1. Activation conditions of iron tailing slag

The optimal activation conditions of iron tailing slag were determined by alkali fusion for 2 h under different temperatures (700, 750, 800, 850, 900 °C) and different alkali-solid ratios (1.0: 1, 1.2: 1, 1.5: 1).

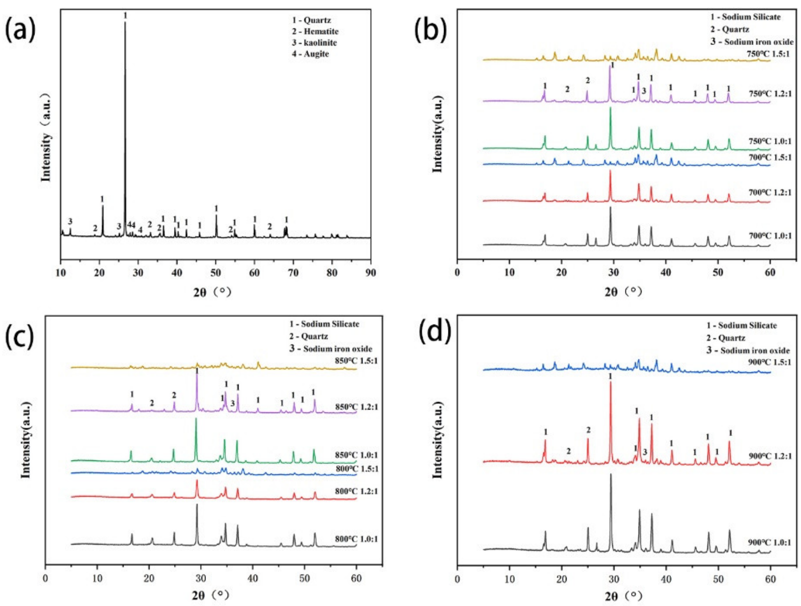

Figure S1. XRD patterns of iron tailing slag (**a**), and activation product under different conditions (**b**–**d**).

After alkali fusion, the crystalline phases of kaolinite, pyroxene and hematite in slag disappeared, and the quartz phase was greatly reduced because the quartz and kaolinite reacted with NaOH (equation S1 and S2). The pyroxene disappeared and was decomposed into aluminate and aluminosilicate, but it did not appear in the XRD of the activation product, possibly because the content of these phases was too low [1]. The sodium ferric oxide ($NaFeO_2$) phase was also found in the XRD of the activation product, which might be formed by the reaction of hematite (Fe_2O_3) with molten NaOH [2]. The XRD analysis of the activation product showed that the content of sodium silicate crystal phase was more when the alkali-solid ratio was 1.0: 1, and the highest proportion of sodium silicate was 93.32 % when the roasting temperature was 850 °C. Therefore, the optimum activation conditions of iron tailing slag were as follows: roasting temperature was 850 °C, alkali solid ratio was 1.0: 1.

$$2NaOH\ (s) + SiO_2\ (quartz) \rightarrow Na_2SiO_3\ (s) + H_2O\ (g) \tag{S1}$$

$$2NaOH\ (s) + Al_2O_3{\cdot}2SiO_2{\cdot}2H_2O\ (kaolinite) \rightarrow 2NaAlSiO_4\ (s) + 3H_2O\ (s) \tag{S2}$$

2. Optimum parameters for analcime synthesis

The effects of liquid-solid ratio, pH of crystallization solution, aging time, crystallization temperature and crystallization time on the synthesis of high crystallinity analcime were studied.

The liquid-solid ratio on the analcime synthesis was determined by adding 30.975 mL (3: 1), 41.3 mL (4: 1), 51.625 mL (5: 1), 61.95 mL (6: 1) deionized water to the mixture of 8.8 g activation product, 0.275 g $NaAlO_2$, 1.25 g TPABr, respectively. It was found that when the liquid-solid ratio was 5: 1, the crystallinity of the synthesized analcime (PDF#99-0007) was the highest (Figure S2).

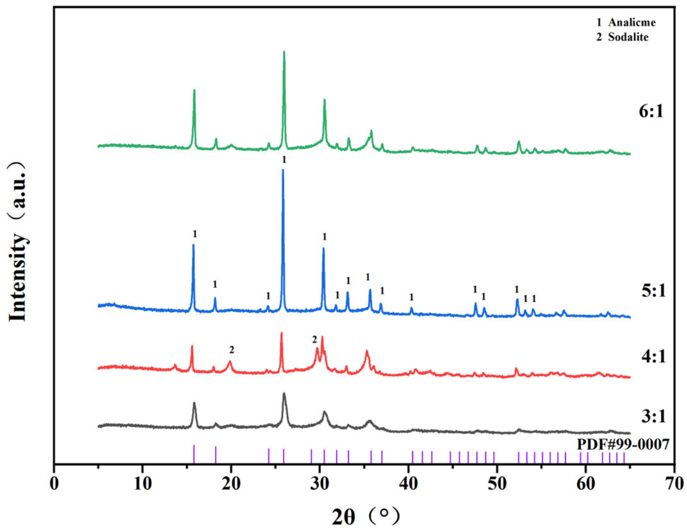

Figure S2. Effect of liquid-solid ratio on analcime synthesis (pH 10.0, aging time 5 h, crystallization temperature 180 ℃, crystallization time 72 h).

The pH of crystallization solution on the analcime synthesis by adjusting pH of crystallization solution to 10.0, 10.3, 10.5, 11.0, 11.5 and 12.0, respectively. It was found that the crystallinity of synthetic analcime (PDF#99-0007) was the highest when pH of the crystallization solution was 10.0 (Figure S3).

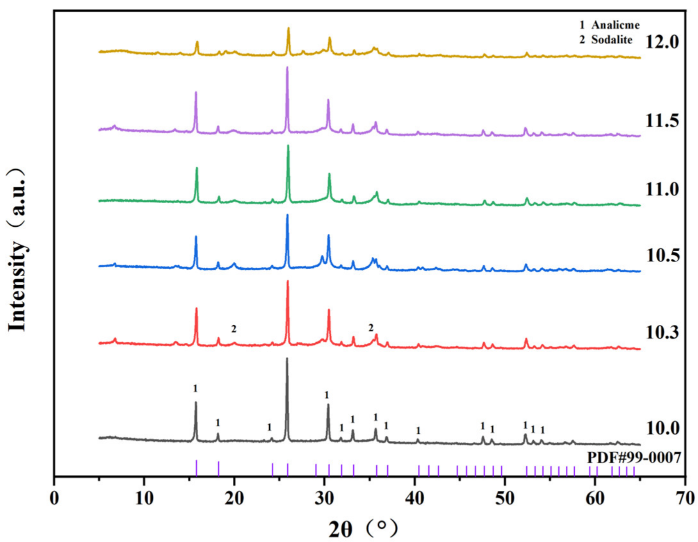

Figure S3. Effect of pH of crystallization liquid on analcime synthesis (liquid-solid ratio 5: 1, aging time 5 h, crystallization temperature 180 ℃, crystallization time 72 h).

The effect of aging time on the analcime by adjusting the aging time to 2, 4, 5 and 6 h, respectively. It was found that the crystallinity of synthetic analcime (PDF#99-0007) was the highest when the aging time was 5 h (Figure S4).

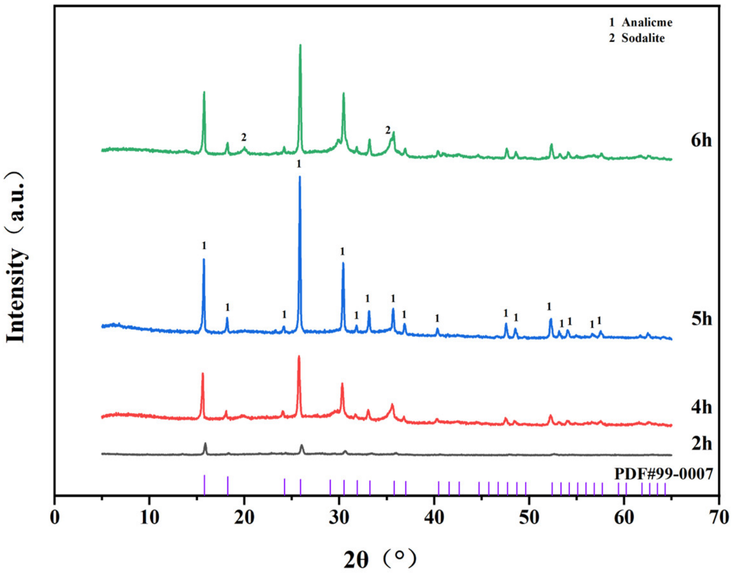

Figure S4. Effect of aging time on analcime synthesis (liquid-solid ratio 5: 1, pH 12.0, crystallization temperature 180 °C, crystallization time 72 h).

The crystallization temperature on the analcime synthesis by adjusting the crystallization temperature at 160 °C, 170 °C, 180 °C and 190 °C, respectively. It was found that the crystallinity of synthetic analcime (PDF#99-0007) was the highest when the crystallization temperature was 180 °C (Figure S5).

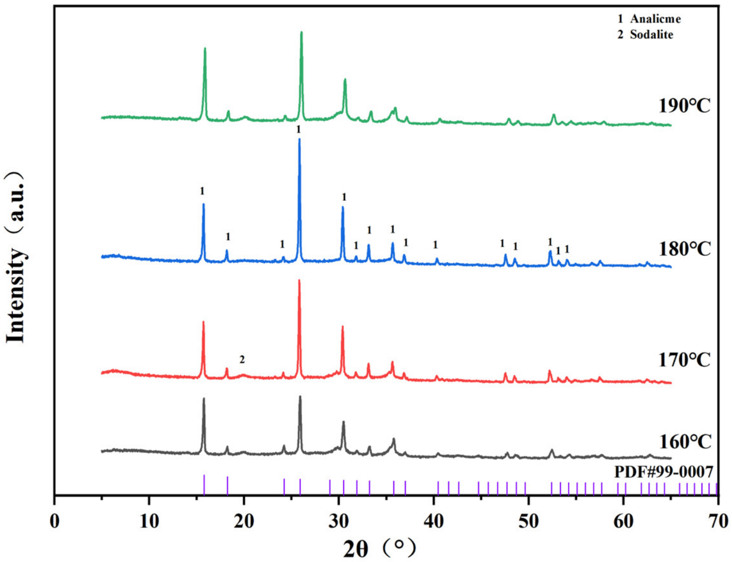

Figure S5. Effect of crystallization temperature on analcime synthesis (liquid-solid ratio 5:1, pH 12.0, aging time 5 h, crystallization time 72 h).

The effect of crystallization time on the analcime synthesis by adjusting the crystallization time to 24 h, 48 h and 72 h, respectively. It was found that the crystallinity of synthetic analcime (PDF#99-0007) was the highest when the crystallization time was 72 h (Figure S6).

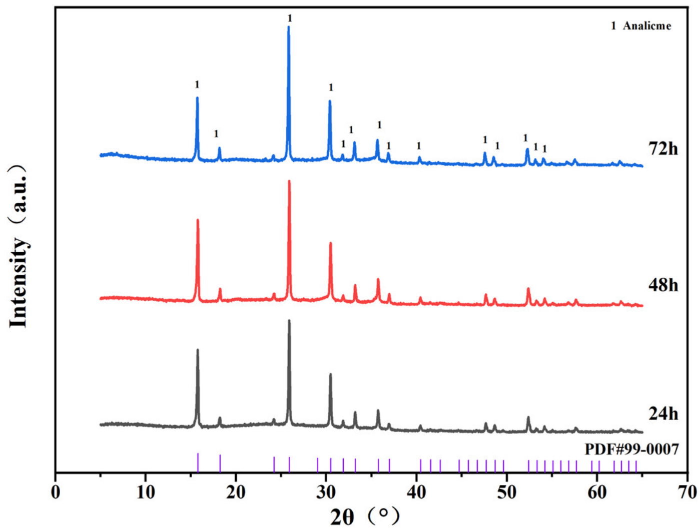

Figure S6. Effect of crystallization time on analcime synthesis (liquid-solid ratio 5:1, pH 12.0, aging time 5 h, crystallization temperature 180 °C).

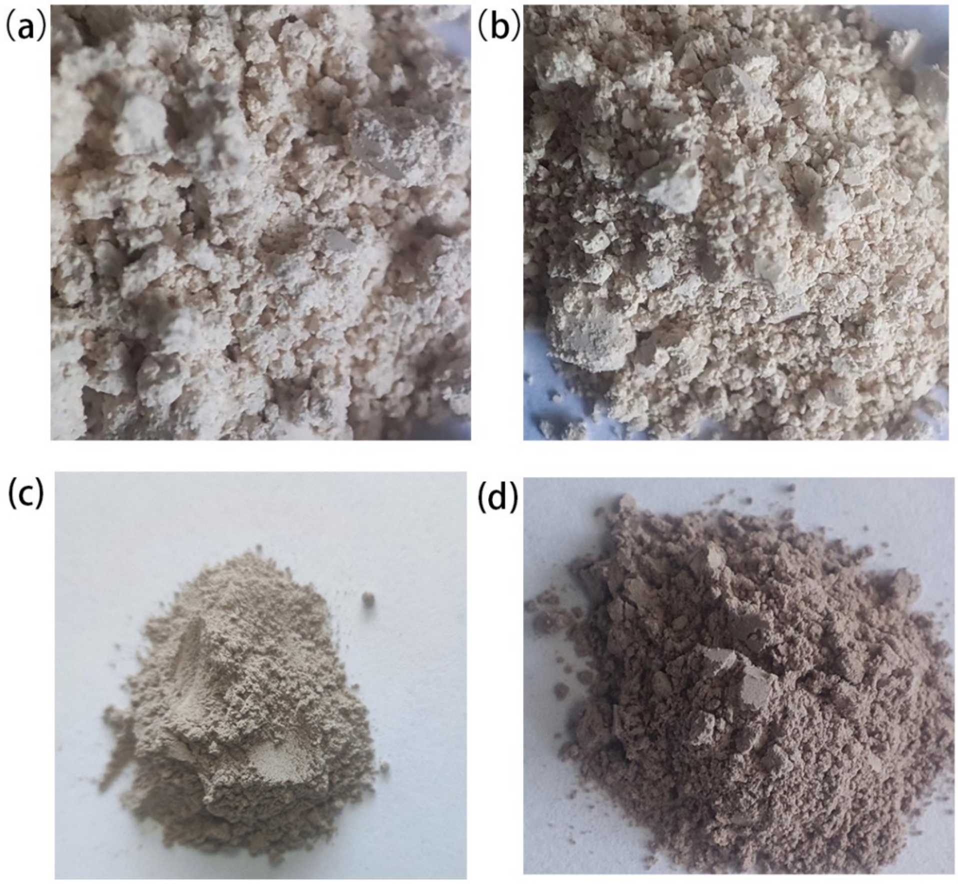

Figure S7. Images of zeolite NaA before (**a**) and after amine modification (**b**), and analcime before (**c**) and after amine modification (**d**).

References:

[1] Fu P, Yang T, Feng J, et al. Synthesis of mesoporous silica MCM-41 using sodium silicate derived from copper ore tailings with an alkaline molted-salt method. Journal of Industrial & Engineering Chemistry, 2015: 338-343.

[2] Han X, Wang Y, Zhang N, et al. Facile synthesis of mesoporous silica derived from iron ore tailings for efficient adsorption of methylene blue. Colloids and Surfaces A Physicochemical and Engineering Aspects, 2021, 617(5): 126391.