Karlsruhe Institute of Technology

Institute of Meteorology and Climate Research (IMK)
Institute of Functional Interfaces (IFG)

D_2O adsorption on K-rich feldspar

Weijia Wang[1], Alexei Nefedov[1], Alexei Kiselev[2], Thomas Leisner[2], Christof Wöll[1]

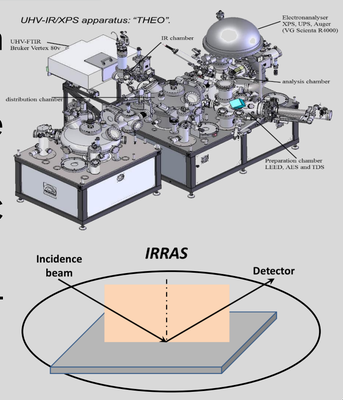
weijia.wang@kit.edu

Introduction

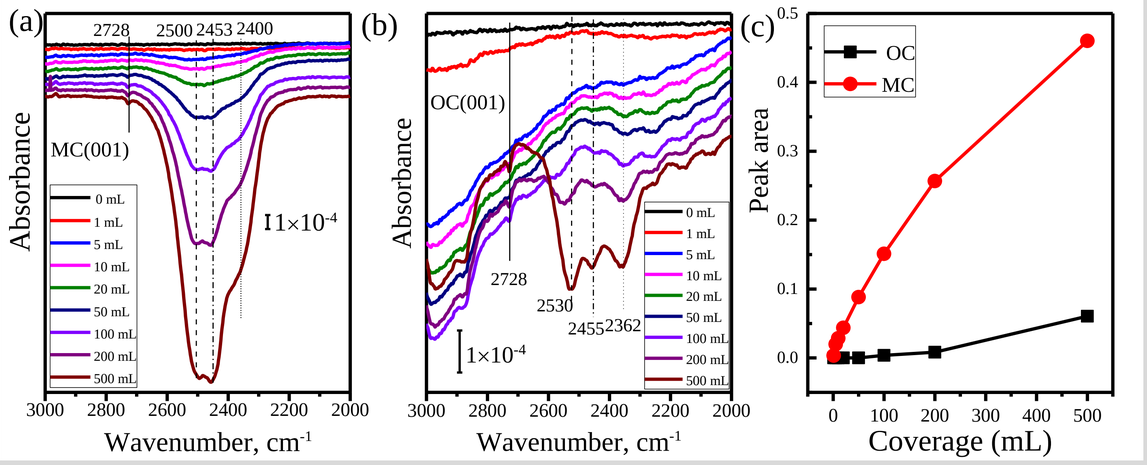
K-rich feldspar ($KAlSi_3O_8$) minerals play an important role in Earth's climate and the environmental sciences owing to its high efficiency in ice nucleation, therefore a fundamental understanding of water interaction with feldspar is absolutely necessary. Up tp now infrared (IR) spectroscopy was employed as a sensitive probe to investigate the ice structure and its bonding states, since each of crystalline as well as amorphous phases has its own distinctive vibrational spectrum with subtle differences. Here a novel UHV-FTIRS apparatus was employed to study D_2O absorption on two specific K-rich feldspar samples (orthoclase and microcline) starting from monolayer coverages up to thick water/ice multilayers. It was found that the discrepancy between orthoclase and microcline samples causes different structures and thermal behavior of the absorbed D_2O.

Experimental details

1. The K-rich feldspar samples are (Na, K)$AlSi_3O_8$ with prevailing K concentration.
2. The K-rich feldspar investigated in our experiments are microcline/orthoclase (010), (001).
3. Microcline and orthoclase are referred as MC and OC in the following context.
4. IRRAS measurements were performed in the UHV-apparatus "Theo'' with a base pressure of 10^{-10} mbar.

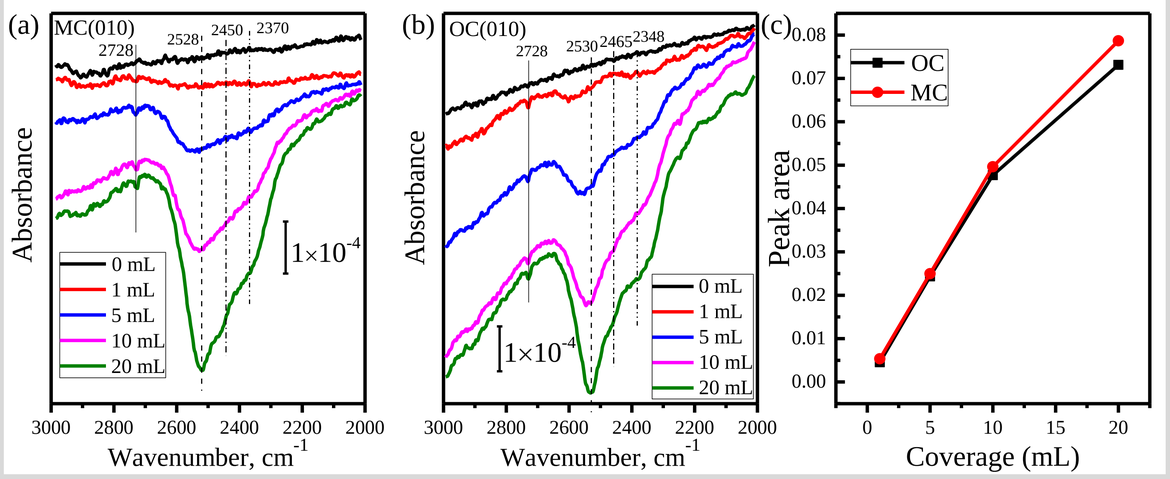


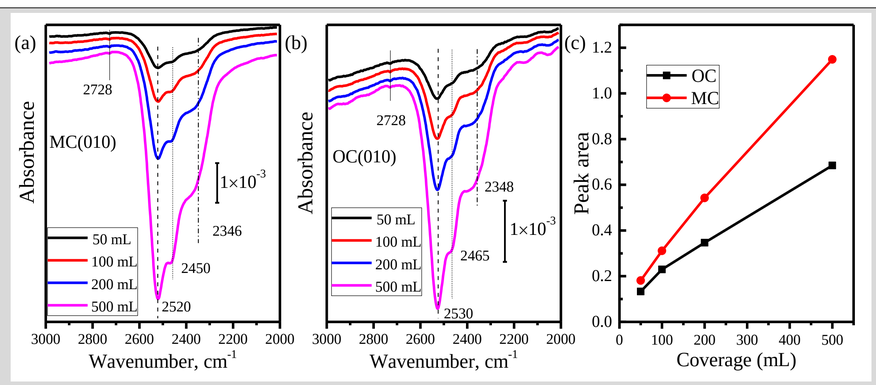
D_2O on K-rich feldspar (001) surfaces at 118 K



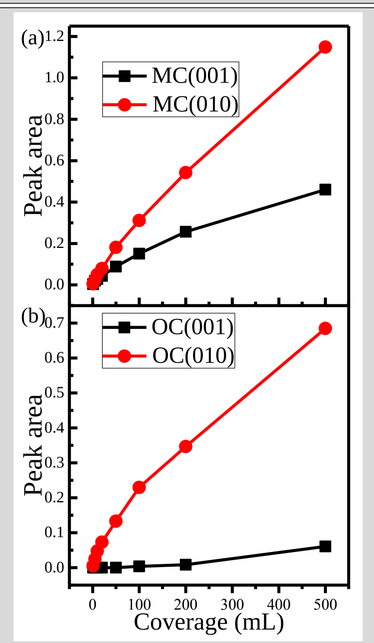
- ◆ 2728 cm^{-1}: dangling O-D band;
- ◆ 2200 - 2700 cm^{-1}: hydrogen-bonded O-D stretching vibration mode;
- ➢ The distinct line shapes of two spectra suggest D_2O adopts different structures on MC(001) and OC(001) surfaces.

D_2O on K-rich feldspar (010) surfaces at 118 K



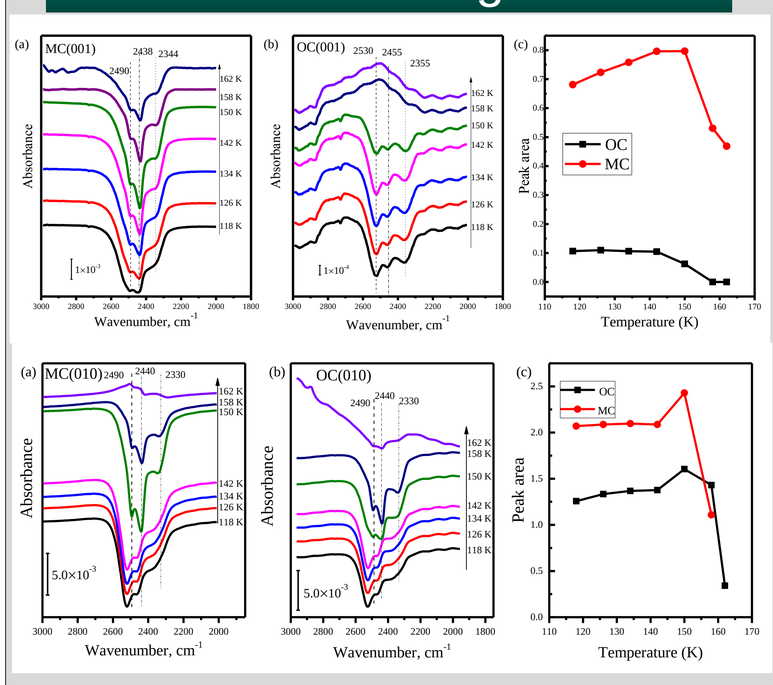


- ➢ From 1 and continuing up to 20 mL, the variation between two spectra indicates the structural differences for D_2O on MC (010) and OC (010).
- ➢ Amorphous solid ice is formed on OC and MC(010) at 118 K.



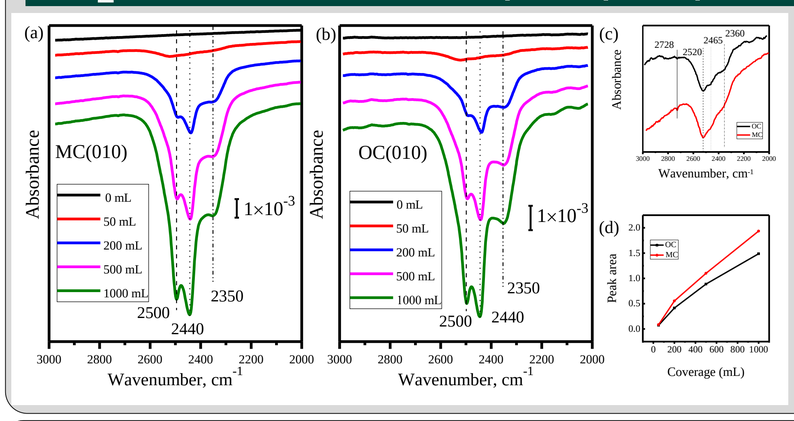
- ➢ D_2O molecules appear to have a weaker adhesion on OC surfaces compared to that of MC surfaces.

Annealing



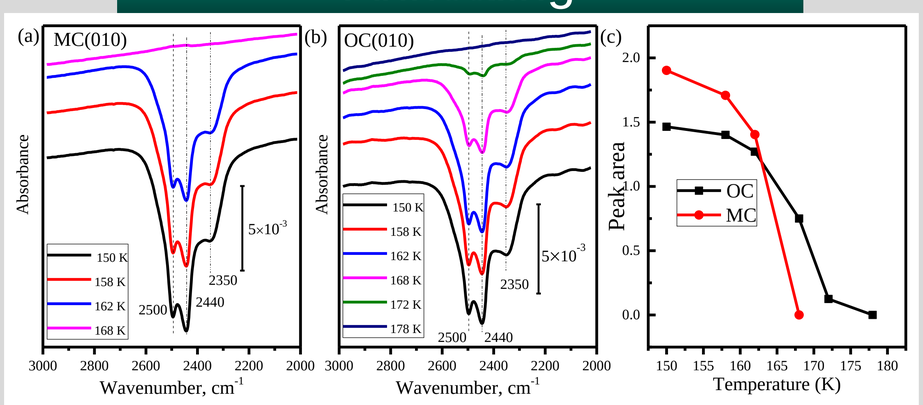
- ➢ The transition of amorphous ice towards crystalline ice occurs at ~150 K.

D_2O on K-rich feldspar (010) surfaces at 150 K



- ➢ Crystalline ice can be formed due to the sufficient mobility of water molecules at 150 K.

Annealing



Conclusions

- Growth of ice clusters at low temperatures (118 K) results in amorphous solid ice and some perturbed state of the polycrystalline reference state;
- The structural transition of amorphous ice towards crystalline ice can be monitored as the sample is annealed;
- Crystalline ice can be formed for increasing D_2O coverages on K-rich feldspar at high temperatures (150 K);
- Annealing experiments show that the structures of the crystalline ice are thermodynamically stable.

References

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