



Table S1. The adsorbent information

Adsorbent	Full name	Raw materials	Pyrolysis temperature(°C)
B300	Biochar was prepared at 300°C	Navel orange peels	300
B500	Biochar was prepared at 500°C	Navel orange peels	500
B700	Biochar was prepared at 700°C	Navel orange peels	700
GO300	Graphene oxide was prepared at 300°C	Flake graphite	300
GO500	Graphene oxide was prepared at 500°C	Flake graphite	500
GO700	Graphene oxide was prepared at 700°C	Flake graphite	700
BGO300	Biochar supported graphene oxide was prepared at 300°C	Navel orange peels and flake graphite	300
BGO500	Biochar supported graphene oxide was prepared at 500°C	Navel orange peels and flake graphite	500
BGO700	Biochar supported graphene oxide was prepared at 700°C	Navel orange peels and flake graphite	700

Table S2. Experimental design and results.

number	Experimental factors			adsorption capacity (mg/g)
	A: solution pH	B: rotating speed (r/min)	C: adsorbent dosage (g)	
1	6	150	0.005	81.35
2	4	100	0.005	75.7
3	2	100	0.0525	2.27
4	2	200	0.0525	2.77
5	4	150	0.0525	109.49
6	6	150	0.10	103.66
7	4	200	0.10	117.12
8	4	100	0.10	97.64
9	2	150	0.10	1.985
10	4	150	0.0525	110.0
11	4	150	0.0525	109.48
12	2	150	0.005	1.57
13	4	150	0.0525	108.96
14	6	100	0.0525	98.16
15	4	200	0.01	84.6
16	6	200	0.0525	100.32
17	4	150	0.0525	109.68

Solution pH, rotating speed and adsorbent dosage were used as independent variables, and Y-Pb²⁺ adsorption capacity(mg/g) was used as the dependent variable. The experimental results were analyzed by quadratic multiple regression analysis with Design-Expert 8.6 software, and the response function model of solution pH, rotating speed and adsorbent dosage on adsorption capacity was established:

$$Y=109.52+46.86A+3.88B+9.65C+0.41AB+5.47AC+2.64BC-52.63A^2-6.01B^2-9.75C^2$$

The results of significance test and variance analysis of regression model were shown in Table 4. The F-value was 107.16 and P-value < 0.0001, which indicates that the establishment of the model is extremely significant. The multivariate fitting correlation coefficient R² was 0.9928 > 0.8, which indicates that the model fits the data well, and the experimental error was small. In addition, the model correction coefficient R²_{adj} was 0.9835, which indicates that the model can explain 98.35% of the change of response value, and the C.V. value was only 7.36%, which indicates that the reliability and accuracy of the experiment are high.

Table S3. Significance test and variance analysis for the quadratic regression model.

Source of variance	Sum of square	Degree of freedom	Mean square	F-value	P-value
model	31288.05	9	3476.45	107.16	<0.0001
A	17568.94	1	17568.94	541.56	<0.0001
B	120.39	1	120.39	3.71	0.0954
C	744.75	1	744.75	22.96	0.0020
AB	0.69	1	0.69	0.021	0.8882
AC	119.86	1	119.86	3.69	0.960
BC	27.95	1	27.95	0.86	0.3842
A2	11663.72	1	11663.72	359.53	<0.0001
B2	151.99	1	151.99	4.68	0.0672
C2	400.10	1	400.10	12.33	0.0098
Residual	227.09	7	32.44	-	-
Misfit term	226.52	3	75.51	528.25	<0.0001
Pure error	0.57	4	0.14	-	-
Total value	31515.14	16	-	-	-

P<0.01 means extremely significant correlation, 0.01<p<0.05 means significant correlation, P>0.05 means not significant.