REFRACTIVE INDICES OF SOLUTIONS OF HYDROCHLORIC ACID, ACETIC ACID AND ETHANOL IN WATER AT 25° AND 30°

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The convenience of the dipping refractometer as a quick means of determining the concentration of solutions of pure substances in water is well known. However, its ready use in our laboratory for the analysis of solutions of hydrochloric acid,¹ acetic acid,² and ethanol³ in water was hampered by the lack of sufficient data at the usual laboratory temperatures, the data of previous observers usually being taken at temperatures not conveniently maintained in many American laboratories, or else not covering the range of concentrations desired.

The hydrochloric acid and acetic acid solutions used in the following measurements were prepared from C. P. chemicals which were diluted with distilled water and the solutions aerated with clean air to remove carbon dioxide. The strength of these acid solutions was then determined by titrating a weighed amount of a solution with standard barium hydroxide. The strength of the barium hydroxide was determined by titrating

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¹ Willigen: Arch. Mus. Teyler, **2**, 209 (1869); Schivers: Jour. Chim. phys., **8**, 530 (1910); Schivers: Bull. Acad. roy. belg. (1910); Le Blanc: Zeit. phys. Chem., **4**, 553 (1889); Wagner: Zeit. öfentl. Chem., **11**, 404 (1905); Wagner: Tabellen zum Eintauchrefraktometer, Sondershausen (1903); Hallwachs: Wied. Ann., **53**, 1 (1894).

² Rimbach and Wintgen: Zeit. phys. Chem., **74**, 233 (1910); Buchkreimer: Diss. Bonn (1890); Halwachs: Wied. Ann., **53**, 1 (1894); Wagner: Tabellen zum Eintauchrefraktometer, Sondershausen (1903); Zeit. öfentl. Chem. **11**, 404 (1905); LeBlanc: Zeit. phys. Chem., **4**, 553 (1889) (R); Landolt: Pogg. Ann., **117**, 353 (1862).

³ Andrews: Jour. Amer. Chem. Soc., **30**, 363 (1908); Schivers: Zeit. phys. Chem., **75**, 357 (1911); Leech and Lythgoe: Jour. Am. Chem. Soc., **37**, 954 (1905); Wagner: Tabellen zum Eintauchrefraktometer. Sondershausen (1903); Zeit. öfentl. Chem., **11**, 404 (1905); Hess: Wien. Ber., **114**, 1231 (1905); Sidersky: Bull. assoc. chim. suc. dist., **27**, 1169 (1910).

it against a hydrochloric acid solution which has been standardized by precipitation as silver chloride.

TABLE I
Refractive Indices of Water Solutions at 25°

Hydrochloric Acid			Hydrochloric Acid		
C	S	N _D	C	S	N _D
160.3	98.06	1.36395	54.79	44.20	1.34433
148.6	92.17	1.36187	46.07	39.46	1.34255
114.6	75.56	1.35590	36.92	34.32	1.34060
103.3	69.62	1.35374	26.81	28.72	1.33847
93.49	64.59	1.35190	17.72	23.57	1.33651
84.67	60.10	1.35025	8.02	17.90	1.33432
73.81	54.46	1.34816	0.00	13.20	1.33251
65.90	50.32	1.34662	—	—	—

Acetic Acid			Acetic Acid		
C	S	N _D	C	S	N _D
405.32	64.52	1.35187	179.87	40.86	1.34308
407.12	65.56	1.35226	152.45	37.25	1.34172
367.90	61.28	1.35068	120.41	32.76	1.34001
333.44	58.06	1.34949	92.93	28.76	1.33848
303.94	55.05	1.34838	71.75	25.40	1.33720
266.89	51.17	1.34694	47.42	21.46	1.33569
239.65	48.11	1.34579	25.37	17.76	1.33427
220.39	45.82	1.34493	—	—	—

Ethanol			Ethanol		
C	S	N _D	C	S	N _D
397.12	62.75	1.35123	161.94	37.51	1.34181
283.73	61.77	1.35086	129.24	32.76	1.34001
341.34	58.37	1.34961	104.72	29.17	1.33864
301.30	54.52	1.34818	82.92	25.87	1.33739
274.87	51.56	1.34709	59.46	22.35	1.33604
241.17	47.75	1.34566	41.23	19.60	1.33498
211.10	44.06	1.34428	24.93	17.11	1.33402
181.05	40.07	1.34278	—	—	—

The ninety-five percent grain alcohol used in preparing the ethanol solutions was diluted with water, filtered through magnesium carbonate, and then twice distilled, the final dis-

tillate¹ being diluted with distilled water to prepare the samples.

TABLE II
Refractive Indices of Water Solutions at 30°

Hydrochloric Acid			Hydrochloric Acid		
C	S	N _D	C	S	N _D
160.3	96.37	1.36336	54.79	43.12	1.34393
148.6	90.58	1.36130	46.07	38.25	1.34210
114.6	74.00	1.35534	36.92	33.24	1.34019
103.3	68.26	1.35325	26.81	27.52	1.33802
93.49	63.33	1.35144	17.72	22.45	1.33608
84.67	58.80	1.34977	8.02	16.76	1.33389
73.81	53.20	1.34769	0.00	12.00	1.33204
65.90	49.00	1.34613	—	—	—
Acetic Acid			Acetic Acid		
C	S	N _D	C	S	N _D
405.32	61.52	1.35077	179.87	38.63	1.34223
407.12	62.53	1.35115	152.45	35.17	1.34092
367.90	58.47	1.34964	120.41	30.80	1.33926
333.44	55.31	1.34847	92.93	26.92	1.33779
303.94	52.41	1.34740	71.75	23.73	1.33657
266.89	48.62	1.34598	47.42	19.86	1.33509
239.65	45.73	1.34490	25.37	16.18	1.33366
220.39	43.44	1.34405	—	—	—
Ethanol			Ethanol		
C	S	N _D	C	S	N _D
397.12	59.43	1.35000	161.94	35.65	1.34111
283.73	58.72	1.34974	129.24	31.00	1.33934
341.34	55.30	1.34847	104.72	27.65	1.33807
301.30	51.82	1.34718	82.92	24.31	1.33679
274.87	48.90	1.34609	59.46	20.94	1.33550
241.17	45.35	1.34476	41.23	18.20	1.33444
211.10	41.79	1.34342	24.93	15.76	1.33351
181.05	38.10	1.34204	—	—	—

The concentrations of these ethanol solutions were then calculated from the densities.² The accurate work on the

¹ The ethanol thus obtained may have contained a trace of aldehydes and ketones.

² Bureau of Standards Circular, No. 19.

refractive indices of potassium chloride solutions at 25° by Baxter and his students¹ was utilized in checking the scale of the refractometer used and it was found to be correct.

The temperature of the solutions was kept constant to $\pm .05^\circ$ during the measurements by an automatically controlled thermostat.

The results obtained are given in Tables (I) and II) where C is the concentration of solute in grams per 1000 grams of water, S is the scale reading of the refractometer and N_D is refractive index for sodium light.

By plotting the above data, curves may be drawn from which a set of tables can be prepared. By reference to these tables, the concentration of a solution of any one of the three substances can be found by taking a single reading with the dipping refractometer at room temperature.

Summary

The refractive indices at 25° and 30° are given for a number of solutions of hydrochloric acid, acetic acid and ethanol in water.

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¹ Jour. Am. Chem. Soc., **33**, 922 (1911).