Self-polarizing molecular films; confined electric fields in ices

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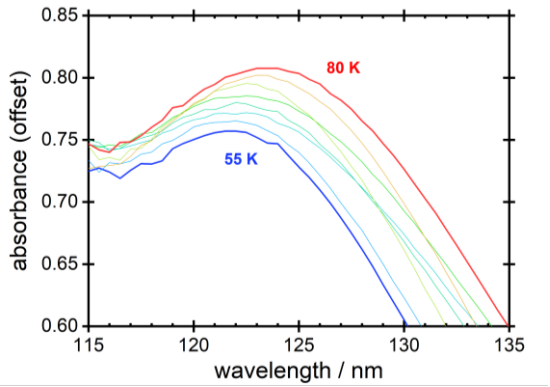
Spontaneous electric fields develop in condensing films of dipolar molecules.[a] The electric fields arise from the concerted orientation of molecular dipoles throughout the film. The 2D geometry of the film orients the electric fields, such that they lie parallel to the substrate normal. There are no macroscopic electric fields in the plane of the film. These electric fields manifest as a polarization charge at the film-vacuum interface and can be detected, as will be shown here, via a Stark effect in the spectroscopic signature of the film in the vacuum ultraviolet range. Data were collected at the AUUVices end station attached to the ASTRID2 synchrotron at Aarhus.

Research in our laboratory has focused on condensed films of small dipolar molecules including ammonia, methanol, carbon monoxide and water ice. All these species produce nanoscale molecular films that can harbour electric fields up to 10^8 V m^{-1}. This contribution will focus on recent results for water ice, in the context of the role of water ice as the reservoir from which chemical complexity is derived in the interstellar medium,[b] and expand to demonstrate how measurements of electric field strength can be used to follow the dynamics of molecular rotation in condensed molecular solids.



The vacuum ultra-violet spectrum of solid ammonia is Stark-shifted to the red as the film is condensed at increasingly higher temperatures, indicating a temperature dependent electric field.

References:

[a]Cassidy, A.; McCoustra, M. R. S.; Field, D. A Spontaneously Electrical State of Matter. Acc. Chem. Res, 2023, 56, 1909-1919. https://doi.org/10.1021/acs.accounts.3c00094
[b]James, R. L.; Pijpers, F. P.; Borchert, L.; Field, D.; Cassidy, A. Spontaneously polarised crystalline water ice. Nanoscale, *accepted.*