



## Pozzolanic behaviour of compound-activated red mud-coal gangue mixture

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### ABSTRACT

The pozzolanic behaviour of compound-activated red mud-coal gangue has been investigated through TG, DTA, XRD, FTIR and <sup>27</sup>Al MAS NMR. From viewpoint of reaction kinetics, it is found that the pozzolanic reaction mechanism of the compound-activated red mud-coal gangue – lime system is clearly consistent with diffusion control up to 14 days, and the reaction rate constant calculated from Jander equation decreases with the increase of CaO addition in the system. The hydration products formed in the red mud-coal gangue – lime systems at ambient temperature are essentially aluminous C–S–H and Ca<sub>3</sub>Al<sub>2</sub>O<sub>6</sub>·xH<sub>2</sub>O. From TG analysis results, it is thought that the high amount of Ca(OH)<sub>2</sub> in the pastes of studied system is not conducive to the continual increase of non-evaporable water content of the hydration products. Of particular interest, <sup>27</sup>Al MAS NMR proved to be an effective technique to obtain valuable information of Al<sup>[4]</sup> in C–S–H and Al<sup>[6]</sup> in Ca<sub>3</sub>Al<sub>2</sub>O<sub>6</sub>·xH<sub>2</sub>O.

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### 1. Introduction

It is known that China has a large capacity of alumina production. However, 0.8–1.5 tons of red mud is generated by per ton of alumina production. It was estimated that over 7 million tons of red mud is impounded annually in China [1]. The large emission of red mud from alumina production has caused severe environmental problems. Meanwhile, there is also a huge capacity of coal production in China. While coal gangue generated from the coal production is a non-ignorable issue. The vast majority of coal gangue is stockpiled, not only causing local ecological and environmental problems, but also threatening the safety of local residents. To ensure the safety of red mud and coal gangue, recycling these two solid wastes has been a challenging task urgently considered by the government authorities in China. Utilizing red mud and coal gangue as cement additions or part cement replacement materials could be a promising direction to effectively consume the huge amounts of these two solid wastes, leading to the prime interest of savings on energy resources and reduction of environmental pollution.

It has been reported that calcined red muds are pozzolanic [2]. For red mud derived from bauxite-calcination method, a calcination temperature of 600 °C has generally given the best cementitious properties [3,4]. Due to bauxite-calcination-method red mud contains some quantities of amorphous aluminosilicate materials and gibbsite, they can be transformed into reactive silica and alumina during the

calcination process, resulting in some pozzolanic properties. The cementitious property of raw coal gangue is very weak. Calcination under 600–700 °C can significantly improve the activity of coal gangue due to the decomposition of clay minerals to form active silica and alumina [5,6]. Besides, addition of CaO or other calcium source during calcination can further improve the activity of coal gangue [7,8]. Considering that bauxite-calcination-method red mud contains large amount of calcium oxide in its chemical composition, we used the bauxite-calcination-method red mud as calcium source to enhance the activity of coal gangue through compound activation method [9]. In our previous literature [9], it was found that compound activation method can significantly improve the cementitious behaviour of red mud-coal gangue mixtures, and appropriate amount of red mud can promote the decomposition of chlorite and lower the crystallinity of quartz occurring in the coal gangue. We have also conducted an experiment on using the subsequent red mud-coal gangue mixture as pozzolanic materials blending with blast furnace slag, clinker and gypsum to produce cementitious material, and it has been demonstrated that the developed red mud-coal gangue based cementitious material had good physical and mechanical properties [10]. However, a confusing question present in most readers' minds might be: what is the pozzolanic behaviour of the compound-activated red mud-coal gangue mixture?

Pozzolanic behaviour is usually defined as the capability of a pozzolanic material reacting with lime in the presence of water at ordinary temperatures to form cementitious compounds. Pozzolanic materials generally used in the cement industry include natural volcanic ash, metakaolin, calcined clays or industrial by-products such as slag, fly ash, calcined red mud and calcined coal gangue. Among all

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