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Natural dew conditions in the laboratory

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Natural dew condensation on a substrate is the result of outdoor radiative cooling below the dew point temperature of the ambient atmosphere. Studies of this phenomenon in the laboratory have been carried out so far by contact cooling. Such procedure is different from radiative cooling and can lead to differences in the condensation process, especially for thin and light structures where contact cooling becomes inefficient in contrast to radiative cooling.

This study describes a device making it possible to perform dew condensation in the laboratory by radiative cooling. It is based on a radiative deficit between a substrate in a humid environment and a cold source. The studied substrate is positioned on a support connected to a precision balance to record the evolution of the condensed mass. The substrate is set in the center of a condensing chamber of approximatively 1 L and supplied in humid air at room temperature. A cold source is positioned under the condensing chamber such as a radiative heat flux is established between source and substrate through a window and a conical mirror surrounding the substrate. The window is made of a polypropylene film, transparent to the infra-red (transmittancy >0.9) and the mirror is an aluminum foil, with reflectivity larger than 0.8. Three thermocouples record the temperature of the coming air, the mirror and the radiative window. Two cameras visualize, through windows, the evolution of condensation on the substrate.

The different heat fluxes exchanged with the substrate are of different nature: (i) radiative (ii) latent heat due to condensation (iii) convective with ambient air (iv) conductive through the support. The incident radiative flow on the studied substrate over the entire wavelengths is measured thanks to a sensor of radiative flow. For materials of great emissivity the value of the incidental heat flux is about 350 W/m2, leading to a radiation deficit of about 55 W/m2 for water (emissivity 0.95), a value currently encountered with natural dew. With incident humid air flow 0.8 L/min., temperature 20.3 °C and relative humidity 85 %, the condensation rate is found around 0.6 L for 10h., corresponding to usual time duration for natural dew. This value corresponds to a latent flux of 40 W/m2. The energy balance gives convective and conductive losses of about 15 W/m2, which compares well with current estimations of the support heat conductivity and convective heat transfer coefficient.

Examples of condensation on different substrates that cannot be efficiently cooled by contact will be presented. Light materials structures (spring, bulb), plants (cactus, flower) and insects (spider, stag beetle) can indeed exhibit interesting condensation features. It is anticipated that small living animals and insects can be studied by this technique.