



SUPPLEMENTARY MATERIAL TO
**Sorption recovery of platinum(II, IV) in the presence of
copper(II) and zinc(II) from chloride solutions**

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BATCH EXPERIMENTS

The sorption of the investigated ions was performed under batch experiment conditions: resin mass, 0.1–0.2 g; volume of contacting solution, 10.0–20.0 mL; stirring in a thermostat at 20 ± 1 °C. The equilibrium time determined by special tests was 24 h.

The efficiency of sorption recovery of the ions investigated was estimated by means of the recovery degree R / % and the distribution coefficient K , which were calculated as follows:

$$R = 100 \frac{c_0 - c_{\text{eq}}}{c_0} \quad (1S)$$

$$K = \frac{WEC}{c_{\text{eq}}} \quad (2S)$$

where c_0 and c_{eq} are the initial and equilibrium molar concentrations of the metal ions, respectively; WEC / mmol g^{-1} is the working exchange capacity of the ion exchanger towards the recovered metal ions. The latter was calculated from the equation:

$$WEC = \frac{(c_0 - c_{\text{eq}})V}{m} \quad (3S)$$

where V / L is the volume of the contacting solution and m / g is the resin mass.

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KINETIC EXPERIMENTS

The resin quantities (0.1 g) were stirred with 10.0 mL of solution at 20 ± 1 °C over a period from 1 min to 24 h. The saturation times were 1, 2, 3, 5, 15, 20, 30 and 45 min and 1, 2, 3, 6 and 24h. The suspensions were intensively stirred (more than 800 rev·min⁻¹). After a certain time, the resins and solutions were quickly separated by filtration through a porous glass filter. Then the concentrations of platinum, copper and zinc were determined in the solutions.

PLATINUM IONIC STATE IN CHLORIDE SOLUTIONS

It is known that the ionic state of platinum depends on the acidity of the medium, the concentration of chloride ions and the temperature. It was shown that the hexachloro-platinate (IV) complex $[\text{PtCl}_6]^{2-}$ predominates in strong acidic solutions ($c(\text{HCl}) \geq 3 \text{ mol L}^{-1}$). With dilution and increase in the pH value of these solutions, complexes of platinum(II) appear in the system, and co-exist in different proportions with the chloride complexes of platinum(IV). Moreover, the dilution leads to hydration and hydrolysis. This causes the formation of different aqua chloro- and aqua hydroxo-complexes of platinum(II) and platinum(IV): $[\text{Pt}(\text{H}_2\text{O})_n\text{Cl}_{4-n}]^{n-2}$, $[\text{Pt}(\text{H}_2\text{O})_k(\text{OH})_m\text{Cl}_{4m-k}]^{k-2}$, $[\text{Pt}(\text{OH})_n\text{Cl}_{4-n}]^{2-}$, $[\text{Pt}(\text{H}_2\text{O})_n\text{Cl}_{6-n}]^{n-2}$, $[\text{Pt}(\text{H}_2\text{O})_k(\text{OH})_m\text{Cl}_{6m-k}]^{k-2}$, $[\text{Pt}(\text{OH})_n\text{Cl}_{6-n}]^{2-}$ (where $n = 1, 2$; $k = 1, 2$ and $m = 1-6$).

COPPER AND ZINC IONIC STATE IN CHLORIDE SOLUTIONS

The ionic states of copper and zinc were described in a previous work.¹ It is noteworthy that, depending on acidity of the medium, both non-ferrous metal ions can form chloride complexes $[\text{CuCl}_4]^{2-}$ and $[\text{ZnCl}_4]^{2-}$ in 1–6 M HCl and $[\text{Cu}(\text{H}_2\text{O})_6]^{2+}$, $[\text{ZnCl}_4(\text{H}_2\text{O})_2]^{2-}$, $[\text{Zn}(\text{H}_2\text{O})_6]^{2+}$, $[\text{ZnCl}]^-$ and $[\text{ZnCl}_2]^0$ in 0.001–0.01 M HCl. Therefore, the initial investigated solution contained different chloride complexes.

TABLE S-I. Sorption pre-concentration of platinum(II,IV) from individual chloride solutions with different acidity on the investigated ion exchangers ($c_0(\text{Pt}) = 0.25 \text{ mmol L}^{-1}$)

Trade name	Parameter	$c_0(\text{HCl}) / \text{mol L}^{-1}$					
		4.0	2.0	1.0	0.1	0.01	0.001
AX 400	$R / \%$	≈100	≈100	≈100	≈100	≈100	≈100
	$\log D$	3.13±0.19	3.52±0.21	3.60±0.22	3.51±0.18	3.33±0.21	3.17±0.19
ALX 220	$R / \%$	≈100	≈100	≈100	≈100	≈100	≈100
	$\log D$	3.39±0.19	3.60±0.22	3.84±0.23	3.71±0.22	3.44±0.17	3.16±0.19
CRX 300	$R / \%$	≈100	≈100	≈100	≈100	≈100	≈100
	$\log D$	2.48±0.15	2.87±0.17	2.84±0.14	2.63±0.16	2.58±0.13	2.42±0.15
CRX 210	$R / \%$	≈100	≈100	≈100	≈100	≈100	≈100
	$\log D$	2.59±0.16	2.55±0.15	2.85±0.15	3.20±0.19	3.51±0.21	3.60±0.22

TABLE S-II. Sorption recovery of copper(II) from individual chloride solutions of different acidities on the investigated ion exchangers ($c_0(\text{Cu}) = 2.0 \text{ mmol L}^{-1}$)

Trade name	Parameter	$c_0(\text{HCl}) / \text{mol L}^{-1}$					
		4.0	2.0	1.0	0.1	0.01	0.001
AX 400	$R / \%$	94±5	93±6	94±5	–	–	–
	$\log D$	4.21±0.25	4.12±0.25	4.17±0.26	–	–	–
ALX 220	$R / \%$	94±5	93±5	94±5	–	–	–
	$\log D$	4.24±0.25	4.15±0.24	4.18±0.25	–	–	–
CRX 300	$R / \%$	94±5	93±6	93±6	–	–	–
	$\log D$	4.22±0.25	4.14±0.25	4.11±0.25	–	–	–
CRX 210	$R / \%$	94±5	95±5	95±5	–	–	–
	$\log D$	4.23±0.25	4.28±0.26	4.24±0.25	–	–	–
EV 023	$R / \%$	–	–	–	95±5	≈100	≈100
	$\log D$	–	–	–	4.45±0.27	5.51±0.28	5.89±0.28

TABLE S-III. Sorption recovery of zinc (II) from individual chloride solutions of different acidities on the investigated ion exchangers ($c_0(\text{Zn}) = 2.0 \text{ mmol L}^{-1}$)

Trade name	Parameter	$c_0(\text{HCl}) / \text{mol L}^{-1}$					
		4.0	2.0	1.0	0.1	0.01	0.001
AX 400	$R / \%$	–	–	–	86±4	92±6	94±6
	$\log D$	–	–	–	4.81±	5.08 ±	5.18 ±
ALX 220	$R / \%$	–	–	–	84±4	92±5	92±5
	$\log D$	–	–	–	4.73±	5.08 ±	5.09 ±
CRX 300	$R / \%$	90±5	89±4	89±4	89±4	95±5	95±5
	$\log D$	4.96±0.29	4.89±0.29	4.88±0.29	4.89±0.29	5.26±0.32	5.34±0.32
CRX 210	$R / \%$	–	–	–	84±4	90±5	92±5
	$\log D$	–	–	–	4.71±0.28	4.99±0.31	5.09±0.31
EV 023	$R / \%$	–	–	–	93±5	95±4	≈100
	$\log D$	–	–	–	5.12±0.31	5.29±0.32	5.57±0.33

REFERENCES

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