Mausam, (1981), 32, 2, 205-208

Letters to the Editor

532.6:551.576.11

A NOTE ON THE EFFECT OF CURVATURE ON SURFACE TENSION AND POSSIBLE APPLICATION TO CLOUD PHYSICS

The well known Kelvin's formula gives the effect of the curvature of a droplet on the vapour pressure :

$$\ln \frac{p}{p_\infty} = 2M\,\sigma_{LV}/\rho_L R T r \qquad (1)$$

where, σ_{LV} is the surface tension or the specific surface energy of the liquid-vapour interface, ρ_L the density of the liquid, p is the pressure of vapour over the surface of the droplet of radius, r, p_∞ is the equilibrium vapour pressure at temperature T, R the universal gas constant and M the molecular weight of the liquid. In the above expression the saturation ratio $S = p/p_\infty$ becomes a function of T and r assuming that σ_{LV} and ρ_L are independent of r.

Recently Navascues (1979) has discussed the effect of variation of curvature on the surface tension. He gives the following table for the variation of surface tension of water with change in radius.

r (cm)	00	10^{-4}	10^{-5}	10^{-6}	10^{-7}
$\sigma r/\sigma_\infty$	1	0.9996	0.996	0.9681	0.7174

From this data we observe that, for drops of radii greater than 10^{-5} cm, there is negligible reduction of surface tension as compared to the value of σ_∞ . But in the range $r = 10^{-7}$ to 10^{-5} cm there is a significant reduction.

Using these values of surface tension or different radii, the Kelvin's formula has been used to recompute the value of S $(= p/p_\infty)$ in the range of $r = 10^{-7}$ to 10^{-5} cm. The modified values of S are shown in the graph along with values of S with constant value of surface tension as in the Kelvin's original formula. It is seen that due to reduction in the surface tension the saturation

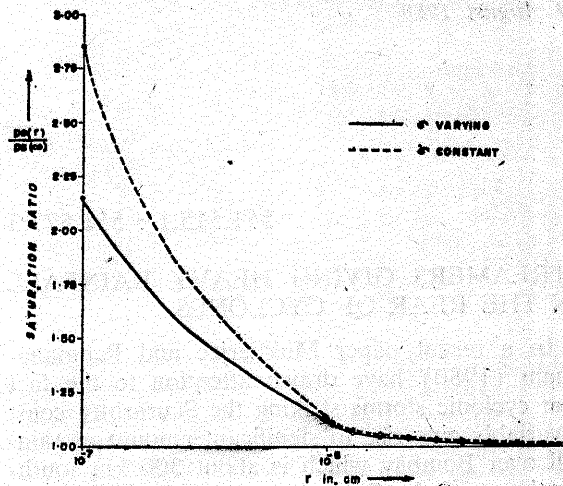

Fig. 1

ratio is also reduced in this radii interval. Kohler investigated the problem of growth of a drop of aqueous salt solution in an environment of humid air. The relationship obtained by him may be rewritten as :

$$\ln \frac{p}{p_\infty} = 1 + \frac{A}{r} - \frac{B}{r^3}$$

where,

$$A = \frac{2M\,\sigma_{LV}}{\rho_L R T} \quad \text{and} \quad B = \frac{3\,\nu\, m_S\, M}{4\pi M_S\, \rho_L}$$

where,

ν is the No. of ions of the dissolved salt,

m_S is the mass of dissolved salt,

M_S is the molecular weight of the salt,

M is the molecular weight of water

The second term indicates increase in equilibrium vapour pressure of a drop of radius r and the third term indicates lowering of vapour pressure due to the presence of dissolved salts. From this equation Kohler drew graphs indicating the existence of critical radius beyond which the water droplets would grow. The present finding indicates that the droplets in the region of radius between 10^{-7} cm and 10^{-6} cm would require lower saturation ratio than expected by the above equation. Natural aerosols have also a high concentration in this range of size (Mason). Thus it is quite possible that condensation nuclei of much smaller radii are actually activated in the atmosphere that hitherto believed due to lowering of the saturation ratio as result of the recent findings on the dependence of surface tension on the curvature of the droplet.

Author's thanks are due to Dr. U. S. De for valuable discussions.

References

Mason, B. J., 1971, *Physics of the Clouds*, Second edition, Ch. 1.

Navascues, G., 1979, *Rep. Prog. in Phys.*, **42**, 7, pp. 1131-86.

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29 August 1980

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