Supplementary

A Systematic Investigation on Synergistic Electroplating and Capacitive Removal of Pb$^{2+}$ from Artificial Industrial Waste Water

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The solution flow rate is calculated based on below equation

$$r_{flow} = \frac{V}{t \cdot \text{gram of carbon used}} \text{ ml } / \text{ (min g)}$$

Where t is the time duration starting from waste water inlet, passing through cell, conductivity meter and pH meter, ending at outlet. The trace is designated by arrows in Figure S1; V is the total volume of waste water during the time duration.

![Figure S1 Schematic diagram of the testing system for the removal of Pb$^{2+}$](image_url)
Figure S2 Concentration change of 100 ppm Pb$^{2+}$ in multi-cations solution (500 ppm Na$^+$) during the first cycle of (A) charge and (B) discharge process; (C) Conductivity change of the solution with multi-salts (Pb(NO$_3$)$_2$, NaCl) under pumping rate of 70 ml/min and the substrate area of 10 cm $\times$ 15cm

Figure S2 displays the impact of multi-ions in the solution on the Pb$^{2+}$ removal performance. Through the analysis, it reflects that the removal performance of Pb$^{2+}$ will not be interfered under the co-existence of Na$^+$. Additionally, the Na$^+$ in the solution can be realized a total removal of 50% that is 100% reversible, which provides a view angle on Na$^+$ separation and collection.
Figure S3 Cyclic voltammetry in 100 ppm Pb$^{2+}$ solution with supporting electrolyte of (A) 0 M and (B) 0.1 M NaCl at a scan rate of 50 mV/s

Cyclic voltammetry was also shown in Figure S3, but the high resistance of the 100 ppm Pb$^{2+}$ solution meant this were of little value with no clear redox peaks being observable. On the addition of 0.1 M NaCl as supporting electrolyte, redox couples that were consistent with Reactions (1) and (2) along with water splitting were obtained.
Figure S4 SEM-EDS analysis on the cathode after five cycles of charge/discharge process.

Figure S5 Concentration change of respective ion in the solution during (A) charging and (B) discharging process.

the competitive behavior between Pb$^{2+}$ and other metals (Na$^+$, Cu$^{2+}$ and Ni$^{2+}$) has been analyzed by dissolving 100 ppm Pb$^{2+}$, 0.1 M NaCl, 5 ppm Cu$^{2+}$ and 62.5 ppm Ni$^{2+}$ in 60 ml DI water, which is shown in Figure S5 and displayed below. When compared to
Figure 3, it can be seen that the co-existence of multi-ions did not significantly affect the removal efficiency of Pb$^{2+}$ during the charging process. When at discharging state, only NaCl reflects a reversibility $>90\%$, all the other heavy metals show a lower reversibility, which indicates the involvement of other electrochemical reactions; such as electroplating. This was included in the supplemental data in Figure S5 and also updated in the text.