Designing an Effective, Low-Cost, and Convenient Air-Cooled Semi-microscale and Small Scale Inverted Cone Vapor Condenser for Waterless Reflux Cooling

Bruno Lunelli*, Consiglio Nazionale delle Ricerche (CNR), Istituto per lo Studio dei Materiali Nanostrutturati (ISMN), via P. Gobetti 101, I-40129 Bologna, Italy, blunelli733@gmail.com

Massimo Baroncini, CLAN-Center for Light Activated Nanostructures, Università di Bologna and Consiglio Nazionale delle Ricerche, via Gobetti 101, I-40129 Bologna, Italy, and Università di Bologna, Dipartimento di Scienze e Tecnologie Agroalimentari, Viale Fanin 50, I-40127 Bologna, Italy, massimo.baroncini@unibo.it

Supplementary Information

Cooling power, vapor speed and mechanical details of the 25 mL condenser.
Taking as 0.05 mL the volume of one drop of methanol (CAS 67-56-1, density 0.792 g mL^{-1}, FW 32 g mol^{-1}, ΔH_{vap} 38.278 kJ mol^{-1}), one drop every 5 s makes a volume of 0.01 mL, or a mass of 0.008 g, or an amount of 0.008/32 = 0.00025 mol per second, hence a power of (0.00025∗38280 =) 9.5 J s^{-1} = 9.5 W. The evaporation of 0.00025 mol gives a vapor volume of about 0.00025 mol ∗ 22 400 mL mol^{-1} ∗ 337 K/273 K ≈ 7 mL passing through the point of smallest diameter of 7 mm each second with a speed of about 18 cm s^{-1}. The truncated conical surface Fig.1-b) had the largest diameter *D* = 4.2, the smallest diameter *d* = 1.6, the height from the vertex to *D*, *H2* = 7.5, the height from the apex to *d*, *H1* = 2.5 cm, area *A* = 26 cm^2.

Boiling point of a solution of DEHP.
The temperature of the boiling point is higher than that of the pure solvent due to the reduction of the chemical potential of the latter species in its solutions (Denbigh, K., The Principles of Chemical Equilibrium, 2nd Ed., Cambridge U.P., Cambridge 1966, p.261); the vapor is superheated and must be slightly cooled prior to be in equilibrium with the pure liquid condensed. For the solution of 0.40 mL of DEHP in 4.00 mL of methanol, the calculated superheating at boiling is about 0.2 °C.

Mechanical details of the 100 mL condenser.
Using the same symbols utilized for the 25 mL condenser: *D* = 6.4, *d* = 1.6, *H2* = 10.5, *H1* = 2.5 cm, *A* = 66 cm^2.

Figure S1. Picture of the 25 mL reflux condenser.

Figure S2. Picture of the 100 mL vapor condenser.