would have a local effect, altering the microenvironment for the benefit of the organism. Macroscopic and microscopic observations showed effects on ice microstructure and a possible increase in brine fraction within the ice caused by AFPs and EPS, implicating changes in ice porosity and permeability.

In the following we describe some of the interactions between sea-ice macromolecules, EPS and AFP, and the sea-ice system. We show their influence in ice structure, and discuss probable implications and consequences for microbial survival, distribution of dissolved material between sea-ice and the water column, and possible effects on the seasonal evolution of the ice. All of these could be relevant to the understanding of biogeochemical processes and the limits of habitability, as well as suggest possible applications of these substances.