Powder Technology 286 (2015) 678–683

Contents lists available at ScienceDirect

Powder Technology

journal homepage: www.elsevier.com/locate/powtec

Tungsten tailing powders activated for use as cementitious material

Kang Peng [a,b], Huaming Yang [a,b,c,*], Jing Ouyang [a,b,**]

[a] Centre for Mineral Materials, School of Minerals Processing and Bioengineering, Central South University, Changsha 410083, China
[b] Key Laboratory for Mineral Materials and Application of Hunan Province, Central South University, Changsha 410083, China
[c] State Key Laboratory of Powder Metallurgy, Central South University, Changsha 410083, China

ARTICLE INFO

Article history:
Received 8 June 2015
Received in revised form 30 August 2015
Accepted 5 September 2015
Available online 9 September 2015

Keywords:
Tungsten tailing
Garnet
Activation
Cementitious material

ABSTRACT

Tungsten tailing powders were activated by mechanical and chemical methods for use as cementitious material in mortar. The composition, microstructure and properties of tungsten tailing were characterized with X-ray fluorescence, X-ray diffraction, scanning electron microscopy, Fourier transformation infrared spectroscopy, differential scanning calorimetry and thermogravimetry. The results showed that garnet was the major mineral in the tailing, which possessed excellent chemical and structural stability but poor cementitious property. Mechanical milling and chemical activator were used to activate the tailing. The activation effects and structural evolution of activated tungsten tailing were assessed, and the possible mechanism was discussed. A series of cement mortar samples was prepared to evaluate the cementitious property of the activated tailing. Effects of activation condition and mixture proportion on mechanical strength of cement mortar were investigated. The mechanical and chemical activations could synergistically improve the cementitious property. The properties of cement mixed with 20% of the activated tailing were well comparable with those of 42.5 ordinary Portland cement. The activated tailing as cementitious material could be used to solve the tailings pollution and reduce cost in cement industry.

1. Introduction

The mineral mining and processing generate numerous tailings after extract valuable minerals and abandon associated minerals [1–3]. Approximately 7–10 tons of tungsten tailings is produced for per ton of tungsten concentrates depending on the tungsten ore grade and dressing level [4,5]. Tungsten as essential element for modern industry has been widely used in many fields, such as energy, environment, military and aerospace [6–9]. China reserves 62.1% of the global tungsten resources and produces 90.9% of tungsten products [10,11]. Currently, most tungsten tailings are stored in tailing dams or backfilled in the mines without effective utilization. These handling methods waste lots of associated resources and lead to potential environmental damage [12,13]. For example, the arsenic and heavy metals leaked from tungsten tailing could pollute waters and soil [14–16]. The effective utilization strategy for tungsten tailing becomes increasingly important.

Many researchers have studied to improve the comprehensive utilization rate of tungsten tailing. Zhao et al. [17] separated molybdenum from tungsten by selective precipitation, and evaluated effects of operation conditions. The results demonstrated that the precipitation of tungsten decreased slightly above 80% with increasing molybdenum. Yang et al. [18] successfully prepared glass ceramics from tungsten tailing after magnetic separation and the main crystalline phases in the glass ceramics were gehlenite and hedenbergite.

Production of cementitious material from tungsten tailing is a significant practice for resources and environment. Activation is necessary for tungsten tailing due to their poor cementitious property. Common activation methods were mechanical activation, thermal activation, and chemical activation [19,20]. Mechanical activation can reduce the particle size, increase the surface area and defect concentration by grinding raw materials [21,22]. Thermal activation can accelerate the reaction rate by curing mortar or concrete under relatively high temperature [23,24]. Chemical activation can improve reactivity by adding chemicals [25,26].

Cement is the most widely used construction material for its high mechanical strength and low cost. Its durability is particularly well suitable for building and road engineering. Many cementitious materials are used as replacement of clinker to save energy and reduce cost, such as blast-furnace slag [27–30], fly ash [31,32], steel slag [33], tailing [34–36] and activated mineral additives [37–40]. These additives could improve the performance of cement, such as high acid resistance, good durability, and low heat of hydration. Wang et al. [41] investigated the effect of steel slag and granulated blast furnace slag as blended mineral admixtures on hydration and mechanical strength of cement. The results showed that mixing the two admixtures at proper ratios

* Correspondence to: H. Yang, Centre for Mineral Materials, School of Minerals Processing and Bioengineering, Central South University, Changsha 410083, China.
** Correspondence to: J. Ouyang, Key Laboratory for Mineral Materials and Application of Hunan Province, Central South University, Changsha 410083, China.
E-mail addresses: hmyang@csu.edu.cn (H. Yang), jingouyang@csu.edu.cn (J. Ouyang).

http://dx.doi.org/10.1016/j.powtec.2015.09.012
0032-5910/

Table 1
Chemical compositions and minerals of tungsten tailing.

Major oxides (wt.%)		Minor oxides (wt.%)		Minerals (wt.%)	
SiO_2	36.52	SO_3	0.16	Garnet	88.14
CaO	28.02	TiO_2	0.12	Amphibole	5.46
Fe_2O_3	11.71	K_2O	0.05	Chlorite	4.27
Al_2O_3	8.70	Cr_2O_3	0.03	Quartz	2.13
MnO	2.56	WO_3	0.03		
MgO	1.12	ZnO	0.02		
LOI	2.30	V_2O_5	0.02		

could obtain satisfactory strength, long setting time, low hydration heat, and good fluidity.

In this study, tungsten tailing was activated by mechanical and chemical methods to prepare cementitious material in mortar. Firstly, we investigated the composition, microstructure and physicochemical properties of tungsten tailing. Mechanical milling and chemical activators were used to activate tungsten tailing, and the effects of different milling times and activators were investigated. XRD analysis was performed to provide an evidence for structural evolution of activated tungsten tailing. A series of cement mortar samples was prepared, and the effects of activation condition and mixture proportion on mechanical strength were investigated. The physical and mechanical properties of cement mortar were compared with Chinese standard to evaluate the activated tailing as cementitious material.

2. Materials and methods

2.1. Materials

The tungsten tailing used in this work was obtained from Hunan Nonferrous Metals Co. Ltd., China, where approximately 700,000 tons of tungsten tailings was generated every year. Cement clinker was supplied by South Cement Co. Ltd., China. Standard sand was produced by China ISO standard sand Co. Ltd., China. Lime (CaO), gypsum ($CaSO_4 \cdot 2H_2O$) and sodium silicate ($Na_2SiO_3 \cdot 9H_2O$) were analytically pure and supplied by Sinopharm Chemical Reagent Co. Ltd., China.

2.2. Characterization of tungsten tailing

Elemental composition of tungsten tailing was determined by X-ray fluorescence (XRF) using radiation at an acceleration voltage of 100 kV and current of 80 mA (PANalytical Epsilon 5). Major oxide contents

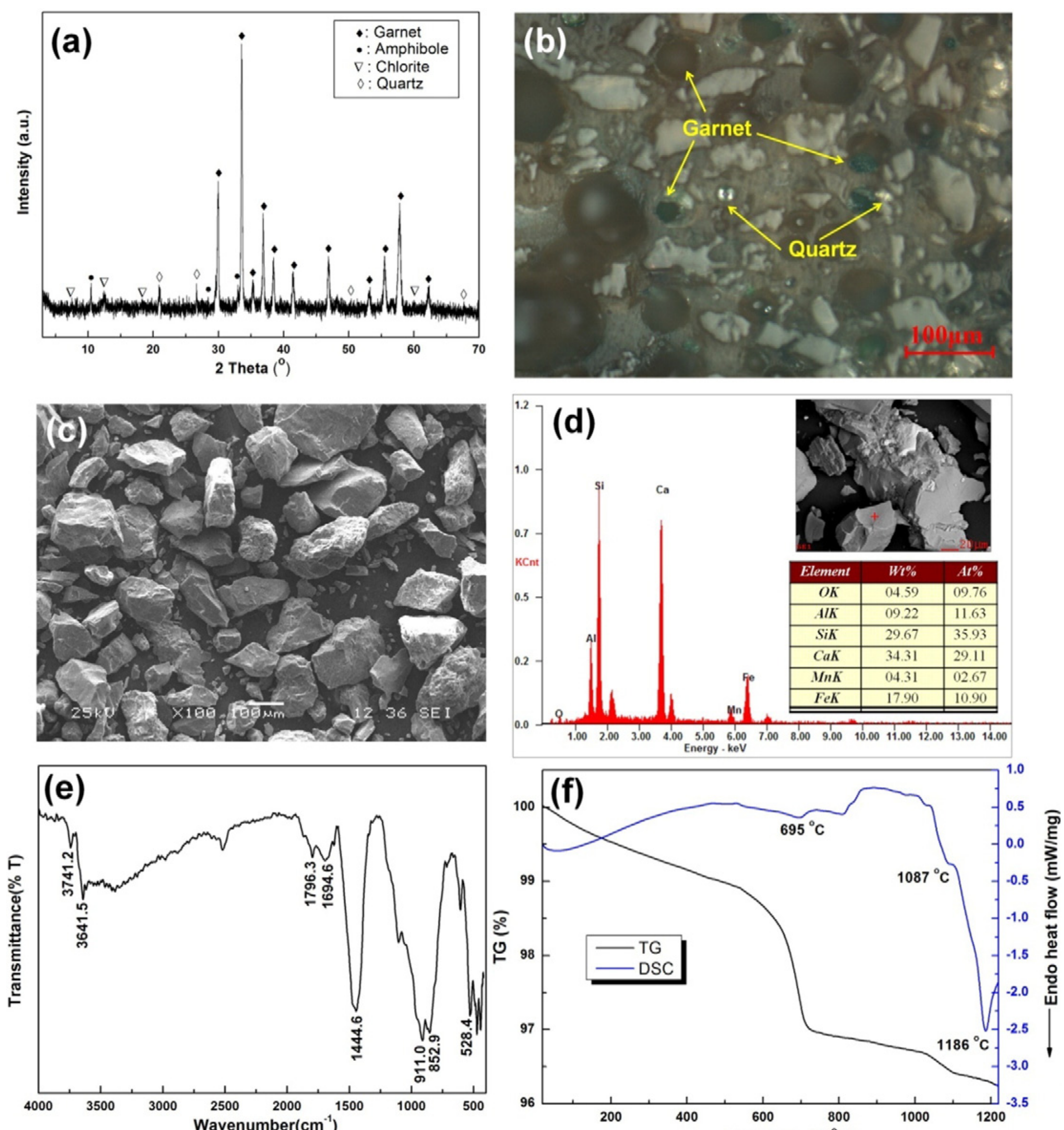

Fig. 1. (a) XRD pattern, (b) petrographic microscopy image, (c) SEM image, (d) EDS spectrum, (e) FTIR spectrum and (f) TG and DSC curves of tungsten tailing.