Aerosol Formation from Isoprene

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Keywords: aerosol formation, growth, isoprene, nucleation rate, SOA.

Due to its high source strength, there has been considerable interest in the potential of isoprene to contribute to the formation of Secondary Organic Aerosol (SOA). Measurements of aerosol formation and growth following isoprene oxidation have been performed in the PSI smog chamber (27 m3 teflon bag) to address this issue. Using only the measured aerosol size distributions as input, we determined empirical particle nucleation and growth rates.

Aerosol size distributions were measured using a twin-SMPS system, one with a short classifier and a TSI 3786 UWCPC (4-150 nm) and one with a long classifier and a TSI 3022 CPC (16-700 nm). From these we made composite size distributions covering the whole size range from 4 to 700 nm diameter which we used for further analysis.

The experiment was started by producing particles through ozonolysis of isoprene. This aerosol was diluted to reduce the particle concentration to around 500 cm⁻³. We then injected 350 ppbv of isoprene in the presence of NO and turned on all chamber lights. An hour later, the pre-existing particle mode started to significantly grow in size, indicative of condensation. Another two hours later a modest nucleation event occurred, producing approximately 4000 new particles cm⁻³. A contourplot of the measured size distributions is shown in Figure 1.

![Figure 1. Measured size distributions following isoprene oxidation.](image)

The condensational growth rate is found by regression analysis of the General Dynamic Equation, using the PARGAN procedure (Verheggen and Mozurkewich, 2006). The effects of particle wall loss and coagulation are taken into account. The growth rate provides an indirect measure of the concentrations of the condensing species, offset by their vapor pressures. Diameter growth rates and the equivalent vapor mixing ratios are shown in Figure 2.

![Figure 2. Particle growth rate during photo-oxidation of isoprene. Solid line is seven-point running mean. The equivalent mixing ratio of the condensing vapor (in excess of saturation) can be read off the right axis.](image)

After the lights had been turned off (23:30), the aerosol evaporated continuously at a rate of 17 nm h⁻¹. This corresponds to a mixing ratio in the chamber of 10 pptv below saturation. Therefore 10 pptv is a lower limit for the effective saturation vapor pressure of the condensable products of isoprene.

The growth rate is then used to estimate the time of nucleation for particles in each measured size bin, defined as the time when their calculated diameter surpassed 1 nm. Their number density at the time and size of nucleation is determined by integrating the particle losses that occurred in the time interval between nucleation and measurement. The nucleation rate is then given by the rate at which particles grow past the critical cluster size, assumed to be 1 nm diameter. The nucleation rate reaches 1 cm⁻³ s⁻¹, which is relatively small compared to other chemical systems involving terpenes and/or SO₂. This suggests that at atmospheric conditions isoprene is not likely to induce nucleation, but it could contribute to SOA formation by condensation on existing aerosol. The yield was 0.8% at an aerosol mass of 5.5 µg m⁻³ (assumed density of 1.4 g cm⁻³).

This work was supported by the Swiss NSF as well as the EC projects EUROCHAMP and POLYSOA.