

Supplementary Materials

Mechanism and Condition Optimization of Acid Leaching Recovery of FePO_4 from Iron-Phosphorus Slag after Lithium Extraction from LiFePO_4

Shanshan Luo ^{1,†}, Yanyun Li ^{1,†}, Qingyou Liu ², Min Chen ¹, Haitao Li ¹, Xueli Chen ¹, Haoyu Tan ¹, Ting Yu ¹, Liping Ai ¹, Man Li ¹ and Kai Zheng ^{1,*}

¹ School of Geography and Environmental Engineering, Gannan Normal University, Ganzhou 341000, China

² School of Materials and Environmental Engineering, Shenzhen Polytechnic University, Shenzhen 518055, China

* Correspondence: zhengkai@gnnu.edu.cn

† These authors contributed equally to this work.

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Table S1. Composition of lithium iron phosphate waste (mass fraction).

Fe	P	Al	Cu
16%	9.04%	1.05%	0.44%

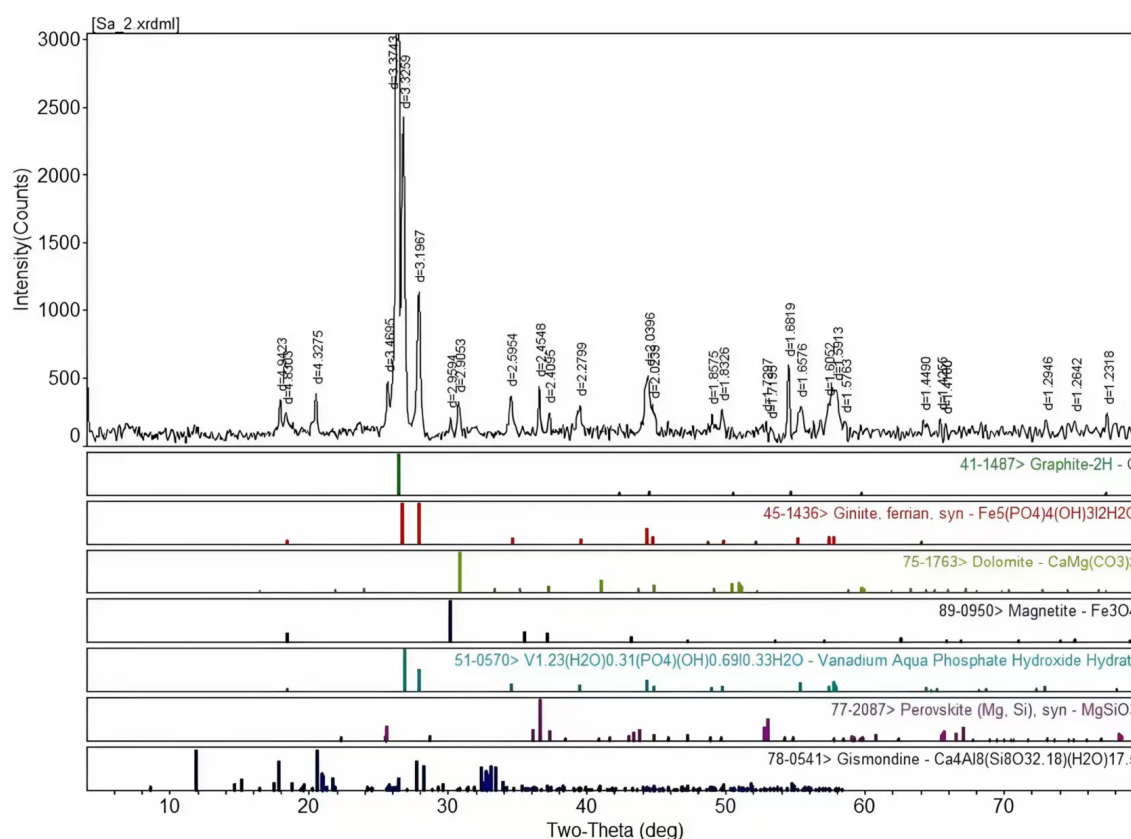
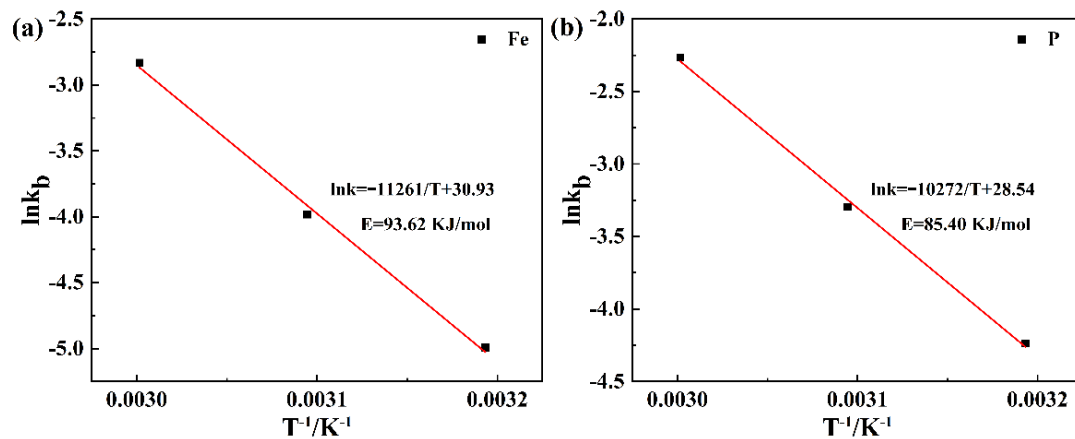


Figure S1. XRD pattern of iron-phosphorus slag.



Table S2. The fitted rate constants of iron and phosphorus leaching at different temperatures and their correlation coefficients.

	Temperature/°C	k_a	R_{a^2}	k_b	R_{b^2}	k_c	R_{c^2}
Fe	40	0.0667	0.934	0.0068	0.999	0.0575	0.999
	50	0.1056	0.951	0.0186	0.990	0.1104	0.986
	60	0.1697	0.878	0.0588	0.954	0.2830	0.901
P	40	0.0943	0.920	0.0144	0.998	0.0928	0.993
	50	0.1414	0.953	0.0370	0.983	0.1859	0.993
	60	0.2068	0.931	0.1036	0.944	0.5552	0.955

**Figure S2.** (a) and (b) are the fitting curves of $\ln k_b - 1/T$ in the leaching process of iron and phosphorus, respectively.**Table S3.** Level table of orthogonal experimental factors.

Number	Leaching Concentration/mol/L	Leaching Temperature/°C	Liquid-Solid Ratio/mL/g	Leaching Time/h
	A	B	C	D
1	4	50	10	2
2	5	60	15	3
3	6	70	20	4
4	7	80	25	5

Table S4. Orthogonal experimental data and results.

Number	Leaching Concentration /mol/L	Leaching Temperature /°C	Liquid-Solid Ratio /mL/g	Leaching Time/h	Iron Leaching Rate (%)	Number	Leaching Concentration /mol/L	Leaching Temperature /°C	Liquid-Solid Ratio /mL/g	Leaching Time/h	Phosphorus Leaching Rate (%)
1	4	50	10	2	8.59	1	4	50	10	2	21.34
2	4	60	15	3	19.10	2	4	60	15	3	36.94
3	4	70	20	4	31.53	3	4	70	20	4	53.33
4	4	80	25	5	43.29	4	4	80	25	5	64.25
5	5	50	15	4	30.77	5	5	50	15	4	48.83
6	5	60	10	5	28.81	6	5	60	10	5	44.76
7	5	70	25	2	64.91	7	5	70	25	2	77.54
8	5	80	20	3	49.76	8	5	80	20	3	68.21
9	6	50	20	5	53.85	9	6	50	20	5	78.40
10	6	60	25	4	71.78	10	6	60	25	4	87.24
11	6	70	10	3	36.81	11	6	70	10	3	52.82
12	6	80	15	2	46.08	12	6	80	15	2	65.56
13	7	50	25	3	63.12	13	7	50	25	3	78.76
14	7	60	20	2	54.80	14	7	60	20	2	72.59
15	7	70	15	5	83.38	15	7	70	15	5	96.35
16	7	80	10	4	49.92	16	7	80	10	4	65.17
k ₁	1.0251	1.7424	2.0853	2.5121	----	k ₁	1.7585	2.3934	2.8401	3.1287	----
k ₂	1.7658	1.8281	1.8805	1.8905	----	k ₂	2.4492	2.4770	2.5628	2.6319	----
k ₃	1.2413	1.5075	1.9826	2.6336	----	k ₃	1.8410	2.2392	2.7869	3.2537	----
k ₄	1.8269	1.8905	1.8400	1.8075	----	k ₄	2.3387	2.5432	2.5457	2.5999	----
K ₁	0.2563	0.4356	0.5213	0.6280	----	K ₁	0.4396	0.5984	0.7100	0.7822	----
K ₂	0.4415	0.4570	0.4701	0.4726	----	K ₂	0.6123	0.6192	0.6407	0.6580	----
K ₃	0.3103	0.3769	0.4957	0.6584	----	K ₃	0.4602	0.5598	0.6967	0.8134	----
K ₄	0.4567	0.4726	0.4600	0.4519	----	K ₄	0.5847	0.6358	0.6364	0.6500	----
R	0.3717	0.0312	0.3481	0.0207	----	R	0.3425	0.0457	0.3532	0.0653	----

Note: (1) k_1 , k_2 , k_3 and k_4 are respectively the sum of four leaching rates of level 1, level 2, level 3 and level 4; (2) $K_1 = k_1/4$, $K_2 = k_2/4$, $K_3 = k_3/4$, $K_4 = k_4/4$; (3) R is $(K_{\max} - K_{\min})$ in the four levels of a factor.

Table S5. Iron and phosphorus contents of iron phosphate.

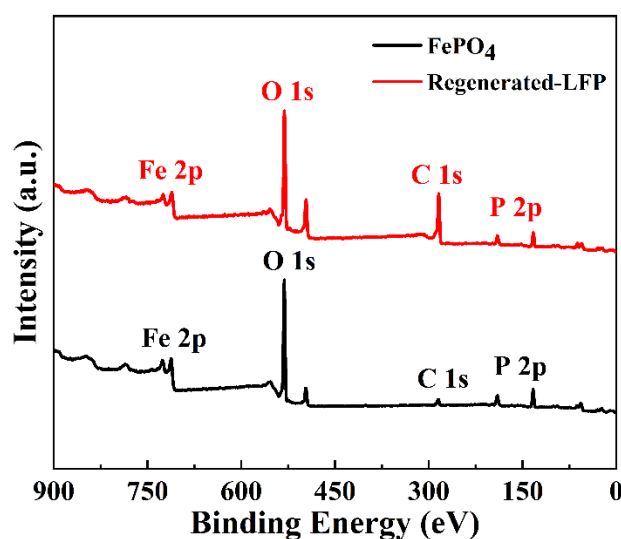
Sample	w (Fe)/%	w (P)/%	N (Fe):n (P)
Occupation standard	≥36	≥20	0.97~1.02
Iron phosphate	33.37	20.04	0.92

Table S6. Quality index of iron phosphate (w/%).

Sample	Co	Zn	Cu	Ni	H ₂ O
Occupation standard	≤0.01	≤0.005	≤0.005	≤0.05	19~21
Iron phosphate	unfound	unfound	unfound	unfound	20.4

Table S7. The content of C, O, P and Fe elements in iron phosphate and lithium iron phosphate.

Element	C (at.%)	O (at.%)	P (at.%)	Fe (at.%)
FePO ₄	3.05	18.94	4.18	2.14
LiFePO ₄	12.39	10.80	2.09	1.00

**Figure S3.** XPS full spectrum of iron phosphate and lithium iron phosphate.**Table S8.** Fe 2p orbitals of iron phosphate and lithium iron phosphate.

Element	Fe 2p _{3/2}				Fe 2p _{1/2}			
	Fe ²⁺		Fe ³⁺		Fe ²⁺		Fe ³⁺	
	BE (eV)	At. (%)	BE (eV)	At. (%)	BE (eV)	At. (%)	BE (eV)	At. (%)
FePO ₄	711.66	0.46	712.96	0.93	723.44	0.21	726.61	0.54
LiFePO ₄	708.99	0.28	710.83	0.43	722.19	0.23	723.83	0.06