Journal of Asian Ceramic Societies 2 (2014) 263–267

Contents lists available at ScienceDirect

Journal of Asian Ceramic Societies

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

Talc as raw material for cementitious products formulation

C.J. Ngally Sabouang[a], J.A. Mbey[a,b,*], Liboum[a], F. Thomas[b], D. Njopwouo[a]

[a] Laboratory of Applied Inorganic Chemistry, Department of Inorganic Chemistry, University of Yaoundé I, P.O. Box 812, Yaoundé, Cameroon
[b] Laboratoire Interdisciplinaire des Environnements Continentaux, UMR 7360 CNRS – Université de Lorraine, 15 Avenue du Charmois, B.P. 40, F-54501, Vandoeuvre-lès-Nancy Cedex, France

ARTICLE INFO

Article history:
Received 26 March 2014
Received in revised form 15 May 2014
Accepted 22 May 2014
Available online 9 June 2014

Keywords:
Talc
Magnesia
Cement
Compressive strength

ABSTRACT

This study reports the characterization of a talc from Cameroon as a possible source material for cement formulation. To that end, the talc sample was characterized and mixed with a solution of sodium polyphosphate to formulate the cementitious products. Addition of magnesia (MgO) was done to analyze the effect of available MgO on the products. Fourier transform infrared, X-rays diffraction, linear shrinkage, compressive strength and scanning electron microscopy were used to analyze the products. The compressive strength increased with addition of MgO and the linear shrinkage decreased. All the analyses indicate that talc is a raw material of interest in cementitious products formulation; however, the inclusion of the MgO is a key factor for a better performance of the products.

1. Introduction

Cement formulation is presently a growing research area due to the variety and development of construction and building material. The ever growing concerns over global warming and other detrimental ecological changes have spurred the research and development of new kinds of cementitious materials produced from nonconventional resources. The reason is that the production of 1 ton of hydraulic cement will generate about 900 kg of carbon dioxide and consume about 5 billion joules of electrical power and fuel energy [1,2]. The geopolymers for instance are a family of cementitious materials developed in late 70s and appear as an alternative of interest [3]. Kaolinite is nowadays a material largely used in geopolymers making as evidenced by the increasing number of publications that deal with metakaolin based geopolymers [4–8]. Some new classes of raw materials are now being introduced in this domain. For instance, the use of volcanic ashes as raw material in geopolymer making is now established [9,10].

Talc is a hydrated layered magnesium silicate with chemical formula $Mg_3Si_4O_{10}(OH)_2$. It is a hydrophobic material that easily blends and disperses within organic media including polymers. Talc is widely used as reinforcing filler in several industrial products such as paper, paints, rubbers, polymers, ceramics, and refractory materials [11,12]. The composition of talc makes it a potential raw material in cement formulation since magnesium can beneficially interact with phosphate to give cementitious material, as in phosphate-magnesia cements [13–16]. One such a talc-based cementitious material is already used as prosthesis in dental surgery [17]. Recently, Pusch et al. [18] have used talc as a super plasticizer for the formulation of cement poor concrete to be used for boreholes sealing in rocks.

Given that some talc deposits are found along the pan-African Yaoundé fold belt at the border of the northwestern edge of the Congo craton [19,20], it is obvious that a research seeking for talc valorization is to be undertaken. In the present work, talc from Cameroon is used as raw material for the formulation of cementitious products. Because the mobilization of magnesia is expected, a study of the effect brought by the addition of magnesia is also carried out. Analysis of some properties of cement paste made from talc is presented here as a first step towards valorization of talc as raw material in cement formulation. Powder X-ray diffraction (XRD), Fourier infrared spectroscopy (FTIR), scanning electron microscopy (SEM), mechanical testing (compressive strength) and linear shrinkage measurements are used to characterize the formulations.

* Corresponding author at: Laboratoire Interdisciplinaire des Environnements Continentaux, UMR 7360 CNRS – Université de Lorraine, 15 Avenue du Charmois, B.P. 40, F-54501, Vandoeuvre-lès-Nancy Cedex, France. Tel.: +237 99 23 89 25.
E-mail addresses: cngally@yahoo.fr (C.J. Ngally Sabouang), mbey25@yahoo.fr, jean-aime.mbey@univ-lorraine.fr (J.A. Mbey), liboum2002@yahoo.fr (Liboum), fabien.thomas@univ-lorraine.fr (F. Thomas), dnjop@yahoo.fr (D. Njopwouo).

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

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http://dx.doi.org/10.1016/j.jascer.2014.05.007

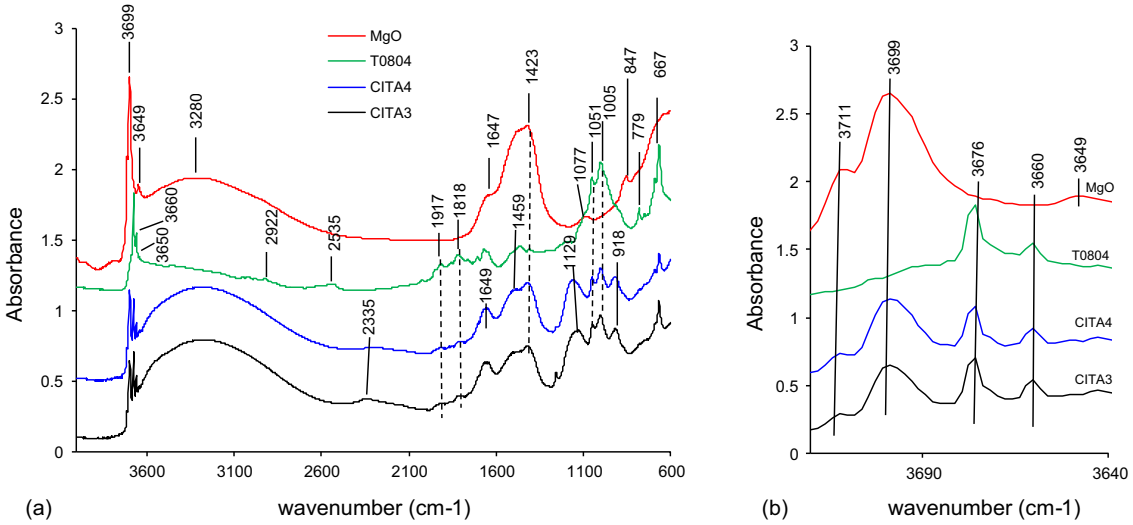

Fig. 1. Infrared spectrum of the raw talc (T0804), the magnesia (MgO), the talc cement with 15% MgO ($CITA_3$) and the talc cement with 20% MgO ($CITA_4$). (a) The global spectrum and (b) zooming on the O-H region.

2. Materials and methods

A talc from Lamal Pougue in the Boumyébèl area at about 93 km from Yaoundé (Center region, Cameroon) was used. The area description is presented in Nkoumbou et al. [19]. The raw material was manually ground and sieved at 100 μm prior to characterization.

Sodium polyphosphate ($(NaPO_3)_n$) analytical grade containing 60% P_2O_5 was purchased from Riedel de Haen AG, and was used as phosphate source.

The magnesia used is an analytical grade product from Rhône-Poulenc. The IR spectrum (Fig. 1) shows traces of sulphur compounds through the stretching band of sulphate at 1423 cm^{-1} and S—O stretching at 847 cm^{-1}. The bands at 1459 cm^{-1} indicates the presence of carbonate. Some silicate impurities are detected from the band at 1077 cm^{-1} due to forsterite (Mg_2SiO_4) as also observed from the XRD pattern (Fig. 2). The X-ray pattern also indicates that the magnesite is almost completely converted into magnesia.

The cement pastes were prepared as follows:

In an acidic solution of sodium polyphosphate, known amounts of talc and calcined MgO were added. The mixture is thoroughly mixed for 5 min using a M & O mixer.

This mixture is used to prepare cylindrical samples using cylindrical mould having a diameter of 30 mm and a height of 60 mm. The paste in the mould is vibrated for 10 min on an electrical vibrating table (M & O, type 202, No. 106) to remove entrapped air bubbles. The samples are covered with a polyethylene bag and left for consolidation. The consolidated samples are kept at the ambient temperature (24–27 °C) and the mechanical analysis is carried out on the 28 days aged samples. The sample indexed $CITA_0$ is prepared without any added magnesia. For this sample, 50 g of talc with 50 g of 40% (in weight) solution of sodium polyphosphate is used. For samples in which magnesia is added, the amounts of magnesia, expressed in percentage mass with respect to the initial mass of talc (50 g), were: 5%, 10%, 15% and 20%. The obtained products are indexed $CITA_1$ to $CITA_4$ in the increasing order of magnesia content.

The cement sample is analyzed using powder X-ray diffraction (XRD), Fourier transform infrared (FTIR) spectroscopy, scanning electron microscopy (SEM) coupled to energy dispersive X-ray spectroscopy (EDS), linear shrinkage and compressive strength measurements.

Chemical analysis of major elements in the raw talc was performed by inductive coupled plasma by atomic emission spectrometry (ICP-AES) at the *Service d'Analyse des Roches et des Minéraux* (SARM, Nancy).

Powder X-ray diffraction patterns were recorded using a D_8 Advance Bruker diffractometer equipped with a Co Kα radiation (λ = 1.7890 Å) operating at 35 kV and 45 mA. The diffraction patterns were obtained from 1.5° to 32° at a scanning rate of 1° min^{-1}.

Infrared spectra were recorded in diffuse reflection mode using a Bruker IFS 55 spectrometer. The spectra, recorded from 4000 cm^{-1} to 600 cm^{-1} with a resolution of 4 cm^{-1}, are an accumulation of 200 scans.

The SEM micrographs and EDS data were obtained on a Hitachi S-4800 using a YAG (Yttrium Aluminium Garnet) backscatter secondary electron detector. The samples were carbon coated prior to analysis.

Measurement of linear shrinkage was done using a calliper on the hardened geopolymer mortars aged of 1, 7, 14 or 28 days

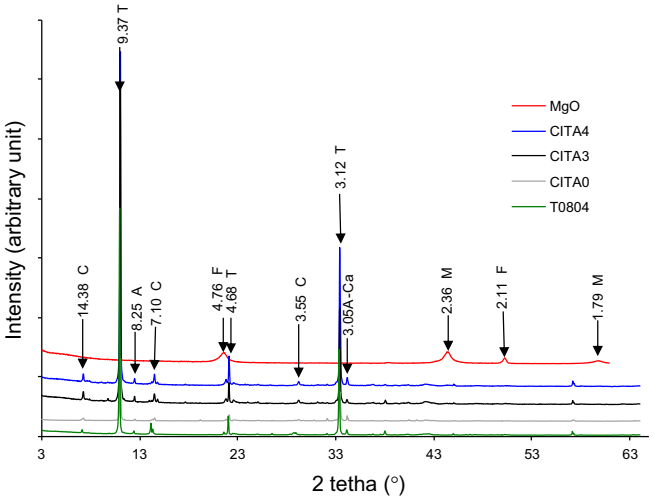

Fig. 2. XRD patterns of the raw talc (T0804), magnesia (MgO), talc cement ($CITA_0$), talc cement with 15% MgO ($CITA_3$) and talc cement with 20% MgO ($CITA_4$) (T, talc; C, chlorite; A: amphibole; Ca: calcite; F, forsterite; M, magnesia).