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(G*) POS-C12 – Studies of seawater spray icing phenomena with unilateral NMR

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Sea spray icing is created by wind/wave-induced spray in harsh arctic and antarctic environments. It is reported that sea spray icing causes hazardous conditions and operational problems for vessels and offshore structures. Nuclear Magnetic Resonance (NMR) is a powerful tool that can provide information about local environment, diffusion, and structure of a sample containing NMR-sensitive nuclei. NMR studies of sea ice are well-known for investigating seawater brine properties and structure. However, typical NMR instruments are big, expensive, and they cannot be moved outside a scientific laboratory. Also, seaspray icing hasn't been studied with NMR until very recently (Wilbur et al, JMR, 2020). This study was focused on how to measure freezing of a sea-water spray with a portable, unilateral NMR instrument consisting of a handheld 3-magnet array.

For our instrument, the 1H NMR signal was generated approx. 1 cm away from the magnet surface, in the presence of a constant 250 G/cm magnetic field gradient. The pulse sequence used in this study was a combination of the Hahn and CPMG sequences (the CPMG echoes could be either added to increase the SNR, or used for obtaining T2 information). An optimum quality factor for a desired slice thickness was chosen to increase the sensitive volume. Additionally, we explored 1D-imaging with a unilateral NMR by performing Fourier Transform of the echoes acquired in the presence of the constant gradient.

The following parameters of NMR signal from freezing seawater accumulating on a cold surface inside the sensitive volume were measured and analyzed: signal intensity (proportional to the brine concentration), T2 relaxation, and diffusion for a range of temperatures (from-6oCto-14oC) and for two different surface orientations (horizontal and vertical). Results showed differences in signal intensity caused by ice growth rates at different temperatures. The diffusion was highly dependent on temperatures and surface orientations. This study shows that portable NMR devices can be useful for studies of seawater freezing, and freezing in general.

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