The Specific Gravities of mixtures of Butyl Alcohol and Water.

By Yeshwant Dattatraya Wad and Ananth Gundo Gokhale.

In the course of our work in connection with the manufacture of acetone, normal butyl alcohol, the chief by-product, was always obtained in a more or less wet state and it became necessary to find out the actual strength of the product by a simple means. Obviously specific gravity was the simplest property that could be used for the purpose. As no data regarding specific gravity values for aqueous mixtures of butyl alcohol were available it was decided to determine the values ourselves. The following gives an account of the work done in this direction.

Preparation of Anhydrous Alcohol.

The alcohol was considered pure and anhydrous when it distilled colourless at its boiling point and did not turn anhydrous copper sulphate blue. It was found that mere fractionation could never give a product answering the above tests. Hence the purified constant boiling product was kept over freshly ignited potassium carbonate for about 15 days and redistilled. It was found out that even in this case a part of the first distillate was always slightly wet and hence it was rejected and the receiver rinsed with a little of the anhydrous product after it began to come over and then an amount was collected for the day's work.

Every day fresh alcohol was prepared as it was found that a slight amount of moisture was always absorbed in a few hours even when stored in dry, perfectly tight, stoppered bottles. The vessels used in the experiments including the weighing bottle were always carefully dried.

Weighing Bottle.

The specific gravity bottle used was about 50 cc. in capacity, had a thermometer in its stopper, the bulb reaching almost to the bottom and had a side arm on to which a mark had been etched. This arm was also closed by a hollow stopper of a conical shape.

Making Mixtures.

The same sample of ordinary laboratory distilled water that left no residue on evaporation was stored once for all in a

carefully cleaned bottle. This was used throughout the experiments in the hope that the same error due to impurities in the water will be present in all the mixtures made. About 60 cc. of the alcohol were transferred to a weighed dry stoppered flask and weighed. The calculated volume of water was added and the mixture again weighed. The whole thing was well shaken and kept for about half an hour before the bottle was filled.

Filling the bottle.

The bottle was at first quickly filled to the brim and the stopper carefully introduced. The liquid that overflowed was wiped away by a filter paper. The bottle was then immersed up to the neck in a bath of water kept nearly at the temperature required. The liquid in the side arm was then brought up to the mark by a small glass capillary. The error in observation was minimised by taking readings when the liquid column rose or fell through a slight variation of temperature purposely made. When the column always stood at the mark at the required temperature whether it was falling or rising it was considered to be correctly filled. The bulb stopper was then put on and the bottle kept at the temperature in question for half an hour and the level of the column was observed. When it was steady throughout, the bottle was taken out wiped dry, and kept for about 30 minutes in the balance which was cooled to a temperature nearly equal to that at which the bottle had been kept, and then weighed twice at an interval of 10 minutes.

Testing the efficiency of the whole method of determining the Specific Gravity.

To test the efficiency of the method the ratio of the density of water at 23°C as compared with the density at 0°C was determined and compared with Kopp's value given in Clowes and Coleman's Quantitative Analysis.

It was as follows:—

$$\frac{\text{Weight of Water at } 23^\circ\text{C}}{\text{Weight of Water } 0^\circ\text{C}} = 0{\cdot}998361$$

Correcting for the expansion of the bottle.

$$= \frac{0{\cdot}998361}{1+23\times 0{\cdot}000025} = \frac{0{\cdot}998361}{1{\cdot}000575} = 0{\cdot}997787$$

The ratio in the book = 0·997780.

It will be seen that the agreement is fairly satisfactory. It was then found out how far the results of duplicates vary. The

following is an example giving an idea of the error of experiment. The variation from the mean in the weight of alcohol at 20°C.

(1) +0·0037
(2) −0·0075
(3) +0·0098

The variation from the mean in the weight of alcohol at 25°C.

(1) −0·027
(2) +0·053
(3) +0·036
(4) −0·063

It was then considered that the method was sufficiently accurate to proceed further. The results are given in the tables attached.

The results were calculated as follows :—

The actual weight of the mixture was corrected for the expansion of the volume of the bottle from 4°C to the temperature in question. The weight of water at that temperature was determined and divided by the specific gravity of water at the same temperature giving the volume of the bottle at the temperature. This volume was then reduced to 4°C.

$$\frac{\text{Weight of water at 20°C}}{\text{Sp. gr. of water at 20°C.}} = \frac{50{\cdot}1092}{0{\cdot}9983}$$

$\therefore$ Vol. of bottle at 20°C = 50·19490 cc.

$$Vt = V4\ 1 + {\cdot}000025\ (t-4)$$
$$= V4\ (1 + 0{\cdot}0004)$$
$$\therefore\ V4 = \frac{Vt}{1{\cdot}0004}$$
$$= 50{\cdot}1748$$
$$\frac{50{\cdot}1748}{50{\cdot}1949} = 0{\cdot}9996$$

Factor for reducing all weights taken at 20°C to the proper value.

Similarly for 25°C the factor is 0·9994.

This corrected weight of the mixture was divided by the weight of the same volume of water at 4°C the specific gravity of

which was assumed to be unity. The result gave the specifi gravity of the mixture in question. In all cases the averag weight of two or three experiments was taken for calculation The values were plotted on curves and the intermediate ones ob tained by interpolation. The position of doubtful values was fixe by calculation.

TABLE I.

The actual weights of the different mixtures togethe with the bottle, at temperatures 20°C and 25°C.

% Water.	20°C.	25°C.
	76·538	76·391
0	76·555	76·384
	76·540	...
2·17	76·7678	76·5772
	76·7715	76·575
4·08	...	76·7701
		76·7708
		76·7720
3·88	76·9429	...
	76·9437	...
5·59	77·1098	...
	77·1081	...
7·41	77·283	...
	77·2792	...
8·78	77·4067	77·2145
	77·4055	77·2157
10·57	77·6191	...
	77·6202	...
13·01	77·8015	77·6136
	77·8014	77·6119
13·75	...	77·6857
		77·6833
13·77	77·8668	...
	77·8707	...
14·86	...	77·7702
		77·7710
16·37	78·1069	...
	78·106	...
17·86	78·2452	...
	78·2429	...
17·78	...	78·0475
		78·0483
18·55	78·3065	...
	78·3069	...

TABLE I.—(Continued)

% Water.	20°C.	25°C.
94·29		85·5105
		85·5113
94·9	85·6202	85·5569
	85·6208	85·5579
96·2	85·7133	85·6510
	85·7132	85·6516
98·43	85·8758	85·8212
	85·8749	85·8211
100	86·0060	85·9493
	86·0058	85·9497

TABLE II.

Specific gravities actually determined.

Temperature 20°C.

% Water.	Actual weight.	Corrected weight.	Specific gravity
0·0	40·6394	40·6231	0·8096
2·17	40·8730	40·8566	0·8143
3·88	41·0465	41·0300	0·8177
5·59	41·2120	41·1955	0·8210
7·41	41·3844	41·3678	0·8245
8·78	41·5094	41·4928	0·8269
10·57	41·7229	41·7062	0·8312
13·01	41·9047	41·8879	0·8348
13·77	41·9710	41·9542	0·8361
16·37	42·2097	42·1928	0·8409
17·86	42·3474	42·3304	0·8436
18·55	42·4100	42·3930	0·8449
19·9	Layers		
92·71	Layers		
94·9	49·7238	49·7039	0·9906
96·2	49·8165	49·7866	0·9924
98·43	49·9787	49·9587	0·9956
100·0	50·1092	50·0891	0·9983

Table III.

Specific gravities actually determined.

Temperature 25°C.

% Water.	Actual weight.	Corrected weight.	Specific gravity.
0·0	40·4908	40·4665	0·8066
2·17	40·6794	40·6550	0·8103
4·08	40·8747	40·8501	0·8142
8·78	41·3184	41·2936	0·8239
13·01	41·7160	41·6909	0·8310
13·75	41·7878	41·7627	0·8324
14·86	41·8739	41·8487	0·8341
17·78	42·1492	42·1239	0·8396
20·19	Layers	...	...
93·04	Layers	...	...
94·29	49·6142	49·5844	0·9883
94·89	49·6607	49·6309	0·9892
96·2	49·7536	49·7237	0·9911
98·43	49·9245	49·8945	0·9945
100·0	50·0528	50·0237	0·9970

Table IV.

Specific gravities of aqueous butyl alcohol as obtained from the graphs.

Temperature 20°C.

% Water.	Specific gravity.
0·0	0·8096
0·5	0·8107
1·0	0·8118
1·5	0·8129
2·0	0·8139
2·5	0·8149
3·0	0·8159
3·5	0·8170
4·0	0·8180
4·5	0·8190
5·0	0·8200
5·5	0 8210
6·0	0·8219
6·5	0·8229

TABLE IV.—(Continued).

Temperature 20°C.

% Water,		Specific gravity.
7·0		0·8238
7·5		0·8247
8·0		0·8256
8·5		0·8265
9·0		0·8274
9·5		0·8283
10·0		0·8292
10·5		0·8301
11·0		0·8310
11·5		0·8320
12·0		0·8329
12·5		0·8338
13·0		0·8347
13·5		0·8356
14·0		0·8366
14·5		0·8375
15·0		0·8384
15·5		0·8393
16·0		0·8402
16·5		0·8411
17·0		0·8420
17·5		0 8429
18·0		0·8439
18·5		0·8448
19·9	Layers	
92·7	Layers	
95·0		0·9908
96·5		0·9914
96·0		0·9921
96·5		0·9928
97·0		0·9935
97·5		0·9942
98·0		0·9950
98·5		0·9958
99·0		0·9966
99·5		0·9974
100·0		0·9983

TABLE V.

Specific gravities of aqueous Butyl alcohol as obtained from the graphs.

Temperature 25°C.

% Water.	Specific gravity.
0·0	0·8066
0·5	0·8075
1·0	0·8083
1·5	0·8092
2·0	0·8101
2·5	0·8110
3·0	0·8120
3·5	0·8129
4·0	0·8139
4·5	0·8149
5·0	0·8159
5·5	0·8169
6·0	0·8179
6·5	0·8190
7·0	0·8200
7·5	0·8211
8·0	0·8221
8·5	0·8231
9·0	0·8241
9·5	0·8250
10·0	0·8258
10·5	0·8266
11·0	0·8275
11·5	0·8284
12·0	0·8292
12·5	0·8301
13·0	0·8310
13·5	0·8319
14·0	0·8328
14·5	0·8337
15·0	0·8346
15·5	0·8356
16·0	0·8365
16·5	0·8375

TABLE V.—(Continued).

Temperature 25°C.

% Water.	Specific gravity.
17·0	0·8385
17·5	0·8395
20·19	Layers
93·04	Layers
94·5	0·9886
95·0	0·9893
95·5	0·9901
96·0	0·9908
96·5	0·9916
97·0	0·9923
97·5	0·9931
98·0	0·9939
98·5	0·9947
99·0	0·9955
99·5	0·9962
100·0	0·9970

In conclusion it must be noted that the bulk of the experimental work after it assumed a routine form was done by Mr. V. L. Chandratreya, junior chemist. Our thanks are specially due to Mr. Paranjpe for useful suggestions.

DEPARTMENT OF APPLIED CHEMISTRY,
INDIAN INSTITUTE OF SCIENCE,
BANGALORE.

I. I. S. No. 68—M. R. P. B.—1-1921.—500.