Journal of Asian Ceramic Societies 2 (2014) 387–398

HOSTED BY

Contents lists available at ScienceDirect

Journal of Asian Ceramic Societies

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

Synthesis of geopolymer composites from a mixture of volcanic scoria and metakaolin

J.N.Y. Djobo[a], L.N. Tchadjié[a], H.K. Tchakoute[a,*], B.B.D. Kenne[a,b], A. Elimbi[a], D. Njopwouo[a]

[a] Laboratory of Applied Inorganic Chemistry, University of Yaounde I, Faculty of Science, Department of Inorganic Chemistry, B.P. 812, Yaounde, Cameroon
[b] Laboratoire Matériaux et Durabilité des Constructions, Université de Toulouse, INSA/UPS Génie Civil, 31077 Toulouse Cedex 04, France

ARTICLE INFO

Article history:
Received 26 June 2014
Received in revised form 6 August 2014
Accepted 8 August 2014
Available online 3 September 2014

Keywords:
Volcanic scoria
Metakaolin
Alkaline solution
Amorphous phase
Geopolymer pastes

ABSTRACT

The aim of this work is to valorize volcanic scoria by using them as starting material for geopolymers production. Nevertheless, volcanic scoria possesses low reactivity. Various amounts of metakaolin (5%, 10%, 15%, 20% and 25%) were added into two volcanic scoria (Z_D and Z_G) in order to improve their reactivity. Two alkaline solutions were used to activate the aluminosilicate materials. The starting materials were characterized by particle size distribution, specific surface area, chemical and mineralogical composition. The geopolymers were characterized by the setting time, XRD, FTIR, SEM and compressive strength. The results indicated that volcanic scoria have low specific surface area (2.3 m^2/g for Z_D, 15.7 m^2/g for Z_G), high average particle size (d_{50} = 13.08 μm and 10.68 μm for Z_D and for Z_G respectively) and low glass phase contents. Metakaolin have a smaller average particle size (d_{50} = 9.95 μm) and high specific surface (20.5 m^2/g). The compressive strength of geopolymers increased in the ranges of 23–68 MPa and 39–64 MPa for geopolymers from Z_D–MK and Z_G–MK respectively. This study shows that despite the low reactivity of volcanic scoria it can still be used to synthesize geopolymers with good physical and mechanical properties.

1. Introduction

Geopolymers are a class of largely X-ray amorphous aluminosilicate materials, generally synthesized by activation of an aluminosilicate powder with a concentrated alkali metal silicate or hydroxide solution. Geopolymers have been the subject of a great deal of research interest, particularly during the last decade owing to their good properties and as they are low emission CO_2 materials. It may be synthesized at an ambient or elevated temperature by alkaline activation of aluminosilicate obtained from industrial wastes [1–5], metakaolin [6–9], melt-quenched aluminosilicate [10], natural minerals such as volcanic scoria [11–15], or mixtures of two or more of these materials [16,17]. Activation is achieved by addition of highly concentrated alkali metal hydroxide or silicate solutions. Tchakoute et al. [17] reported that volcanic scoria contain low amount of alumina oxide (Al_2O_3), which can be compensated by addition of amorphous alumina. However, amorphous alumina is very expensive and the compressive strength of geopolymers synthesis at ambient temperature from a mixture of volcanic scoria and an excess (40% by weight) of amorphous alumina is less than 48 MPa, thus compensating partially the deficiency. This deficiency can be efficiently compensated by adding high reactive amorphous minerals such as metakaolin and fly ash because these amorphous aluminosilicate materials contain a good source of amorphous Al_2O_3 and SiO_2.

A previous study [18] has shown that geopolymer cements obtained only from volcanic scoria at ambient temperature exhibit long setting time, low compressive strength, and some volcanic scoria-based geopolymers swelled and presented cracks after demolding. Also, geopolymers synthesized from volcanic scoria collected in Djoungo could handle easily only after 14 days at ambient temperature; this is probably due to their low reactivity assessed by a low specific surface area (2.3 m^2/g) and low glass phase content (34.8%) [18].

The present work aims at altering the reactivity of volcanic scoria by adding 5%, 10%, 15%, 20% and 25% by weight of metakaolin (MK) in the volcanic scoria in order to compensate the deficiency of Al_2O_3 and to increase the amount of amorphous phase in the volcanic scoria, thus reducing the amount of metakaolin to be used for the synthesis of geopolymers and therefore reducing the cost of geopolymer cements. The effect of the addition of metakaolin on the geopolymerization reaction, structure and mechanical properties of the volcanic scoria-based geopolymer has been studied using

* Corresponding author. Tel.: +237 77979617/96811939.
E-mail addresses: htchak@yahoo.fr, hervetchakoute@gmail.com (H.K. Tchakoute).

Peer review under responsibility of The Ceramic Society of Japan and the Korean Ceramic Society.

2187-0764 © 2014 The Ceramic Society of Japan and the Korean Ceramic Society. Production and hosting by Elsevier B.V. Open access under CC BY-NC-ND license.
http://dx.doi.org/10.1016/j.jascer.2014.08.003

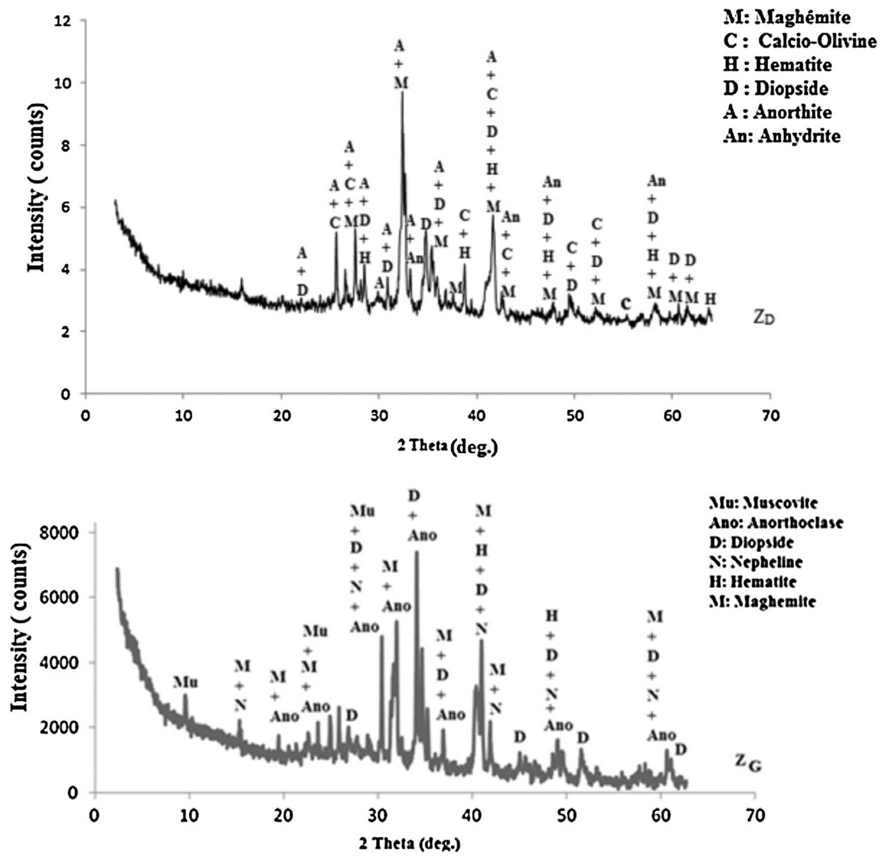

Fig. 1. XRD patterns of volcanic scoria (Z_D and Z_G).

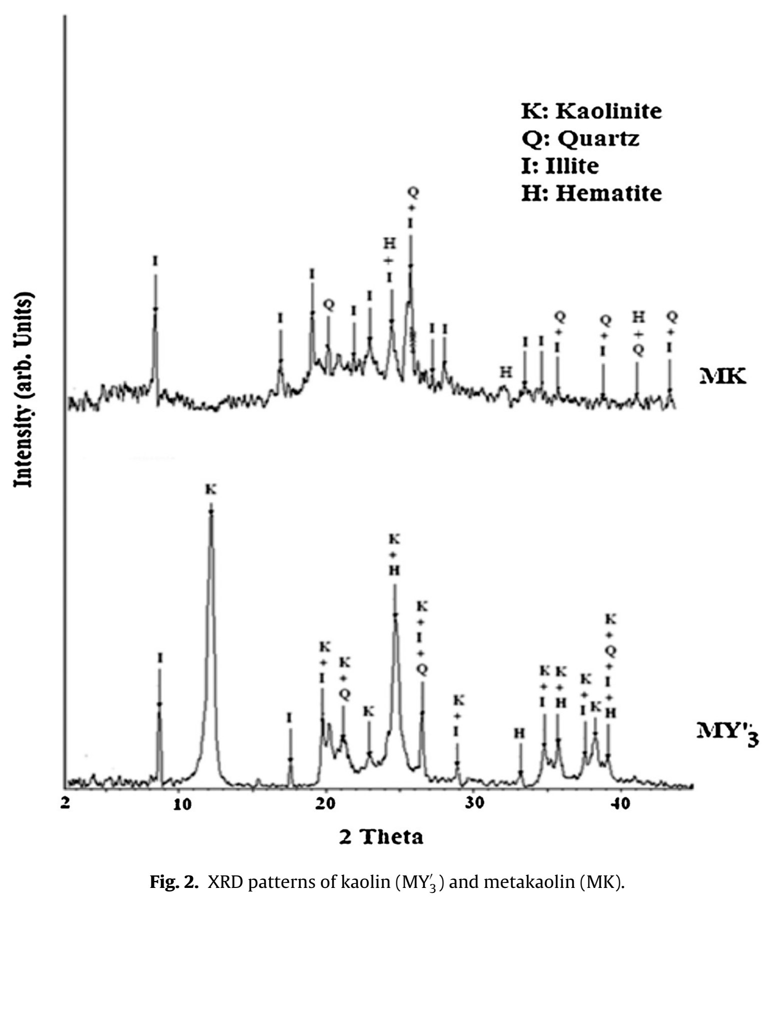

Fig. 2. XRD patterns of kaolin (MY'_3) and metakaolin (MK).