Investigations on the Adsorptive Property of Silica Gel. Part V. The Specific Gravity of Silica Gel under Various Liquids.

By M. R. Aswathnarayana Rao.

Measurements of the apparent density of activated charcoal under various iiquids have been carried out by Cude and Hulett (*J. Amer. Chem. Soc.*, 1920, **42**, 391) and by Harkins and Erving, (*ibid.*, 1921, **43**, 1787). The apparent density of silica gel under water has been measured by Mc Gavack and Patrick (*ibid.*, 1920, **42**, 952). But Duright and co-workers (*ibid.*, 1930, **52**, 4635) have found the true density by making use of helium as the pore-filling substance. The term apparent density usually means the density determined by the displacement of mercury which cannot enter the microscopic and ultra-microscopic pores (*cf.* McBain, "Sorption of Gases and Vapours by Solids," 1932, p. 79), hence the term specific gravity has been used in this paper.

Experimental.

A specific gravity bottle was fitted with accurately ground cap that prevented the loss of liquid by evaporation. The measurements were carried out in a thermstat at 30±° 0·01. A weighed amount of the gel was placed in the specific gravity bottle (the weight of the bottle having been previously determined) and was evacuated by means of the device shown in Fig. 1. The desiccator D, had a funnel F, and a side-tube S, which were connected by means of a ground glass joint at G. The bottom of the funnel passed through the neck of the specific gravity bottie as in the figure. After evacuating the desiccator for an hour (with the gel in the bottle kept in position as in the figure) the liquid was introduced through F, and the gel was allowed to remain with the liquid for 12 hours to attain equilibrium. The bottle was weighed again and the specific gravity was calculated in the usual manner. The following results were obtained.

Fig. 1.

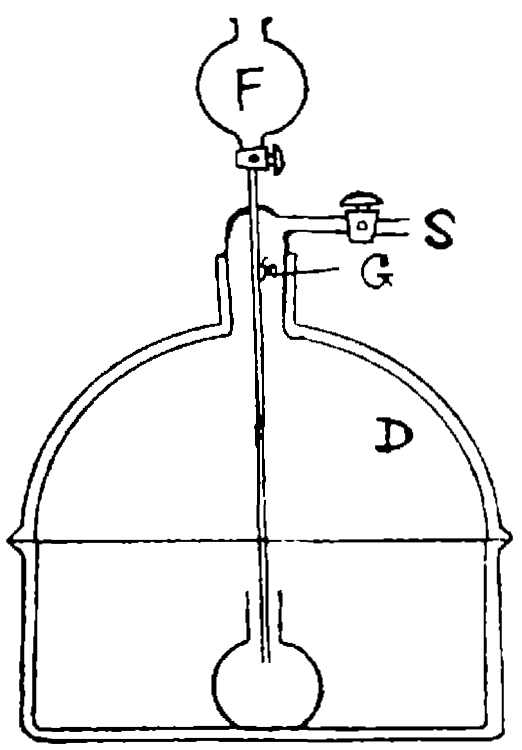

TABLE I

Liquid.	Sp. gr.	Liquid.	Sp. gr.
Water	2·241	Nitrobenzene	2·189
Benzene	2·201	CCl_4	2·127
Xylene	2·189	Aniline	2·195

Duplicate experiments agreed within 0·1 to 0·2%.

DISCUSSION.

That the specific gravity should be greatest in water and least in carbon tetrachloride is to be expected from the fact that in silica gel, water has the greatest penetrating power and carbon tetrachloride the least. This may be gathered from the earlier experiments considered in Part III (p. 332). The question whether the difference in compressibility is responsible for the variation in specific gravity, has been considered by McBain with reference to charcoal in his book (*loc. cit.*, p. 87, 459). There has been a considerable difference of opinion about this subject. If the theory of compressibility is accepted, it will be difficult to explain the liberation of air, when water wets the silica gel immersed in other liquids. The following calculation shows the relationship between the specific gravity and the volume decreases described in part III.

Reference to column 2 of Table II of Part IV (p. 338) gives the displacement effect per g. of the gel. In the case of benzene this is 0·0085 c.c. of the gel space more than the space occupied by benzene. That is 2·24 g. of the gel would appear in water to have a volume of 1 c.c. and in benzene a volume of $1{\cdot}0015 \times 2{\cdot}241 = 1{\cdot}019$ c.c. Hence the specific gravity of the gel in benzene would be $2{\cdot}241/1{\cdot}019 = 2{\cdot}200$. That is, the calculated value for the specific gravity of the gel in benzene is 2·200 where as the observed value is 2·202 as shown in Table I. The agreement between the calculated and the observed values can be gathered from the following table.

TABLE II.

Liquid.	Specific gravity.	
	Calc.	Obs.
Benzene	2·200	2·202
Xylene	2·190	2·189
Nitrobenzene	2·189	2·189
CCl_4	2·140	2·127
Aniline	2·197	2·195

The agreement between the theoretical and the observed values is quite satisfactory except in the case of carbon tetrachloride, where the experimental errors were appreciable owing to the high volatality of the heavy liquid. It is interesting to note that in spite of the fact that the correction for volume change on mixing aniline (Table II, Part III, p. 332) is quite appreciable in the displacement experiment, yet the valve for aniline agrees well with the calculated one. It is worthy of notice that the specific surface of silica gel is $5{\cdot}0 \times 10^6$ for water adsorption and $4{\cdot}3 \times 10^6$ per sq. cm. for organic liquids as calculated by Bartell and Fu ("Colloid Syposium Annual," Vol. VII, p. 144). This means that silica gel offers a larger area to water than to organic liquids. This is in agreement with the observation that silica gel has the greatest specific gravity in water.

SUMMARY.

All the experimental observations noted, the volume changes on displacement of adsorbed liquids by water, the values for the volume of air liberated and those for the specific gravity of silica gel in different liquids can be satisfactorily explained on the basis of the assumption that liquids vary in their power of penetrating into the capillaries present in silica gel, water having the greatest penetration and carbon tetrachloride the least.

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DEPARTMENT OF CHEMISTRY,
CENTRAL COLLEGE, UNIVERSITY
OF MYSORE, BANGALORE.

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