

734. *Spectrophotometric Determinations of the Second Dissociation Constant (as pK_a) of 5- and of 6-Aminoquinoline.*

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The absorption spectra at different pH values being used, pK_a values for 5- and 6-aminoquinoline are found to be about 0.97 and 1.63, respectively, for the mono-cation–di-cation change, as against 5.5 and 5.6 for the first pK_a values (due to acceptance of a proton by the ring nitrogen atom) previously determined potentiometrically.

THE absorption curves of 5- and 6-aminoquinoline vary markedly with the pH of the medium. The spectra of both substances dissolved in 2*N*-hydrochloric acid bear an unmistakable resemblance to that of quinoline in 0.01*N*-hydrochloric acid, *i.e.*, to that of the quinolinium ion. A similar resemblance between the spectra of benzene and of aniline in hydrochloric acid is well known (cf. Scheibe, Backenkoller, and Rosenberg, *Ber.*, 1926, 59, 2617; Harberts, Heertjes, Hulst, and Waterman, *Bull. Soc. chim.*, 1936, 3, 643; Sklar, *J. Chem. Physics*, 1939, 7, 984; *Rev. Mod. Physics*, 1942, 14, 232; Kumler and Strait, *J. Amer. Chem. Soc.*, 1943, 65, 2349). The same resemblance is shown between 3-, 8-, and 10-amino-1:2-benzanthracene in hydrochloric acid and 1:2-benzanthracene; between 5-amino-3:4-benzopyrene in acid and 3:4-benzopyrene; and between 4-aminopyrene in hydrochloric acid and pyrene (Jones, *J. Amer. Chem. Soc.*, 1945, 67, 2127). Furthermore, the spectra of the heterocyclic compounds, pyridine, quinoline, and acridine resemble respectively those of benzene, naphthalene, and anthracene (Braude, *Ann. Reports*, 1945, 42, 105).

Craig and Short (*J.*, 1945, 419) have observed that for all monoaminoacridines except the 5-isomeride the absorption spectra in 5*N*-hydrochloric acid agree with that shown by acridine itself in acid (acridinium ion). The amino-group in 5-aminoacridine is not converted at any time into the NH_3^+ form. By showing that the spectrum of the acridinium ion is observable only at low pH values when the di-cations of the aminoacridines are formed and not at an intermediary pH value (*e.g.*, 3), Craig and Short proved that the ring nitrogen atom accepts the first proton on acidification, and the nitrogen atom of the amino-group accepts the second. The former atom is thus the more basic one.

As shown below, the ring nitrogen atom in 5- and 6-aminoquinoline also accepts the first proton and the absorption spectrum shows a bathochromic shift. The second proton is accepted by the amino-nitrogen atom and the spectrum is changed to that of the quinolinium ion.

If the absorption spectra are determined quantitatively at various accurately determined pH values, pK_a values for the change from mono-cation to di-cation can be obtained. The equation

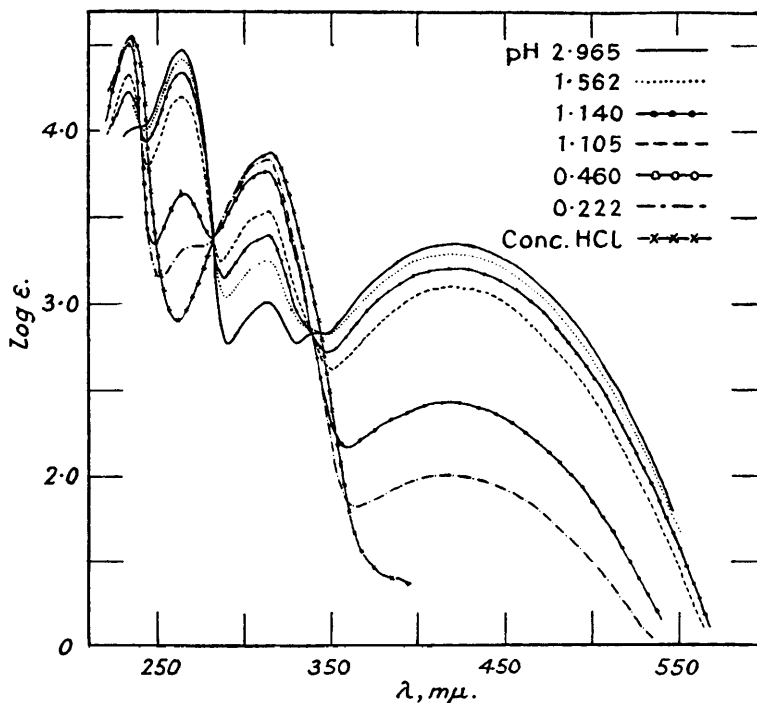
$$pK_a = \text{pH} - \log[(\epsilon_{BH^+} - \epsilon)/(\epsilon - \epsilon_B)]$$

TABLE I.
Absorption maxima and minima in quinoline and 5- and 6-aminoquinoline.

	$\lambda_{\text{max.}}, \text{A.}$				$\lambda_{\text{min.}}, \text{A.}$		
	λ	ϵ	λ	ϵ	λ	ϵ	λ
Quinoline :							
in 95% EtOH *	3120	2980	2780		3100	2950	2430
	3000	2800	3500		1900	2700	1500
in 0.01N-HCl	3120	2350			2500		
	6900	35000			190		
5-Aminoquinoline :							
in abs. EtOH	3550	2520			2890		
	3000	26000			900		
in ca. 0.005N-NaOH (aq. EtOH)	3420	2480			2815	225	
	3090	28200			944	9550	
in ca. 0.01N-HCl	4240	3140	2630	2340	3355	2905	2380
	2100	1100	30000	10000	600	680	9000
in ca. 2N-HCl	3150	2670	2340		2715	2500	
	6610	2140	34300		1950	1200	
6-Aminoquinoline :							
in EtOH	3575	2880	2460		3130	2745	
	3780	3910	36310		1220	3750	
in ca. 0.01N-HCl	3820	3085	2590		3330	2920	2360
	3240	2940	27500		1170	2390	8650
in ca. 0.005N-NaOH (aq. EtOH)	3460	2825	2430		3055	2735	2210
	3670	3410	34000		1330	3160	16000

* Ewing and Steck, *J. Amer. Chem. Soc.*, 1946, **68**, 2181.

FIG. 1.
Absorption spectra of 5-aminoquinoline in aqueous hydrochloric acid.



(Irvin and Irvin, *J. Amer. Chem. Soc.*, 1946, **68**, 2181) applies to measurements of molecular extinction coefficients (ϵ) at a given wave-length; ϵ_{BH^+} is determined at a low pH value at which the equilibrium is overwhelmingly in favour of the proton-donor BH^+ , and ϵ_{B} at some higher pH value at which the solute exists almost entirely as the proton-acceptor B; ϵ is the molecular extinction coefficient at a defined or measured intermediate pH at which B and BH^+ co-exist.

TABLE II.

 ϵ Values for 5-aminoquinoline at various pH values (see Fig. 1).

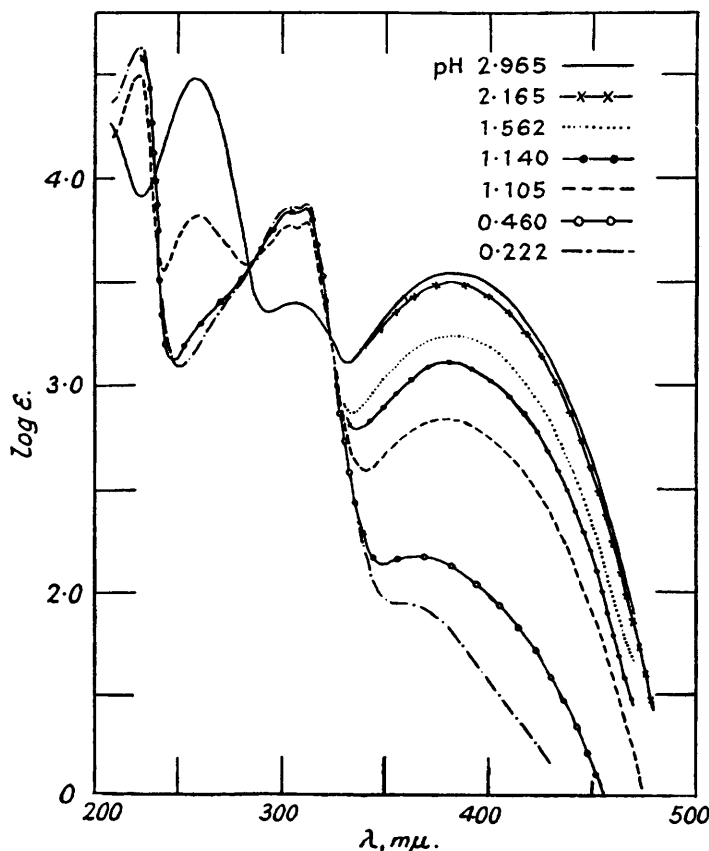
pH :	2.965	2.165	1.562	1.140	1.105	0.460	0.222	Conc. HCl
$\lambda_{\text{max.}}$, A.								
4160—4200	2210	2140	1940	1600	1260	270	100	0.24
3400	680	670	—	—	—	—	—	—
3120—3140	1030	1170	1790	2520	3440	5930	6900	7620
2700	—	—	—	—	—	—	2160	—
2640	29800	28500	26400	22100	15900	4330	—	—
2330—2350	10400	10400	14200	16900	21300	32800	35400	36200

Not all wave-lengths will be equally suitable; at some points near to isosbestic points the values of $\Delta\epsilon/\Delta\lambda$ may be high for the different ions and the results may be inaccurate. The validity of the procedure depends, however, on the existence of such crossing points in the spectra.

Table I shows that the change from ethanol to 0.01N-acid results in displacement of spectra, whereas alkali causes a shift in the opposite direction. Between 0.01N-acid and 2N-acid the spectra acquire the characteristics of the quinolinium ion (quinoline in 0.01N-acid).

FIG. 2.

Absorption spectra of 6-aminoquinoline in aqueous hydrochloric acid.



The data in Tables II and III were obtained by using a Beckman spectrophotometer, and the pH readings were made with a Marconi pH meter.

For both 5- and 6-aminoquinoline the mono-cations exist alone at pH 2.965 and the di-cations exist alone in concentrated hydrochloric acid.

TABLE III.

 ϵ Values for 6-aminoquinoline at various pH values (see Fig. 2).

pH :	2.965	2.165 *	1.562 *	1.14 *	1.105	0.460	0.222
$\lambda_{\max.}$, A. :							
3820	3520	3190	1720	1300	688	—	—
3650—3700	—	—	—	—	—	151	—
~3620	—	—	—	—	—	—	87.6
3120	—	—	—	—	6130	7200	7550
3050	2510	—	—	—	6900	6900	7200
2600	—	—	—	—	6630	—	—
2580	30300	—	—	—	—	—	—
2320	—	—	—	—	31200	39500	42600

* Readings made from 3400 to 5000 A. only.

Calculations of pK_a values were carried out at a large number of wave-lengths for the different pH values between the extremes. For 5-aminoquinoline calculations were made at 60-A intervals between 3650 and 5700 A., and for 6-aminoquinoline at 100-A. intervals between 3400 and 4700 A. The results are shown below :

	pK_a Values.						
pH at which curve was measured ...	2.165	1.562	1.140	1.105	0.460	0.222	
5-Aminoquinoline (average)	0.628	0.698	0.707	1.037	1.314	1.456	Average 0.97
6-Aminoquinoline (average)	1.240	1.591	1.414	1.820	2.092	—	Average 1.63

The degree of agreement between the pK_a at the various intermediate pH values is reasonably good considering the range and the fact that in neither of the two families of curves is there a *strictly* isosbestic point in the region 3300—3500 A. It is, however, perfectly clear that the overall average pK_a values are very different from the "first" pK_a values of 5.5 and 5.6 recorded for the ring nitrogen atom in 5- and 6-aminoquinoline, respectively, by Morley and Simpson (*J.*, 1949, 1014).

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