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Interfacial premelting of ice in nanocomposite materials

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Material properties of ground ice and permafrost strongly depend on the molecular scale structure and dynamics of the quasi-liquid premelting layer (qll) formed at ice/solid interfaces. Already in 1859, Faraday proposed the existence of a qll at ice surfaces. However, despite the extensive amount of research devoted to the understanding of interfacial ice melting, the structure of the qll adjacent to solids is still under debate. Layered sheet silicates with high interface to volume ratios such as vermiculite or kaolin are ideal model systems to study the interfacial melting of ice in geologically relevant materials. We employed high-energy x-ray diffraction (HEXRD) to measure the temperature dependence of the crystalline ice fraction in these ice/clay composites. Well below the melting point of bulk water, the formation of a qll was observed. The thickness of this qll is gradually increasing with temperature. Pronounced differences in the growth law are observed between the charged vermiculite and uncharged kaolin minerals. For higher temperatures, the qll thickness is compared with theoretical predictions from continuum models. The data is best described by a logarithmic growth law, originating from short range interactions.

Significance statement

Using well defined and characterized ice/clay nano composite samples, this work bridges the gap between studies on single crystalline ice/solid model interfaces and naturally occurring soils and permafrost.

Primary author: Dr LI, Hailong (Max Planck Institute for Polymer Research)

Co-authors: Dr DIPPEL, Ann-Christin (PETRAIII, DESY); Mr WEISS, Henning (Max Planck Institute for Polymer Research); Mr MARS, Julian (Max Planck Institute for Polymer Research); Prof. MEZGER, Markus (Max Planck Institute for Polymer Research); Mr GUTOWSKI, Olof (PETRAIII, DESY); Dr HONKIMÄKI, Veijo (ESRF-The European Synchrotron)

Presenter: Dr LI, Hailong (Max Planck Institute for Polymer Research)

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