**Supplementary Information**

# Carbonate-activated binder modified by supplementary materials for mine backfill and the associated heavy metal immobilization effects

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**Fig. S1.** Particle size distribution: (a) BFS; (b) tailings.

**Table S1.** Heavy metals content in tailings and the results of TCLP

|  |  |  |  |
| --- | --- | --- | --- |
| Element | Total content / (mg⋅kg‒1) | TCLP / ppm | Limited valuea  / ppm |
| Pb | 1217 ± 22 | 1.52 ± 0.12 | 1.5 |
| Zn | 3214 ± 28 | 2.31 ± 0.81 | 1.5 |
| Cu | 2875 ± 19 | 1.27 ± 0.24 | 0.05 |
| Mn | 1137 ± 20 | 2.17 ± 0.31 | 5 |

Note: aChinese GB/T 14848―2017 type Ⅴ.

 

 

**Fig. S2.** Leaching concentrations of the heavy metals: (a) Pb; (b) Zn; (c) Cu; (d) Mn.

**Table S2**.Slope of lg(*Bt*)–lg(*t*) and leaching mechanisms

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Heavy metal | Sample | Cumulative release / (μg∙L−1) | Slope | *R*2 | Mechanism |
| Pb | Control | 36.04 | 0.64 | 0.991 | Diffusion |
| Mg2-CLDH3 | 17.68 | 0.61 | 0.966 | Diffusion |
| NaO | 26.51 | 0.57 | 0.973 | Diffusion |
| OPC | 18.41 | 0.52 | 0.991 | Diffusion |
| Zn | Control | 123.99 | 0.49 | 0.969 | Diffusion |
| Mg2-CLDH3 | 45.87 | 0.53 | 0.960 | Diffusion |
| NaO | 73.95 | 0.47 | 0.977 | Diffusion |
| OPC | 60.03 | 0.46 | 0.993 | Diffusion |
| Cu | Control | 71.83 | 0.51 | 0.966 | Diffusion |
| Mg2-CLDH3 | 26.66 | 0.53 | 0.987 | Diffusion |
| NaO | 51.68 | 0.57 | 0.934 | Diffusion |
| OPC | 28.72 | 0.55 | 0.977 | Diffusion |
| Mn | Control | 47.40 | 0.47 | 0.971 | Diffusion |
| Mg2-CLDH3 | 19.97 | 0.51 | 0.961 | Diffusion |
| NaO | 29.59 | 0.45 | 0.946 | Diffusion |
| OPC | 19.68 | 0.42 | 0.982 | Diffusion |

Note: *B*t―Total leaching amount; *t*―Leaching time.

**Table S3**. Cost data for 1 t of binder slurry

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Component | Unit cost / ($∙t−1) | NaC | Ca5 | Mg5 | CLDH5 | Ca2-CLDH3 | Mg2-CLDH3 | NaO | OPC | Reference |
| OPC | 84 |  |  |  |  |  |  |  | 56.00 | [1] |
| BFS | 40 | 24.69 | 23.60 | 23.60 | 23.60 | 23.60 | 23.60 | 24.69 |  | [2] |
| Na2CO3 | 170 | 8.40 | 8.02 | 8.02 | 8.02 | 8.02 | 8.02 |  |  | [3] |
| NaOH | 346 |  |  |  |  |  |  | 17.09 |  | [4] |
| CaO1 | 43 |  | 1.27 |  |  | 0.51 |  |  |  |  |
| MgO | 89 |  |  | 2.63 |  |  | 1.05 |  |  |  |
| CLDH | 460 |  |  |  | 13.57 | 8.14 | 8.14 |  |  |  |
| Water | 2.5 | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 | 0.83 |  |
| Total |  | 33.92 | 33.72 | 35.08 | 46.02 | 41.10 | 41.64 | 42.61 | 56.83 |  |

Note: 1the price of CaO, MgO, and CLDH was provided by Shenyang Taioke Chemical Co., Ltd., China.

**References**

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