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Temperature Dependent Refractive Indices of Formic Acid Aerosols

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Formic acid (HCOOH) is the most abundant trace gas organic acid in the atmosphere, resulting from oxidation or photochemical processing of alkanes from biogenic and anthropogenic sources.[1] Formic acid dissolves well in water and thus contributes significantly to rain acidity in remote regions. Due to its good solubility it is believed that formic acid contributes to cloud condensation.[2] It is also considered to be a source of OH radical which is one of the most active oxidising agent in the atmosphere. Temperature dependent refractive indices of formic acid are needed for composition analysis of aerosols and interstellar ices.[3]

In this work, we present mid-infrared (IR) spectra of formic acid aerosols recorded at atmospherically relevant temperatures of 80 – 210 K, and demonstrate an efficient method to extract refractive indices from measured spectra. The spectra indicate that the spectral bands below 1800 cm-1, especially around the C=O stretch region, show strong temperature dependence. The C=O stretch band profile show interesting temperature and particle size dependence. Initial analysis indicate that the band profile may be used to characterise the phase (crystalline vs amorphous) and particle size. We will discuss possible mechanisms that produce the C=O stretch band profile.

We also present the refractive indices retrieved from IR spectra using classical damped harmonic oscillator (CDHO) model. In this model, we input the CDHO band and particle size distribution parameters to simulate the Mie scattering spectra of spherical particles, and optimise the parameters to minimise the difference between the simulated and measured spectra. We evaluate the accuracy of the method with respect to particle size and CDHO band parameters, and the errors associated with assuming the spherical shape of the formic acid aerosol particles. At the end, we compare the IR spectra of formic acid thin films to our aerosol spectra and demonstrate the advantages of using aerosols to extract refractive indices from IR spectra.

References:

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