Dual Roles of Coal Fly Ash in Copper Ion Adsorption Followed by Thermal Stabilization in a Spinel Solid Solution

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Supporting Information

Including 2 equations, 5 tables and 1 figure in 8 pages

Equations

1. The linear form of the Langmuir isotherm can be expressed as:

$$\frac{1}{q_e} = \frac{1}{c_e q_m k_L} + \frac{1}{q_m} \qquad (1)$$

where c_e is the equilibrium concentration of copper ions in solution ($mg \cdot L^{-1}$), q_e is the ratio between the mass of copper ions and mass of fly ash at equilibrium ($mg \cdot g^{-1}$), q_m is Langmuir constant expressing the maximum adsorption capacity ($mg \cdot g^{-1}$), and the constant k_L represents the adsorption free energy ($L \cdot mg^{-1}$).

2. The linear form of Freundlich isotherm model is:

$$\ln q_e = \ln k_F + \frac{1}{n} \ln c_e \qquad (2)$$

where k_F ($mg^{-1/n} \cdot L^{-1/n} \cdot g^{-1}$) relates to the adsorption capacity, and n is the dimensionless number related to surface heterogeneity. The value of $1/n$ ranging from 0.1 to 1.0 represents a favorable adsorption conditions.

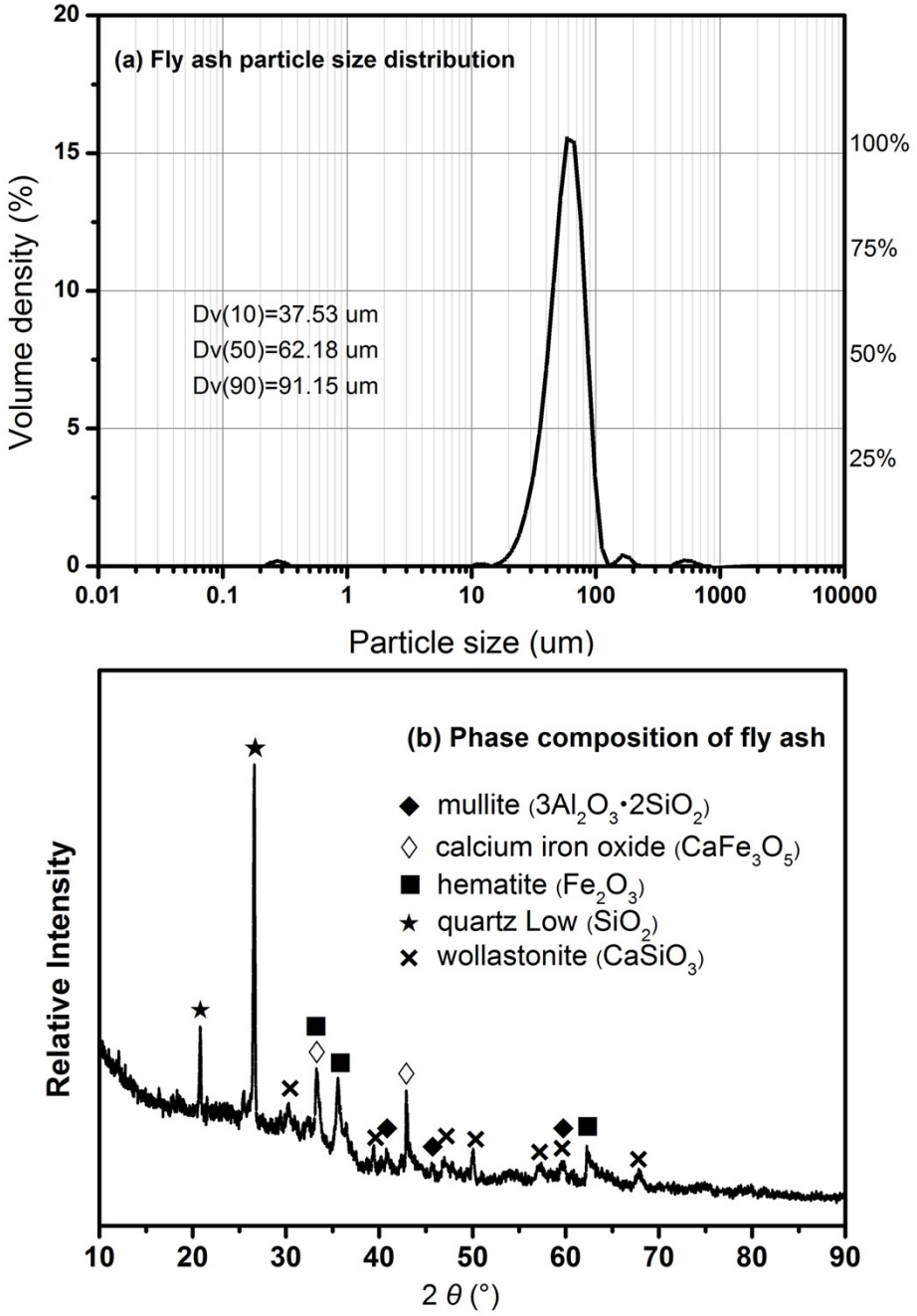

Figure S1. (a) The particle size distribution of the coal fly ash which $D_v(10)$, $D_v(50)$, and $D_v(90)$ is 37.5 μm, 62.2 μm, and 91.1 μm, respectively. (b) XRD pattern of the coal fly ash used in this study. The standard patterns retrieved from the ICDD database include quartz (SiO_2; PDF#89-1961), mullite ($3Al_2O_3 \cdot 2SiO_2$; PDF#79-1455), calcium iron oxide ($CaFe_3O_5$; PDF#72-0890), wollastonite ($CaSiO_3$; PDF#43-1460), and hematite (Fe_2O_3; PDF#85-0599).

Table S1 Chemical compositions (wt%) of the coal fly ash

Components	Weight Percentage (wt%)
SiO_2	41.6
Fe_2O_3	17.3
Al_2O_3	16.3
CaO	15.1
MgO	3.9
P_2O_5	1.6
K_2O	1.4
SO_3	1.3
TiO_2	1.0

The elemental compositions were measured by X-ray fluorescence spectrometry (XRF) and expressed as the basic metal oxide forms.

Table S2. EDS analysis for the dark-color matrix marked as “S” in Figure 5c in the main body of the paper

Element	Weight %	Error%	Atomic %
O	25.54	8.76	36.41
Al	6.78	4.43	5.73
Si	56.38	3.99	53.58
Cu	6.20	3.79	2.21
Fe	5.10	3.19	2.07

Table S3. EDS analysis for the $CuAl_xFe_{2-x}O_4$ spinel solid solution marked as "C" in Figure 5c in the main body of the paper

Element	Weight %	Error%	Atomic %
O	27.63	6.54	52.09
Al	15.34	3.27	17.14
Si	3.20	2.22	4.02
Cu	33.38	2.87	15.73
Fe	20.45	3.11	11.02

Table S4. EDS analysis for the light-color grains marked as “C” in Figure 5d in the main body of the paper

Element	Weight %	Error%	Atomic %
O	35.18	7.26	61.36
Al	14.24	3.34	14.72
Cu	28.66	2.65	12.49
Fe	22.92	4.02	11.42

Table S5. EDS analysis for the light-color grains marked as “A” in Figure 5d in the main body of the paper

Element	Weight percentage (%)	Atomic percentage (%)	Error (%)
O	45.18	59.95	2.53
Al	48.25	37.94	4.65
Cu	4.21	1.40	3.28
Fe	1.86	0.71	2.01