846. *The Apparent Dissociation Constants of Various Weak Acids in Mixed Aqueous Solvents*

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We have continued a series of measurements of the p*K*s of various weak acids in mixed aqueous solvents using the techniques previously described.[1] The interest in the previous work lay in the practically invariant apparent p*K*s of α-amino-acids in the solvent mixtures used. The Table shows that some other bifunctional acids such as sulphamic and sulphanilic acids also show less variation as between the different solvents than do normal carboxylic or other weak acids. There is a gradation in behaviour between ordinary acids, whether aliphatic, aromatic, or inorganic, in which Δp*K* is generally greater than 1, and the aliphatic amino-acids in which Δp*K* is usually much less than 0·5 (*N*-phenylglycine has Δp*K* 0·73 and 0·95 in the solvents used).

Apparent dissociation constants of various weak acids in mixed aqueous solvents
[$\Delta pK_A = pK$(aq. acetone) $-$ p*K* (water)] etc.

Acid	Water	Acetone 44·2% aq. A	Dioxan 50·9% aq. B	DMF ‡ 48·7% C	ΔpK_A	ΔpK_B	ΔpK_C
Acetic	4·75	5·90	6·30	6·30	1·15	1·55	1·55
α-Alanine	10·02	10·04	10·35	10·27	0·02	0·13	0·25
β-Alanine	10·25	10·07	10·51	10·25	−0·18	0·26	0·00
Anthranilic	5·00	6·22	6·75	6·35	1·22	1·75	1·35
m-Aminobenzoic	4·80	5·93	6·17	5·92	1·13	1·37	1·12
p-Aminobenzoic	4·60	6·45	6·84	6·68	1·85	1·24	2·08
o-Aminophenol	10·05	11·50	11·70	11·70	1·45	1·65	1·65
m-Aminophenol	9·96	11·66	11·74	11·83	1·70	1·78	1·87
Arsenious	9·38	10·35	10·68	10·31	0·97	1·30	0·93
Aspartic	3·92	4·76	5·06	4·88	0·84	1·14	0·96
	9·95	10·33	10·79	10·46	0·38	0·84	0·51
Benzoic	4·25	5·32	6·20	5·50	1·17	1·95	1·25
Glutamic	4·35	5·18	6·13	5·47	0·83	1·78	1·12
	9·85	10·14	10·63	10·33	0·29	0·78	0·48
Histidine	9·40	9·10	9·67	10·19	−0·30	0·27	0·79
o-Nitrophenol	7·15 †	8·25	8·43	—	1·1 †	1·28 †	—
p-Nitrophenol	7·28	7·67	8·13	8·04	0·39	0·85	0·76
m-Nitrophenol	8·37	9·5 *	9·5 *	—	1·1 *	1·1 *	—
Phenylalanine	9·30	9·30	9·45	9·71	0·00	0·15	0·41
N-Phenylglycine	4·59	5·32	5·54	5·42	0·73	0·95	0·83
Phosphoric	2·75	3·20	3·85	4·08	−0·45	1·15	1·23
	7·15	8·15	8·62	8·92	1·00	1·47	1·77
Proline	10·83	10·98	10·95	11·11	0·15	0·12	0·28
Sarcosine	10·45	10·30	10·51	10·45	−0·15	0·06	0·00
Sulphanilic	2·93	3·01	3·27	3·18	0·08	0·34	0·25
Sulphamic	1·19	1·62	1·83	2·56	0·43	0·64	1·37
Taurine	9·07	8·87	9·28	9·25	−0·20	0·21	0·18

* Estimated values; titration curve shows no break. † Aqueous solution 0·008N; others 0·025N.
‡ N.N. Dimethylformamide.

The small variation in the p*K*s of ordinary α-amino-acids has been attributed to a buffering action on the electrode system.[1] If this idea has any validity the results for sulphanilic [2] and sulphamic [3] acid imply that the buffering action may be effective in quite

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acid solution. The fact that these two acids fall in a group with the zwitterions is confirmation of their zwitterionic character in solution about which there has been some debate,[2,3] although this characteristic has been confirmed for crystalline sulphamic acid.[4]

The amino-benzoic acids, as expected from the weakly basic character of their amino-group, show no allegiance to the zwitterionic group. Similarly *N*-phenylglycine behaves as an ordinary carboxylic acid, whereas proline, which has the secondary nitrogen atom in a pyrrolidine ring (and is thus strongly basic), behaves like a normal amino-acid and has small values of ΔpK.

The results for *p*-nitrophenol are interesting since ΔpK (water–acetone) is of the same order as that found for some amino-acids, although for the other solvents it is rather higher. This implies that *p*-nitrophenol falls into the zwitterionic group, which is not the case either with *o*-nitrophenol or the aminophenols. The behaviour of the *p*-nitrophenol must therefore derive from its overall structural characteristics with the proton being released either from the nitro-group or from the ethereal oxygen of a quinonoid form.

Experimental.—Acids were reagent quality, recrystallised where necessary; they were 0·025N unless otherwise stated. 0·5N-Sodium hydroxide was used in the titrations. The determinations were carried out as previously described [1] using a Doran or Cambridge pH meter, standardised at pH 4 and 9·2, a wide-range glass electrode and a calomel cell. The p*K*s were calculated using the simplified form of the Henderson equation corrected below pH 4 for the actual concentration of acid at half neutralisation.

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