Proportionate crystal growth

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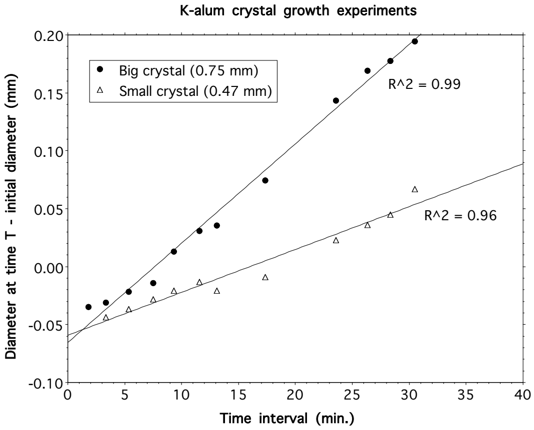
It is often assumed that crystals grow at a rate that is independent of their size (constant growth). However, it is readily shown that most crystals grow at a rate that is proportional to their diameter. This effect is demonstrated in the figure below, which depicts the result of growing initially large- and small-diameter crystals side-by-side in a flowing, supersaturated, K-alum solution. The crystal growth law for this system is:

$$X_{final} = X_{initial} + kX_{initial},$$

where X is the crystal's diameter and k is a constant (k = 0.3 for the experiment depicted).



At very small diameters (nanometer scale), a crystal experiences a heterogeneous solution during growth, and k is a random number that varies from 0 to 1. The growth equation then is termed the Law of Proportionate Effect (LPE). When iterated several times for many crystals, LPE yields the commonly observed lognormal crystal size distribution (CSD). The lognormal CSD shape then is preserved as crystals grow larger and k becomes constant.

Generally, the shapes of CSDs formed at the nanometer scale are preserved by proportionate growth as crystals grow larger. The common CSD shapes, formed during and immediately after nucleation, are the lognormal, discussed above, the asymptotic, formed by simultaneous nucleation and growth, and the universal steady-state shape (reverse skew) formed by Ostwald ripening. These three mechanisms prevail at different levels of supersaturation; therefore, CSD shapes often yield information on the initial conditions of crystallization.

Electronmicroscopic individual particle analysis of ice nuclei

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The effects of aerosol particles on heterogeneous ice formation are currently insufficiently understood. Therefore, the physicochemical identification of ice nuclei (IN) is crucial for a better understanding of formation, life cycles, and the optical properties of clouds.

During the CLACE 5 campaign in 2006 at the high alpine research station Jungfraujoch (3580 m asl), Switzerland, the single particle composition of IN and the interstitial aerosol within mixed-phase clouds was studied. The size, morphology, elemental composition and mixing state of more than 7000 particles were analyzed by scanning electron microscopy (SEM) combined with energy-dispersive X-ray analysis (EDX).

Pb bearing particles (up to 24% by number), aluminium oxide particles and different complex internal mixtures (main components: soot, silicates and metal oxides) were identified to act as IN.

The high abundance of Pb-bearing particles in the IN-samples was an unexpected finding. A smaller number of these particles are Pb-dominated (PbO and $PbCl_2$). However, the majority of these particles are sea salt, soot or silicates, while Pb is present as small (50 – 500 nm) heterogeneous Pb or PbS inclusions.

As the component with best IN capability present in an individual particle determines its IN behaviour, the determination of the main-component of a particle is not sufficient for the prediction of its IN-capability.