**Supplementary Information**

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

Xinghang Dai1,2), Xiaozhong Gu3), Jingru Zheng3), Liang Zhao1,2), Le Zhou4), and Haiqiang Jiang3),🖂

1) School of Civil Engineering, Liaoning Petrochemical University, Fushun 113001, China

2) Liaoning Key Lab of Petro-chemical Special Building Materials, Fushun 113001, China

3) Key Laboratory of Ministry of Education on Safe Mining of Deep Metal Mines, Northeastern University, Shenyang 110819, China

4) Changchun Gold Research Institute Co. Ltd., Changchun 130012, China

🖂 Corresponding author: Haiqiang Jiang E-mail: jianghaiqiang@mail.neu.edu.cn

 

**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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