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The Apparent Density

Of

Silica Gel Measured in Various Liquids

Thesis

Submitted to the Faculty of Michigan State College in Partial Fulfillment of the requirements for the Degree of Master of Science.

By

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June 1929

It has been definitely proven that such physical properties of an adsorbent, as density, available pore volume, and adsorptive power vary with the liquid employed.

The variation in density or apparent density of activated carbon was studied by Harkins and Ewing[1]. Their conclusions were that the liquid at the surface of the carbon was compressed, giving a variation in density relative to the compressibility of the liquid used and varying inversely as the surface tension.

Cude and Hulett[2] observed this same phenomena, but interpreted it differently. They assumed incomplete penetration of the capillarys in the carbon and show that the densities obtained were proportional to the surface tension of the liquids employed and inversely proportional to their viscosities. They also observed that there appeared to be a lag or drift and that the density measurements increased with time. Howard and Hulett[3] attributed this increase to more complete penetration.

The apparent density of silica gel has been measured in various liquids by several investigators, but the data is meager and the measurements have been made for only a few liquids.

Berle and Urban[4] studied the variation in density of silica gel when activated under varying conditions and also of quartz, using ether as the liquid for their density determinations. Their choice of ether was based on the assumption that it would have a greater penetrating power than water.

Nutting[5] calculated the pressure necessary to produce these apparent densities in the case of water with silica gel by determining the heat of wetting on gels of various water contents. He plotted the water adsorbed as a function of the heat of wetting and computed the pressure. He found that when a layer of water, 100 mols thick, had been adsorbed there was a decided break in the curve and assumed this to be the limit of the range of adsorption. He gives a value of 17,410 atmospheres pressure for a layer 100 moles thick with a pressure gradient near the silica gel surface of 237 atmospheres per mol layer.

In this work the apparent density of silica gel has been measured in 13 liquids in order that a comparison may be made with similar existing measurements on activated carbon and also gain information as to the magnitude of the pressure necessary to produce these abnormal densities.

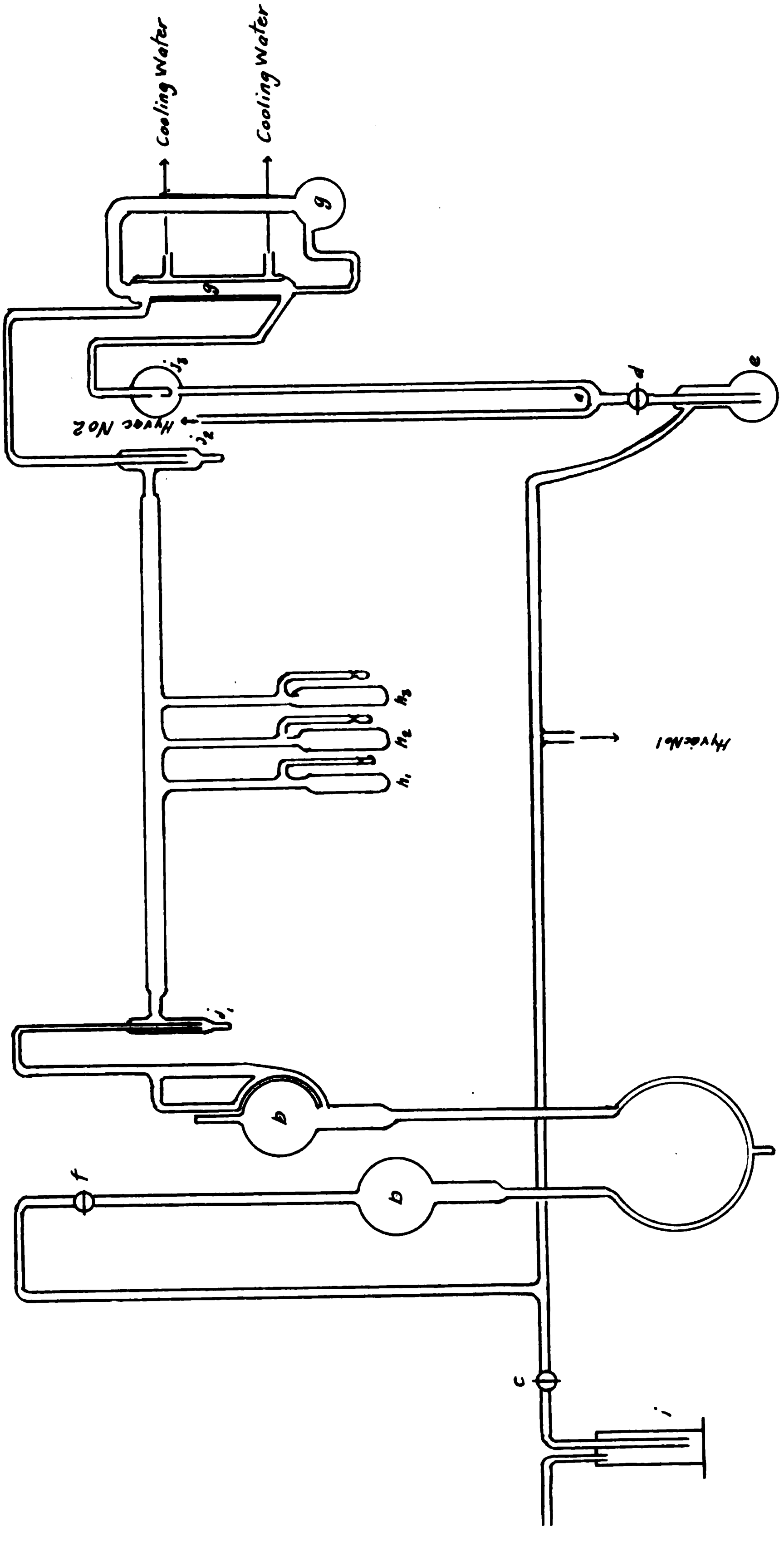
Apparatus

The apparatus consists essentially in a high vacuum system for evacuating the tubes filled with gel. It is unique in that the vacuum system proper is made entirely of pyrex glass, has no stopcocks, and is sealed from the atmosphere on one side by the mercury column in the McLeod gage and on the Hyvac pump side by a mercury seal.

Figure 1 is a detailed drawing of the apparatus. Two Central Scientific Hyvac pumps are used, Pump No. 1 to pull the mercury out of the McLeod gage (b) and control the mercury seal (a); pump No. 2 as an exhausting pump to the atmosphere from the Langmuir mercury vapor pump which is in series with it. In sealing off the vacuum system, stopcock (c) and (d) are opened and the mercury rises in the two arms of the mercury seal (a) to barometric height from the reservoir (e). Then stopcock (d) is closed. To continue evacuating the system after it has been sealed, stopcock (d) is opened (c) closed and the mercury pulled from the mercury seal with pump No. 1. Pulling the mercury down until the seal is open, but not to the stopcock. Now (d) is closed (c) opened to the atmosphere and the pump stopped. Stopcock (f) is used to open the McLeod gage to vacuum pump No. 1 and the atmosphere. (g) is the Langmuir mercury vapor pump. (h) 1, 2 and 3 are tubes filled with gel ready to evacuate. (i) is a calcium chloride tower to remove moisture from the air entering the gage. (j) 1, 2 and 3 are mercury traps.

Figure 2 is a detailed drawing of the tube used. C is an etched graduation on the stem to which the meniscus of the liquid under investigation is adjusted. The tubes have a capacity of approximately 25 cc. and will hold about 10 grams of gel. The side arm of the tube is constricted at (b) in order to facilitate breaking off the tip when immerced in the liquid.

Figure I



Preparation of Materials

(1) Mercury

The mercury was aerated over night by bubbling air through it while covered with 1 : 3 nitric acid, passed thrua capillary into a column of 1 : 3 nitric acid, through another capillary into a column of distilled water, dried with caustic soda, and then again passed through a capillary to remove the caustic soda.

(2) Isopropyl Alcohol

A commercial c.p. product. The isopropyl alcohol was distilled from lime and then fractionated.

B.P. 79.7° - 79.8° 738.9 mm.

(3) Chloroform

A commercial c.p. product. The chloroform was treated with concentrated sulphuric to remove the alcohol, washed with dilute sodium hydroxide and finally with water. It was dried over fused calcium chloride, followed by anhydrous copper sulphate then fractionally distilled.

B. P. 60.6° - 60.8° 746.2 mm.

(4) Carbon tetrachloride

Product - Central Scientific c.p. The carbon tetrachloride was washed with water, sulphuric acid, water, sodium hydroxide and finally water. It was then dried over calcium chloride and fractionally distilled.

B. P. 75.8° 734.9 mm.

(5) Carbondisulphide

Product - Central Scientific Co. c.p.

The same method of purification was used as for carbon tetra chloride.

B. P. 44.5o 747.5 mm.

(6) Nitrobenzene

Product - Central Scientific Co. c.p.

The nitrobenzene was shaken with an equal volume of 10% solution of sodium sulphite and stood in contact with the solution for 24 hours. The nitrobenzene was separated by use of a separatory funnel and washed with water. It was then dried over calcium chloride and fractionally distilled.

B.P. 209.9 - 210.2° 744.6 mm.

(7) Benzene

Product - Wilkins Anderson Co., c.p. Thiophene free.

The benzene was treated with concentrated sulphuric acid until a sample of acid did not darken on standing in contact with the benzene for a day. It was treated with sodium hydroxide to neutralize the acid washed with distilled water, dried over calcium chloride and fractionally distilled three times. The purified benzene was stored in glass stoppered bottles over metallic sodium.

B.P. 77.9 - 78° 738.6

(8) Pentane

Product - Eastman Kodak Co. Practical

No purification

B. P. 27.4° 740.1 mm.

(9) Water

Distilled water collected directly from the still which supplies the laboratories with water.

(10) Petroleum Ether (Benzene)

Product - Baker Analyzed. B.P. 30° - 60°

No purification.

(11) Ethyl Alcohol

The ethyl alcohol used was purified in this laboratory by Clark G. Sinclair[1].

B. P. 77.6° 740.1 mm.

(12) Acetone

Product - Wilkins and Anderson Co., c.p.

The acetone was fractionally distilled and dried over calcium chloride.

B.P. 55.2°-56° 743.7 mm.

(13) Ether

Product - Wilkins and Anderson Co. c.p. over sodium.

The ether was washed with water, then alkaline permanganate until there was no green coloration of the

permanganate over a period of ten minutes and with water until free from alkali. The green coloration shows the presence of alcohol. The purified product was dried over calcium chloride then phosphorus pentoxide and fractionally distilled.

B.P. 34° 743.0 mm.

All the liquids were shaken in a flask under reduced pressure before using in order to remove any absorbed air.

Silica Gel

Product - Silica Gel Corporation, Battemore.

This gel was hand picked to remove the obvious blanks, crushed and screened through a 3 mm. sieve.

Experimental

Evacuation:

The tubes in groups of three as shown under description of apparatus were filled with silica gel, sealed on to the apparatus, and evacuated for a period of six hours at a temperature of 250°C, then sealed off under vacuum. All tubes were sealed at a pressure from 10^{-4} mm. to 10^{-5} mm. as shown by the McLeod gage.

Weighings:

After the sealed tube had cooled to room temperature it was scratched with a file at the points (a) and (b), then its weight in air (W_1) and water (W_2) determined. The end of the side arm was then immersed in the liquid under investigation and the tip broken off with forceps at the file scratch (b), thus filling the evacuated system with liquid. The top of the tube was broken off at the file mark (a), the tube placed in a thermostat regulated to 25° ± .01°C and the meniscus adjusted to the etched mark on the stem. The tube adjusted to volume was stoppered and weighed (W_5). In most cases this adjustment was made two or more times and the mean weight used. The tube was emptied and filled with the liquid, meniscus adjusted to the mark and weighed as before (W_6). The liquid was emptied out of the tube and the dry weights of the top and tip (W_4) and tube (W_3) determined.

Formulae & Computation:

From the above weights the apparent density of the silica gel was calculated with the following formulae:

$$W_{t-g} + W_1 + \frac{(W_1 - W_2)\ Da}{D_w} - \frac{W_1\ 1\ Da}{D_b}$$

W_1 = Weight of evacuated tube gel system in air

W_2 = Weight of evacuated tube gel system in water

Da = density of air

D_b = density of brass

D_w = density of water at temperature of weighings

W_{t-g} = corrected weight of tube and gel

W_t = corrected weight of tube, tip and top

$$W_t = (W_3 + W_4) + (W_3 + W_4)\ D_a \left(\frac{1}{D_p} - \frac{1}{D_b}\right)$$

W_3 = weight of dry tube

W_4 = weight of top and tip

D_p = density of pyrex glass

W_g = corrected weight of gel

$$W_g = W_{t-g} - W_t$$

W_{dl} = Corrected weight of displaced liquid

$$W_{dl} = W_6 - (W_5 - W_g) + (W_5 - W_6)\ Da \frac{1}{D_b}$$

W_5 = Weight of tube liquid gel stopper

W_6 = Weight of tube liquid stopper

D_{gel} = apparent density of gel

$$D_{gel} = \frac{W_g \times D_l}{W_{dl}}$$

D_l = density of liquid used

Precision of Measurements

The least accurate measurements are the weight of the bulb liquid gel and the weight of the bulb liquid. Their accuracy is determined by the ability to reproduce exact adjustments of the meniscus.

The following series of weights were made on a tube plus water to determine with what accuracy the weights could be duplicated:

Trial No.	Weight of tube		d.m.
1	41.5461	+	.0001
2	41.5459	-	.0001
3	41.5461	+	.0001
4	41.5459	-	.0001
5	41.5463	+	.0003
6	41.5456	-	.0004

Av a d .0002

$$A.D. \frac{.0002}{\sqrt{6}} = \pm .00008$$

This degree of accuracy is of the same order as the accuracy of the analytical balances used, thus the determinate errors are all of the same magnitude.

Example of Calculation:

Run #9 Ethyl Alcohol

Bar 734.3 mm. 21°C Tube No. 4

Evacuated 6 hrs to 10^{-5} mm.

Temperature of thermostat 25°C

$$W_{t-g} = W_1 + \frac{(W_1 - W_2)}{D_w} D_a - W_1 \frac{1}{D_b} D_a$$

$W_1 = 51.9884$ D_w at 734.3 mm. 21°C = 0.99602

$W_2 = 8.9000$ D_a at 734.3 mm. 21°C = 0.001161

$W_1 - W_2 = 43.0884$ $\frac{1}{D_b} = 0.1184$

$$W_{t-g} = 51.9884 + \frac{43.0884 \times .001161}{.99602} - 51.9884 \times .1184 \times .001161$$

$$= 51.9884 + .0501 - .0071$$

$$W_{t-g} = 52.0314$$

$$W_t = (W_3 + W_4) + (W_3 + W_4)\left(\frac{1}{D_p} - \frac{1}{D_b}\right) D_a$$

$W_3 = 28.6295$ $\frac{1}{D_p} = \frac{1}{2.25} = 0.4444$

$W_4 = 10.3060$ $\frac{1}{D_b} = \frac{1}{8.85} = 0.1184$

$D_a = 0.001161$ $\frac{1}{D_p} - \frac{1}{D_b} = 0.3260$

$$W_t = (28.6295 + 10.3060) + (28.6295 + 10.3060) \times .3260 \times .001161$$

$$= 38.2209 + 38.2209 \times .3260 \times .001161$$

$$= 38.2209 + .0144$$

$$= 38.2353$$

$$W_g = W_{t-g} - W_t$$
$$= 52.0314 - 38.2353$$
$$= 13.7961$$

$$W_{d1} = W_6 - (W_5 - W_g) + (W_5 - W_6)\ D_a \frac{1}{D_b}$$

$$W_5 = 54.0150$$

$$W_6 = 44.8937$$

$$W_{d1} = 44.8937-(54.0150-13.7961)+(54.0150-44.8937) \times .1184 \times$$
$$.001161 = 44.8937 - 40.2189 + 9.1213 \times .1184 \times .00161$$
$$= 44.8937 - 40.2189 + .0013$$
$$= 4.6716$$

$$D_{gel} = \frac{W_g \times D_1}{W_{d1}}$$

$$D_1 = 0.7851$$

$$D_{gel} = \frac{13.7961}{4.6716} \times 0.7851$$
$$= 2.9503 \times 0.7851$$
$$= 2.3163$$

D A T A

Substance	Run No.	Tube No.	W_g/W_{dl}	D_{gel}	Deviation
Mercury	21	7	0.09494	1.2849	+ .0008
	"	8	0.09480	1.2830	- .0011
	"	10	0.09490	1.2844	+ .0003
		Total	0.28464	3.8523	.0022
		Av	0.09488	1.2841	± .0007
			Deviation of Mean		± .0004
Carbon disulphide	19	III	1.7200	2.1665	- .0008
	"	7	1.7147	2.1598	- .0074
	"	8	1.7270	2.1753	+ .0082
		Total	5.1617	6.5016	0.0164
		Av	1.7206	2.1672	± .0054
		Deviation of Mean			± .0031
Benzene	4	1	2.5000	2.1848	- .0003
	"	2	2.5009	2.1848	- .0003
	5	1	2.5079	2.1854	+ .0003
	"	2	2.5041	2.1851	
	10	1	2.5071	2.1854	+ .0003
		Total	12.5020	10.9255	.0012
		Av	2.5004	2.1851	± .00024
		Deviation of Mean			± .0001

Substance	Run No.	Tube No.	W_g/W_{dl}	D_{gel}	Deviation
Carbontetra-chloride	6	1	1.3538	2.1543	+ .0065
	6	2	1.3470	2.1435	- .0043
	7	1	1.3493	2.1471	- .0007
	7	3	1.3535	2.1538	+ .0060
	12	4	1.3451	2.1405	- .0073
		Total	6.7487	10.7392	.0248
		Av	1.3497	2.1478	± .0050
		Deviation of Mean			± .0020
Nitrobenzene	18	III	1.8251	2.1870	- .0054
	18	7	1.8322	2.1955	+ .0031
	18	8	1.8315	2.1947	+ .0023
		Total	5.4888	6.5772	.00108
		Av	1.8296	2.1924	± .0036
		Deviation of Mean			± .0021
Iso propyl alcohol	17	10	2.8297	2.2100	+ .0051
	17	X	2.8168	2.1999	- .0051
	Total		5.6465	4.4099	.0102
	Av		2.8232	2.2049	± .0051
		Deviation of Mean			± .0036
Chloroform	16	III	1.4938	2.2108	+ .0015
	16	7	1.4932	2.2099	+ .0016
	16	8	1.4913	2.2071	- .0022
			4.4783	6.6278	.0044
			1.4928	2.2093	± .0015
		Deviation of Mean			± .0009

Substance	Run No.	Tube No.	W_g/W_{dl}	D_{gel}	Deviation	
Petroleum ether	15	0	3.5320	2.2216	+	.0006
	15	3	3.5322	2.2228	-	.0006
		Total	7.0624	4.4444		.0012
		Av	3.5312	2.2222	±	.0006
		Deviation of Mean			±	.0004
Water	2	2	2.2358	2.2293	+	.0083
	2	3	2.2309	2.2244	-	.0011
	4	3	2.2365	2.2300	+	.0045
	5	3	2.2271	2.2206	-	.0049
	6	3	2.2275	2.2210	-	.0044
	10	III	2.2328	2.2263	+	.0008
	8	3	2.2332	2.2267	+	.0012
		Total	15.6238	15.5783		.0207
		Av	2.2320	2.2255	±	.0029
		Deviation of Mean			±	.0011
Pentane	13	II	3.6190	2.2507	+	.0005
	13	X	3.6173	2.2496	-	.0005
		Total	7.2363	4.5003		.0010
		Av	3.6181	2.2502	±	.0005
		Deviation of Mean			±	.0003

Substance	Run No.	Tube No.	W_g/W_{dl}	D_{gel}	Deviation
Ethyl alcohol	8	1	2.9159	2.2893	- .0115
	8	2	2.9517	2.3174	+ .0166
	9	4	2.9503	2.3163	+ .0155
	9	5	2.9365	2.3054	+ .0046
	11	7	2.9213	2.2935	- .0073
	11	8	2.9080	2.2831	- .0177
		Total	17.5837	13.8050	.0783
		Av	2.9306	2.3008	± .0122
		Deviation of Mean			± .0050
	11	9	2.9768	2.3371	43 days
Acetone	10		2.9589	2.3210	- .0021
	10		2.9643	2.3252	+ .0021
		Total	5.9232	4.6462	.0042
		Av	2.9616	2.3231	± .0021
		Deviation of Mean			± .0015
Ether	14	0	3.3531	2.3730	+ .0029
	14	3	3.3612	2.3787	- .0029
		Total	6.7143	4.7517	.0058
		Av	3.3571	2.3759	± .0029
		Deviation of Mean			± .0014

Summary of Data

Substance	W_g/W_{dl}	D_{gel}	Deviation of Mean
Mercury	0.09448	1.2841	± .0004
		1.277+	
Carbontetrachloride	1.3497	2.1478	± .0020
Carbondisulphide	1.7206	2.1672	± .0031
Benzene	2.5004	2.1851	± .0001
Helium		2.188+	
Nitrobenzene	1.8296	2.1924	± .0021
Isopropylalcohol	2.8232	2.2049	± .0036
Chloroform	1.4928	2.2093	± .0009
Petroleum ether	3.5312	2.2222	± .0004
Water	2.2320	2.2255	± .0011
		2.226+	
Pentane	3.6181	2.2502	± .0003
Ethyl alcohol	2.9306	2.3008	± .0005
Acetone	2.9616	2.3231	± .0015
Ether	3.3571	2.3759	± .0028

+Values by J. A. Ikerman

Table 1 and Table 1-a are a comparison of the apparent densities of silica gel with those determined by Harkins and Ewing[1] for gas mask charcoal, and they are arranged in order of increasing apparent densities. This table also contains the calculated pore volume, per cent compressibility at 12,000 atmospheres, surface tension γ, viscosity η in absolute units, the ratio γ/η and the value of b for Vander Waal's equation. The pore volumes in these tables are calculated not on a basis of compressibility of the liquids, but on a change in density of the silica gel and charcoal as calculated by Harkins.

This is not a true assumption, but was used as a basis of calculation due to the uncertainty of the true block density of carbon. The pore volume is given by the following equation:

$$1 - \frac{d \text{ in mercury}}{d \text{ in liquid}}$$

The density determined with mercury being the weight of 1 cc. of charcoal in vacuum, for the mercury does not wet the surface or enter the pores of the charcoal. On this basis any increase in density is due to the weight of liquid entering the charcoal system. This same reasoning applys to a silica gel system. There appears to be no correlation between the two sets of data which is not at all unexpected.

Table I SILICA GEL

1	2	3	4	5	6	7	8
Liquid	Apparent Density	Pore Volume 1 cc.	% compressed 12,000 atmospheres	Surface Tension Dynes per Cm. γ	Viscosity Absolute Units η	γ/η	b X 104
Mercury	1.2841			57.0			
	1.277+						
Carbon Tetrachloride	2.1478	0.4021		26.15	0.0096		
Carbon disulfide	2.1672	0.4075	25.75	31.38	0.0037	8480	34
Benzene	2.1851	0.4123		28.88	0.0064	4510	54
Helium	2.188+						
Nitrobenzene	2.1924	0.4143		43.4			
Iso Propyl Alcohol	2.2049	0.4176		21.3	0.0204	10430	
Chloroform	2.2093	0.4188		27.13	0.0223	4760	45
Petroleum Ether	2.2222	0.4221					
Water	2.2255	0.4229	20.51	72.8	0.0101	7200	14
	2.226+						
Pentane	2.2502	0.4293	More than ether	About 15	0.0024	6200	65
Ethyl Alcohol	2.3008	0.4419		21.85	0.0114	19190	37
Acetone	2.3231	0.4472	27.0	23.50	0.0033	7120	44
Ether	2.3759 2.390 20o++	0.4596	30.0	17.10	0.0024	7125	39

+ J.A.Ikerman[5]; ++ Berle and Urban[4]; Values by Harkins

Table I-a GAS MASK CHARCOAL

1	2	3	4	5	6	7	8
Liquid	Apparent Density	Pore Volume 1 cc.	% compressed 12,000 atmospheres	Surface Tension Dynes per Cm. γ	Viscosity Absolute Units η	γ / η	b X 10^4
Mercury	0.865			57.0			
Water	1.843	0.534	20.51	72.8	0.0101	7200	14
Propyl Alcohol	1.960	0.559	22.93	23.7	0.0223	1062	76
Chloroform	1.992	0.566		27.13	0.0057	4760	45
Benzene	2.008	0.568		28.88	0.0064	4510	54
p-Xylene	2.018	0.571		28.33	0.0064	4430	81
Petroleum Ether	2.042	0.579					
Carbon disulfide	2.057	0.580	25.75	31.38	0.0037	8480	34
Acetone	2.112	0.590	27.0	23.50	0.0033	7120	44
Ether	2.120	0.592	30.0	17.1	0.0024	7125	39
Pentane	2.129	0.593	More than Ether	About 15	0.0024	6200	65

Table 2 and 2-a shows the pore volumes for carbon and silica gel recalculated on a basis of density change. Using a density of 2.26 for the true density of the charcoal for this was the value found by Howard and Hulett[3] using helium as a non-polar indifferent medium and checks very closely with their value determined for graphite. This density is also verified by the fact that the xray analysis made by Debye and Scherrer[6] shows no difference between graphite and charcoal.

In recalculating it should be pointed out that the pore volume of silica gel, a density of 2.651[7], has been used as the true density for the gel. 2.651 is the density of quartz and is based on the work of Berle and Urban[4] using ether as a liquid. They obtained a value of 2.625 for a gel that had been dehydrated with hydrochloric acid and a value of 2.685 for quartz. This same gel when activated at 300° gave an apparent density with ether of 2.390 at 20°. This is in agreement with our value determined with ether.

The value 2.651 may be too high, but in calculating the degree to which the various liquids must be compressed to give the apparent density measured, we are using the limiting value, for 2.651 is the maximum density of quartz and will give the maximum pore value for 1 cc. of gel. Thus in calculating the volume change in the various liquids, we are determining the minimum possible.

The following values are also tabulated in tables 2 and 2-a: Normal density of liquid at 25o, grams of

liquid adsorbed per cc. of system, grams liquid adsorbed per gram gel or carbon, density of adsorbed liquid, compression of 1 cc. of liquid, volume of liquid adsorbed per cc. of system, available data per cent compressibility of liquids at 8000 atmospheres, and pressure necessary to cause compression. The pressure calculations are only approximations, as no exact data exists for the higher pressures.

Table 2

SILICA GEL VOL GEL 1 CC SYSTEM .4844 CC PORE VOLUME 1 CC SYSTEM .5156 CC

Liquid	Density of Liquid 25°	Grams Liq. adsorbed per cc. system	Grams Liq. per gram SiO_2	Density of adsorbed liquid	1 cc. Liq. compressed to	Vol. of Liq. adsorbed per cc. of system	% Compressed at 8000 At.[1]	Pressure At.
Mercury	13.5340							
Carbon-tetrachloride	1.5913	0.8637	0.6726	1.6751	0.9500	0.5427		
Carbon-disulfide	1.2596	0.8831	0.6877	1.7127	0.7354	0.7011	22.16	10,470
Benzene	0.8739	0.9010	0.7017	1.7474	0.5001	1.0310		
Nitro-benzene	1.1983	0.9083	0.7073	1.7616	0.6820	0.7560		
Isopropyl-Alcohol	0.7810	0.9208	0.7171	1.7859	0.4373	1.1790		
Chloroform	1.4800	0.9252	0.7205	1.7944	0.8247	0.6252		
Petroleum Ether	0.6293	0.9381	0.7306	1.8194	0.3459	1.4906		
Water	0.9971	0.9414	0.7331	1.8258	0.5461	0.9441	17.64	20,550
Pentane	0.6219	0.9661	0.7524	1.8737	0.3319	1.5534		
Ethyl-Alcohol	0.7851	1.0167	0.7918	1.9719	0.3981	1.2951	22.92	20,975
Acetone	0.7844	1.0390	0.8091	2.0151	0.3893	1.3244	23.87	12,580
Ether	0.7077	1.0918	0.8502	2.1175	0.3342	1.5428	26.68	19,980
Water+ No Temp.given			.7694					

+ Nutting

1 International Critical tables

Table 2-a

GAS MASK CHARCOAL VOL 1 CC SYSTEM .3827 cc PORE VOLUME 1 CC SYSTEM .6173 cc

Liquid	Density of Liq. 25°	Grams Liq. adsorbed per cc.	Grams Liq. per gram charcoal	Density of adsorbed Liquid	1 cc. Liq. compressed to	Vol of Liq. adsorbed per cc. system	% Compressed at 8000 atmos.[1]	Pressure Atmospheres
Mercury	13.5340							
Water	0.9971	0.978	1.131	1.584	0.629	0.981	17.64	16,850
Propyl-Alcohol	0.8001	1.095	1.266	1.773	0.451	1.368	20.58	17,010
Chloroform	1.4800	1.127	1.303	1.825	0.811	0.761		
Benzene	0.8739	1.143	1.321	1.851	0.472	1.308		
p-Xylene	0.8600	1.153	1.333	1.868	0.460	1.341		
Petroleum Ether	0.6293	1.177	1.361	1.907	0.321	1.923		
Carbon-disulfide	1.2596	1.192	1.378	1.931	0.652	0.947	22.16	16,300
Ether	0.7077	1.255	1.451	2.033	0.348	1.774	26.68	19,600
Acetone	0.7844	1.247	1.442	2.020	0.388	1.591	23.87	20,500
Pentane	0.6219	1.264	1.461	2.048	0.304	2.031		

1 International Critical Tables

Table 3 is a tabulation of data in regard to change in apparent density with time.

Table 3

Substance	Run No.	Tube No.	Time	Density	Deviation
Water	8	3	5 days	2.2267	+ .0020
Water	10	III	20 "	2.2263	+ .0016
Mean 5 determinations (1-6) hrs				2.2247	± .0040 Av deviation of 5 determinations
Alcohol	11	7	19	2.2935	- 0136
Alcohol	11	8	19	2.2831	- 0240
Alcohol	11	9	41	2.3371	+ 0300
Mean 4 determinations (1-6) hrs				2.3071	± 0072 Av deviation of 4 determinations

Water shows no increase over a period of 5 to 20 days, and alcohol no increase at the end of 19 days. The tube which run 41 days does show an increase, but this being an isolated case and not checked on definite conclusions can be made in regard to it.

Conclusions

The apparent density of silica gel was determined in thirteen liquids. There seems to be no correlation between the densities in this series and the corresponding apparent densities determined with the same liquids in charcoal.

Evacuated silica gel treated with a liquid reaches equilibrium conditions with it in a few hours.

Bibliography

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