Letters To The Editor

551·574·1: 661·56

THEORETICAL CONSIDERATION ON NITRIC ACID AS CONDENSATION NUCLEUS

It has been mentioned by Junge (1951) that oxides of nitrogen or more specifically nitric oxide and nitrogen peroxide are effective in creating condensation nuclei for clouds. Simpson (1941) has suggested that it is probably these substances that are acting as the chief condensation nuclei in nature. Houghton (1951) is more careful in suggesting that these substances may be responsible for the formation of one of the chief condensation nuclei occurring in nature. Banerji and Mukherjee (1955) observed in course of their laboratory experiments on cloud formation that they were certainly effective in forming cloud in cloud-flasks. In the present note, however, an attempt has been made to consider from a theoretical point of view as to how in nature they form condensation nuclei, and what will be the physical properties of these nuclei.

Condensation nuclei are known to be present as minute droplets of solutions. Fuchs and Oschman (1935) came to the conclusion that any gaseous substance, reacting with water vapour will, under suitable conditions, give rise to mists of size of the order of 10^{-5} cm in diameter. In the case of nitric oxide and nitrogen peroxide they will undergo the following reactions —

$$2NO+O_2 = 2NO_2$$
$$2NO_2+H_2O = HNO_2+HNO_3$$

Hence when these oxides are giving rise to droplets of the size of the condensation nuclei (10^{-7} to 10^{-5} cm in diameter) both nitrous acid and nitric acid should be present. But as nitrous acid is unstable, it is more likely that condensation nuclei will contain mainly nitric acid and not nitrous acid as suggested by Houghton (1951).

TABLE 1

Wt % of nitric acid solution	Surface tension (dynes/cm)
7·35	73·10
9·0	72·70
22·0	71·48
37·0	68·10
50·0	65·43
70·0	59·36

The next question which we should consider is how these minute droplets of nitric acid solution act. As is usually expected vapour pressure of water over nitric acid solution is less than that of pure water.

According to Kelvin's equation

$$\rho RT \log \acute{e}_r/e' = 2\sigma/r$$

where ρ is the density of the liquid, R the gas constant, T the absolute temperature, $\acute{e}_r$ the saturation vapour pressure over droplet of radius r, e' the saturation vapour pressure over flat surface and σ the surface tension of the liquid.

Hence small droplets will have higher vapour pressure and consequently higher partial pressure of water vapour than flat surface, *i.e.*, liquid in bulk. Hence lowering of vapour pressure is somewhat minimised when drops are very small. In the case of nuclei whose size may vary from 10^{-7} to 10^{-5} cm in diameter, this effect will be particularly noticeable. But, in this case, we know that nitric acid solution has lower surface tension than water. Hence, the increase in vapour pressure due to increased curvature in small droplets is less in case of concentrated solutions. Table 1 gives surface tension of nitric acid solution at 20°C.

It is known that aging of nucleus droplets tends to bring them to uniform size. In the case of nitric acid it can be shown that it has a tendency to come to uniform concentration also. It is well known that nitric solution shows azeotropism with a minimum of total pressure at about 62 per cent concentration. Thus as a result of aging, nuclei will have a tendency to come to that concentration which evaporates last and vapour and liquid phase will have the same composition. Houghton (1951), Junge (1951) and Eriksson (1952) have dealt in their articles about the origin of the oxides of nitrogen which ultimately give rise to nitric acid nuclei. About the propagation of such nuclei it is obvious that they may be carried by wind to any place or they may diffuse in the gaseous form.

One may expect that since nitric acid is present in atmospheric precipitation, rain water should be slightly acidic. It has, however, been mentioned by Cauer (1951) that atmospheric aerosols are acidic at higher altitudes and that when rain water falls, it is neutralised by ammonia present near the ground. It is probable that part of the acidity is due to the nitric acid present in the cloud particles.

A. K. MUKHERJEE

Meteorological Office,
Jodhpur
November 8, 1955.

REFERENCES

Banerji, S. K. and Mukherjee, A.K.	1955	*Symposium on Artificial rain*, C.S.I.R. (India), p. 40.
Cauer, H.	1951	*Compendium of Meteorology*, p. 1126.
Eriksson, E.	1952	*Tellus*, **4**, p. 215.
Fuchs, M. and Oschman, N.	1935	*Acta phys. - Chim. URSS*, **3**, p. 61.
Houghton, H.G.	1951	*Compendium of Meteorology*, p. 167.
Junge, C.	1951	*Ibid.*, p. 182.
Simpson, G. C.	1941	*Quart. J. R. met. Soc.*, **67**, p. 163.