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A laser trapping-spectroscopy study on mass transfer processes across a single micro-droplet/air interface

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Clouds regulate the earth's energy balance by reflecting and scattering solar radiation and by absorbing the earth's infrared radiation. The fundamental knowledge about mass transfer processes across a micro-droplet/air interface is very important to give mathematical equations that describe the growth process of clouds for climate models. So far, experimental studies on the condensation growth of water droplets have been conducted by using either an aerosol flow tube or a vibrating orifice aerosol generator. However, the mass accommodation coefficients evaluated by such techniques are very scattered and, therefore, the detailed mechanisms of condensation growth of micrometer-sized water droplets are still controversial. The primary reason for this is difficulties in observing the growth processes of single water droplets in air. In this study, we demonstrate a novel approach for *in situ* observation of the evaporation and condensation processes of single water droplets levitated in air by means of a laser trapping technique.

As shown in Fig. 1, a micrometer-sized aqueous ammonium sulfate droplet was trapped in air by a focused 532 nm laser beam from a CW-Nd:YVO_4 laser introduced to an inverted optical microscope through an objective lens (×60, NA = 0.70). Since vapor pressure of the droplet is governed by both the solute concentration and the temperature, an irradiation of an infrared (IR) laser beam (1064 nm, 3.1 mW) to the droplet was shown to lead to an increase in the temperature (0.25 °C) and a decrease in the size of the trapped droplet to attain an equilibrium state at which the droplet vapor pressure is balance with the surrounding relative humidity (RH = 99.4 %). We succeeded in reversible control of the size of the trapped aqueous ammonium sulfate droplets by switching on/off of the IR laser beam irradiation, as shown in Fig. 1. Here, we show that resolving the time evolution of the change in size provides a novel approach for investigating the mass transfer accompanying condensation or evaporation at the single micro-droplet/air interface.

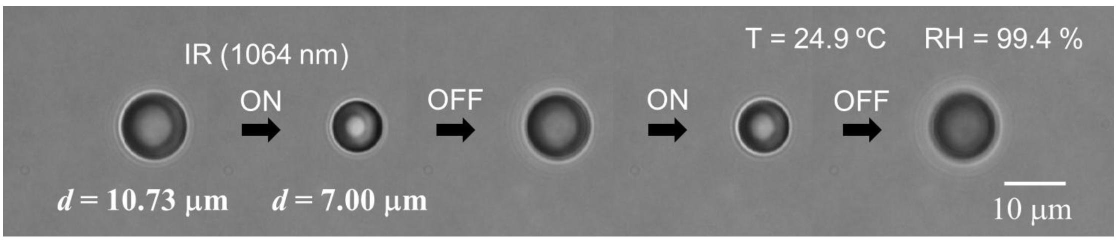

Fig. 1 Reversible size changes of the aqueous ammonium sulfate droplet in air upon switching on-off of IR laser irradiation.