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Functional Mechanisms of Anti-Caking Agents for NaCl

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Summary

Salt-bridging experiments between single crystals of KCl and NaF, with a liquid pillar of respective aqueous solution, were performed. The KCl solution crept all over the substrate surface, and solid bridging did not occur. In the case of NaF, epitaxially grown pyramid crystals, having polar {111} sidewalls, were formed along the air/liquid/solid three-phase boundary. However, the solution dried up before the crystals were bridged. The stabilization of the polar {111} faces was in accordance with a previous experiment of micro-crystal formation at NaF(100) surface in the air. The differences with the case of NaCl were discussed. Comparison of surface energies did not explain the difference between the materials. Kinetic consideration is required.

Creeping experiments were performed with NaCl aq. and KCl aq. using glass plates soaked in the saturated aqueous solutions. Micro-crystals with random orientations were formed in the case of NaCl aq., while well-developed single crystals were formed with KCl aq. Crystal nucleation is scarce with KCl aq. However, the KCl solution crept more quickly than NaCl aq., because the solution moved smoothly on the flat crystal faces formed by the creeping. On the other hand, NaCl solution needed to travel through tiny capillaries between micro-crystals in random directions.

The differences between Na⁺ and K⁺ were discussed. The smaller ionic radius of Na⁺ gives a larger size as a hydrated ion, resulting in slower movement in the solution. On the other hand, NaCl moves more quickly at the crystal face in the presence of adsorbed water. NaCl will most probably make thicker solution layer in contact with air. The hypothesis explains the effective bridge formation between the NaCl crystals and the rapid creeping of the KCl solution.