
Supplementary Information

Study of Structural Transformation and Chemical Reactivity of Kaolinite-Based High Ash Slime during Calcination

Hongfei Xue, Xianshu Dong *, Yuping Fan, Xiaomin Ma and Suling Yao

College of Mineral Processing Engineering, Taiyuan University of Technology,
No. 79 Yingze West Street, Taiyuan 030024, China

* Correspondence: dongxianshu@tyut.edu.cn

Supplementary Caption

Supplementary methods

Reaction for carbon reacted with O_2

Reaction for char gasification with CO_2

Reaction for minerals under calcination

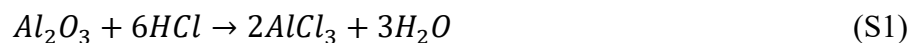
Supplementary methods

Determination of active Al₂O₃ and SiO₂ contents.

The chemical reactivity of coal tailings, i.e., the chemical reactivity of aluminum and silicon in coal tailings, was evaluated by hydrochloric acid and sodium hydroxide leaching methods. The specific test methods are as follows (step 1-4):

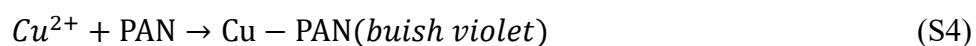
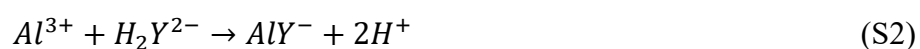
Step 1: Preparation of Al₂O₃ leaching solution

Coal tailings was treated with boiling 25 wt.% HCl solution at a solids ratio of 20% for 2 h. After treatment, reactive Al₂O₃ was leached, while SiO₂ and unreacted Al₂O₃ remained in the solid residue. Then, the suspensions were filtered by a suction filter system, and the solid residue were rinsed with deionized water repeatedly until the pH of the rinse water becomes neutral. The main reaction during the acid leaching process took place below:



Step 2: Ethylenediaminetetraacetic acid (EDTA) titration methods for determination of Al₂O₃ leaching rate

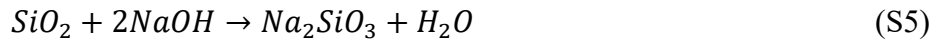
First, the Al₂O₃ leaching solution from step 1 was mixed with excessive EDTA solution. Then, the EDTA that has not been consumed by Al³⁺ was back-titrated with a known concentration of Cu²⁺ solution to the endpoint, using 1-(2-pyridylazo)-2-naphthol (PAN) as an indicator. The titration reaction is as follows:



where H_2Y^{2-} is on behalf of EDTA molecules. The content of leached Al_2O_3 was obtained by the amount of EDTA that react with the Al^{3+} .

Step 3: Preparation of reaction SiO_2 leaching solution

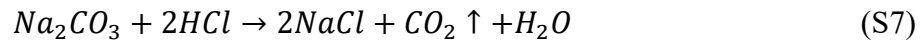
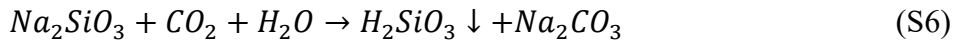
Reactive SiO_2 in the solid residue from step 1 can be leached after treatment with boiling 25 wt.% NaOH solution at a solids ratio of 20% for 2 h. The reaction is as follows:



Step 4: alkali-soluble carbon methods for determination of SiO_2 leaching rate

The reactive SiO_2 was precipitated as H_2SiO_3 when CO_2 was passed into the SiO_2 leaching solution from step 3. After the reaction, the precipitate was filtered and HCl solution was continuously sprayed to the filter cake to remove the impurities until the filter cake had no bubble. The filter cake was then washed and dried. Finally, the content of leached SiO_2 was obtained by weighing the mass of the filter cake.

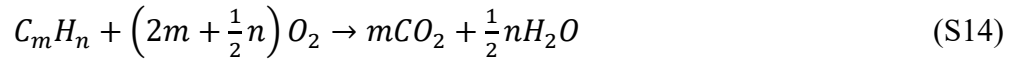
The relevant reactions during the process are as follows:



The leaching rate (X) of Al_2O_3 and SiO_2 in coal tailings can be calculated according to the formula (S9).

$$X = m_1/m_0 \times 100\% \quad (S9)$$

where m_1 is the amount of Al_2O_3 or SiO_2 in the leachate (g), m_0 is the amount of Al_2O_3 or SiO_2 in the coal tailings (g).

Reaction for carbon reacted with O₂:**Reaction for char gasification with CO₂****Reaction for minerals under calcination**