Supplementary materials

Table S1 Inventory for of usage 1 g dried sludge material powder for carbon electrode in different pretreatment processes

Samples	S.No.	name	unit	quantity
	1	electricity	kWh	0.1
	2	cationic polyacrylamide(PAM)	g	2.5
sludge disposal	3	coal	g	640
	4	hydrogen chloride	g	4.4
	5	sodium hydroxide	g	3.88
	6	limestone	g	50.5
	1	H_2SO_4	g	3.92
	2	KOH	g	1
	3	pure water	mL	20
	4	heating	min	700℃/120 min
AS-S-1	5	N_2	99.99%	120 min/100 mL/min
	6	acetylene black	g	0.125
	7	PVDF	g	0.125
	8	DMF	g	4
	9	heating	min	60℃/480 min
	1	HF	g	0.8
	2	KOH	g	1
	3	pure water	mL	20
	4	heating	min	700℃/120 min
AS-F-1	5	N_2	99.99%	120 min
	6	acetylene black	g	0.125
	7	PVDF	g	0.125
	8	DMF	g	4
	9	heating	min	60℃/480 min
	1	HNO_3	g	2.52
	2	KOH	g	1
	3	pure water	mL	20
AS-N-1	4	heating	min	700℃/120 min
	5	N_2	99.99%	120 min
	6	acetylene black	g	0.125

	7	PVDF	g	0.125
	8	DMF	g	4
	9	heating	min	60℃/480 min
	1	HNO_3	g	2.52
	2	KOH	g	2
	3	pure water	mL	20
	4	heating	min	700℃/120 min
AS-N-2	5	N_2	99.99%	120 min
	6	acetylene black	g	0.125
	7	PVDF	g	0.125
	8	DMF	g	4
	9	heating	min	60℃/480 min
	1	HNO_3	g	2.52
	2	KOH	g	3
	3	pure water	mL	20
	4	heating	min	700℃/120 min
AS-N-3	5	N_2	99.99%	120 min
	6	acetylene black	g	0.125
	7	PVDF	g	0.125
	8	DMF	g	4
	9	heating	min	60℃/480 min
	1	HNO_3	g	2.52
	2	KOH	g	4
	3	pure water	mL	20
	4	heating	min	700℃/120 min
AS-N-4	5	N_2	99%	120 min
	6	acetylene black	g	0.125
	7	PVDF	g	0.125
	8	DMF	g	4
	9	heating	min	60℃/480 min

Table S2 Elemental analysis of the raw floc sludge (FS) and derived best-performing carbon material (AS-N-3)

Content (wt.%)	FS	AS-N-3
Carbon (C)	63.56 ± 1.23	71.61 ± 0.68
Oxygen (O)	26.13 ± 2.56	20.04 ± 1.89
Iron (Fe)	4.80 ± 0.45	6.41 ± 1.75
Zirconium (Zr)	1.93 ± 0.57	0
Aluminum (Al)	1.04 ± 0.65	0.51 ± 0.14
Platinum (Pt)	0.74 ± 0.33	0.52 ± 0.26
Silicon (Si)	0.71 ± 0.25	0.10 ± 0.01
Calcium (Ca)	0.51 ± 0.06	0.21 ± 0.05
Potassium (K)	0.12 ± 0.03	0.41 ± 0.08
Chlorine (Cl)	0.11 ± 0.02	0.06 ± 0.02
Nitrogen (N)	0	0.23 ± 0.09

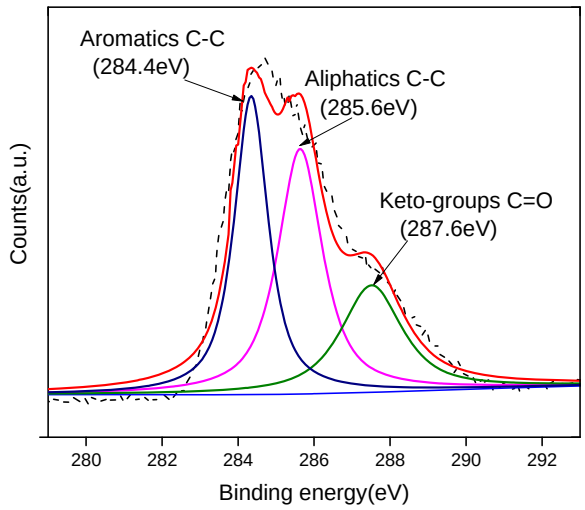

Fig. S1 XPS high-resolution C1s spectra of the raw floc sludge

We have tested the XPS curve of the raw floc sludge. The result was exhibited in Fig. S1. The C1s XPS spectrum of floc sludge showed peaks corresponding to aromatics (C-C (284.4eV)), aliphatics (C-C) (285.6eV), and ketone groups (C = O) (287.6 eV). Fewer oxygen groups were embedded in the raw material.

However, magnetic properties occurred due to the increased Fe content of the material after carbonization. The magnetic field of the as-synthesized carbon sample interfered with the trajectories of the photoelectrons in X-ray photoelectron spectroscopy machine. Therefore, the as-synthesized carbon materials could not be performed by XPS characterization.