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Are Water-in-Oil-Emulsions Suitable Model Systems for Cloud Glaciation?

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The technique of studying aqueous solutions emulsified in oil matrices is widely used in the scientific community as a model system for aqueous droplets in the atmosphere, e.g., in the context of ice nucleation and cloud glaciation. These studies are based on the assumption that the interaction between aqueous and oil phase is negligible.

In this study we critically test the validity of this assumption by systematically varying the parameters of the emulsification procedure for the study of the freezing behaviour of dilute and concentrated solutions of organic acids, e.g., citric acid, and inorganic salts, e.g., ammonium sulphate. In particular we vary the type of oil, the type of surfactant, the water to oil ratio, the mixing time and the temperature, at which the emulsion is prepared.

These emulsions are studied in the context of cloud glaciation by cooling to < 150 K and reheating to ambient temperature. We specifically check for the droplets sizes and distribution as well as imperfectly emulsified regions from optical microscopy observations, first and second freezing events, cold-crystallization upon heating, melting events and possible glass-transitions from differential scanning calorimetry experiments as well as for the phase mixtures and types of ice (cubic vs. hexagonal) formed by powder X-ray diffraction as a function of temperature.

The results clearly show that not all emulsions behave alike in these experiments and that it is important to be aware about the possibility of the oil matrix interfering with the experiment, e.g., for oils that vitrify at atmospherically relevant temperatures.