

Direct observation of elementary steps and quasi-liquid layers on ice surfaces by advanced optical microscopy

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Ice is one of the most abundant crystals on the earth, and hence the molecular-level understanding of ice crystal surfaces holds the key to unlocking the secrets of a number of fields. We and Olympus Engineering Co., Ltd. have developed laser confocal microscopy combined with differential interference contrast microscopy (LCM-DIM), by which we succeeded in the direct visualization of 0.37-nm-thick elementary steps on ice for the first time [1]. Subsequently, the direct observations on ice basal faces revealed the various features of elementary steps [2-4].

On the other hand, we could also visualize the quasi-liquid layers (QLLs) on ice crystal surfaces [5], which are covered with thin liquid layers even below the melting point (0°C). The direct observations of QLLs revealed the appearance of two types of QLLs with different morphologies [5,6], the appearance temperatures and partial pressure of water vapor [6-8], the inducement of the formation of QLLs by strain [9], and the characteristic velocities of QLLs [10].

In addition, we also found that atmospheric acidic gas (hydrogen chloride gas) strongly induced the appearances of droplets on ice surfaces (further details will be presented in "A-AS06: Atmospheric Chemistry" session). The droplets were observed in the temperature range of -15.0 ~ -1.5°C, where no QLL appears in the absence of HCl gas [11]. The HCl induced droplets were embedded into ice crystals by growth of ice crystals [12]. These results show the possibility that ice crystals can store large amount of gas components as fluid inclusions.

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