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Short Communication

Acidity constants for *cis*-diaquadiammineplatinum(II), the aquated form of cisplatin

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Abstract

pK_a values for *cis*-$[Pt(NH_3)_2(OH_2)_2]^{2+}$ have been measured between 0.5 and 37 °C and values of $\Delta H°$ and $\Delta S°$ obtained.

The anticancer drug, *cis*-$[Pt(NH_3)_2Cl_2]$, is aquated/hydrolysed in the cell, so that the following equilibria can exist in principle

$$cis\text{-}[Pt(NH_3)_2(OH_2)_2]^{2+} \rightleftharpoons cis\text{-}[Pt(NH_3)_2(OH_2)(OH)]^+ + H^+ \quad (1)$$

$$cis\text{-}[Pt(NH_3)_2(OH_2)(OH)]^+ \rightleftharpoons cis\text{-}[Pt(NH_3)_2(OH)_2] + H^+ \quad (2)$$

Nearly all the pK_a values for these systems have been measured at room as opposed to blood temperature and moreover there is an inconsistency in pK_{a2}, see Table 1. Here we have checked values at room temperature and extended the range of measurements down to 0.5 and up to *c.* 40 °C.

TABLE 1. Values of pK_a for *cis*-$[Pt(NH_3)_2(OH_2)_2]Y_2$

Y	*T* (°C)	pK_{a1}	pK_{a2}	Ref.
NO_3^-	20	5.56	7.32	1
NO_3^-	25?	5.63	9.25	2
NO_3^-	20	5.52	7.10	3
NO_3^-	5	5.93	7.87	4

In these systems, *cis*-$[Pt(NH_3)_2(OH_2)_2](CF_3SO_3)_2$ is a useful salt to work with since the anion is a much poorer ligand than water. 0.02 M aqueous solutions of this salt were titrated against 0.1 M sodium hydroxide, pH being measured with a Semimicro Ross combination pH electrode connected to a Jenway 3010 pH meter. pK_a values are given in Table 2. Both values fall with rise in temperature. (The greater lack of reproducibility in pK_{a2} compared with pK_{a1} may arise from anhydrodimerisation of *cis*-$[Pt(NH_3)_2(OH)_2(OH)]^+$ which occurs over periods of minutes at the concentrations used here [5, 6]. This process appears to involve several steps, at least one reversible, which results in the overall rate actually falling with rise in temperature [6].) In the presence of 0.05 M $Li(CF_3SO_3)$, the pK values rise by about 0.05.

As the pK_a values determined here for the triflate are slightly lower than earlier values involving nitrate, the effect of changing the anion to nitrate was investigated using the same procedure as for the triflate system (Table 2). Our results using *cis*-$[Pt(NH_3)_2(OH_2)_2](NO_3)_2$ agree well with those of the sets of earlier values and also suggest that the counter anion is significant. Data at 22 °C using the perchlorate salt support this point. Unfortunately it was not possible to study the effect of a phosphate counter anion as is present in the cell because of solubility problems in attempting to make 0.02 M solutions.

TABLE 2. Values of pK_a for *cis*-$[Pt(NH_3)_2(OH_2)_2]Y_2$ measured here

Y	*T* (±0.5) (°C)	pK_{a1}	pK_{a2}
$CF_3SO_3^-$	0.5	5.59±0.02	7.47±0.10
	10	5.43±0.04	7.36±0.10
	17	5.32±0.02	7.25±0.10
	22	5.24±0.03	7.10±0.10
	37	4.99±0.02	6.84±0.10
NO_3^-	3.4	5.95±0.01	7.65±0.02
	6.0	5.89±0.01	7.59±0.02
	13.5	5.66±0.04	7.51±0.01
	16.1	5.63±0.02	7.48±0.01
	20.2	5.55±0.03	7.33±0.03
	24.9	5.39±0.02	7.23±0.02
	30.4	5.20±0.09	7.10±0.05
	36.9	5.02±0.02	6.93±0.10
	45.5	4.88±0.02	6.68±0.02
ClO_4^-	22.0	5.24±0.05	7.42±0.10

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TABLE 3. Thermodynamic parameters for equilibria (1) and (2)

Y	$\Delta H_1°$ (kJ mol^{-1})	$\Delta S_1°$ (J K^{-1} mol^{-1})	$\Delta H_2°$ (kJ mol^{-1})	$\Delta S_2°$ (J K^{-1} mol^{-1})
$CF_3SO_3^-$	27 ± 2	-10 ± 7	29 ± 3	-37 ± 9
NO_3^-	44 ± 1	46 ± 4	38 ± 3	-10 ± 9

Values of standard enthalpy and entropy changes for the triflate and nitrate systems are given in Table 3. A possible explanation for the differences between values of pK_a and of $\Delta H°$ and $\Delta S°$ is that nitrate though a poor ligand can bond weakly at the fifth and sixth coordination sites of platinum whereas triflate cannot.

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References

1 K. A. Jensen, *Z. Anorg. Allg. Chem.*, *87* (1939) 87.
2 J. R. Peramareddi and A. W. Adamson, *J. Phys. Chem.*, *72* (1968) 414.
3 A. A. Grinberg, A. I. Stentsenko, N. D. Mitkinove and L. S. Tikhonova, *Russ. J. Inorg. Chem.*, *16* (1971) 137.
4 T. G. Appleton, J. R. Hall, S. F. Ralph and C. S. M. Thompson, *Inorg. Chem.*, *28* (1989) 1989.
5 D. S. Gill and B. Rosenberg, *J. Am. Chem. Soc.*, *104* (1982) 4598, ref. 8.
6 D. M. Orton and M. Green, unpublished work.