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VITRIFICATION and GEOPOLIMERIZATION of WASTES for IMMOBILIZATION or RECYCLING

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Editores

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WELCOME to VITROGEOWASTES 2017

Miguel Hernández University is hosting the **VITROGEOWASTES 2017** international workshop, due to be held from **14 to 15 September** in Elche (Alicante-Spain). Over what are expected to be two intense days, discussions will be centred on a series of topics of enormous interest connected with **vitrification** and **geopolymerization** of waste for immobilisation or recycling.

We'll be listening to **internationally renowned** speakers who are leaders in these fields. We're also going to be expanding our knowledge in discussions based on more than fifty scientific papers due to be presented in the panel sessions.

Here at Miguel Hernández University we're delighted to be holding this workshop, which aims to disseminate **interesting studies** with the potential to improve our everyday lives. The importance of environmental protection is plain to see and it's up to us to raise awareness of this issue and set future generations on the right path.

Sessions will take place in the **'Ciutat d'Elx' Conference Centre**, a modern setting for sharing and discussing ground-breaking work on vitrification and geopolymerization. The workshop is an exceptional networking opportunity for researchers, academics and students alike.

Elche, host venue for **VITROGEOWASTES 2017,** is a typically Mediterranean city, where visitors are given the warmest of welcomes. I invite you to take some time to wander through the streets and explore the endless palm tree groves. During the workshop, you'll have the chance to learn more about El Palmeral and the Misteri, both of which hold UNESCO World Heritage status. You'll also be able to see how the two ancient crafts of palm tree caretaking and palm leaf weaving are still practised. Plus, the closing gala dinner promises to be a feast of the very best local Elche cuisine.

I'd like to give you a very warm welcome to **VITROGEOWASTES 2017** and to Elche, please make yourselves at home.

Manuel Jordán Vidal
Research and Innovation Vice-chancellor UMH
Dept. of Agrochemistry and Environment Sciences UMH

LOCAL SCIENTIF AND TECHNICAL ORGANIZING COMMITEE

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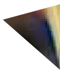

INAUGURAL LECTURES

Proto-historical wall vitrification in Europe: a precedent to modern vitrification and sintering?

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ABSTRACT

This work briefly reviews the evidence for vitrification of proto-historical walls in Europe, and its consideration within the historical evolution of knowledge on vitrification and sintering until current days. During the last decade, several studies have confirmed the origin of glass found in hundreds of fortifications throughout Europe as a result from partial melting of rocks derived from the local substrate under high temperature conditions. In a few cases, the glass had previously been erroneously assigned to volcanism or meteoritic impact metamorphism. The large volume of glassy material and the absence of metallic ore in the surroundings allowed to discard the possibility of lightning strike fusion (fulgurite) and metallurgy (smelt slag). Assessment of all available information suggested that the glass originated from vitrification of human constructions made of wood and stone which were partially or totally destroyed by fire. Proto-historical archaeological remains are commonly present at and/or near the sites, suggesting that the source rock originally formed part of former human constructions, most frequently related with Bronze Age and Iron Age (Celtic) hill-forts. The depletion of natural wood resources and widespread clearcutting of forests throughout Europe marked the abandonment of formerly-traditional defence construction techniques. Archaeomagnetic dating of the glass and carbon dating of charcoal residues allow for the precise timing of wall burning [1]. In most cases, vitrification seems to be related with wall burning due to territorial conflicts (wars) or accidents (lightning, forest fires), but there is at least one proven case for systematic intentional burning of the wall, most probably for its consolidation towards greater stability and resistance [2]. High-phosphorous content and the identification of bones and ceramic fragments within the vitrified walls points towards an early case for the vitrification of urban waste residues [3].

Keywords

Vitrification; Bronze Age; Iron Age; hill-forts; geoarchaeology

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Glass- ceramics in Spain: R+D+i five decades and some highlights about the implementation of ATC in Spain

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ABSTRACT

Since1970 that started the glass- ceramics research in Spain at the ICV-CSIC by González-Peña and Rincón, there have been intense activity in this science and technological lines during the last five decades. After the pioneer work carried out in this institute, other universities departments, research centres and even Spanish industries have developed R+D+i on several types of glass-ceramics. Being pendant to write the full history on this field in Spain, here is given a general and short view about this evolution. At the same time, the next implementation in Spain of the ATC (Centralized Storage for high activity nuclear wastes) is highlight and related to the past pioneer experience during 80´ decade last century with celebration of the first Seminar on Vitrification in 1985 under the bilateral USA- Spain Agreement (may 21th and 22th) at former Junta de Energía Nuclear, Madrid (…now named Ciemat) with the visit of recognized researchers from Berkeley Lab and Davis Materials Department, both from the California University. Therefore, this historic milestone and the actual situation, nowadays in Spain for this research, is related to the worldwide context.

Keywords

Vitrification, glass- ceramics, industrial wastes, nuclear wastes, Glass ceramics, ATC in Spain

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INVITED LECTURES

Nuclear waste vitrification: Focus on French experience

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ABSTRACT

Glass, because of its disordered structure, was identified in the 1950s as an excellent material for confining the wide range of elements present in fission product solutions arising from reprocessing of spent nuclear fuel. Glass can actually host most of the radioactivity generated in nuclear power plants. After two decades of research in this area, the first industrial vitrification plant was commissioned at Marcoule site in 1978 followed by the R7 and T7 vitrification plants at La Hague site in the early nineties. Industrial vitrification lines have been commissioned in several other countries involved in nuclear energy. In nuclear containment glass, radionuclides generally form chemical bonds with the glass constituent atoms. The preferred glass formulations are mixed alkali aluminum borosilicates because they combine the possibility of incorporating a wide range of radioactive elements with a relative ease of synthesis and long-term stability. The specification for the chemical composition of a containment glass represents a trade-off between three main objectives: satisfactory long-term resistance, chemical flexibility ensuring the incorporation of dozens of chemical elements in the glass structure at the atomic scale, and feasible implementation by an industrial process. These three objectives are considered at the early stage of glass formulation studies. These objectives can be translated in terms of constraints on physical and chemical properties of glass melt and final glass. Different types of vitrification furnaces have been developed for this application. The elements to be immobilized are mixed at high temperature with glass-forming additives to form a glass melt which, after cooling, becomes a chemically durable glass material with low radiation sensitivity. The debate on safe management of high-level waste converges on deep geological disposal.

Keywords
Nuclear waste, alkali aluminium borosilicates, French experience.

Current challenges in the vitrification of nuclear waste in the UK

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ABSTRACT

Spent fuel from both UK nuclear reactors and overseas customers has been reprocessed at the Sellafield Site since the 1950s. In general, reprocessing involves dissolving spent nuclear fuel in nitric acid and removing the uranium and plutonium for re-use using a solvent extraction process. The resulting high level liquid waste (HLLW) stream that contains the majority of the fission products is initially concentrated and stored in the Highly Active Liquor Evaporation and Storage (HALES) plant prior to being converted into a glass in the Waste Vitrification Plant (WVP) at Sellafield for long term storage and final disposal. Since WVP began operations in the early 1990s, ~2500 tonnes of HLW glass have been produced with development work focussing on improving waste incorporation and throughput.

However, over the next few years, reprocessing operations at Sellafield will come to an end, which will result in a change in focus to decommission and remediation activities. Once the existing stocks of HLLW have been vitrified in WVP, the HALES plant will enter a post operational clean out (POCO) phase to clean out the radioactive inventory from the storage tanks, including any historic and legacy liquors, and prepare for future decommissioning. The POCO feeds are expected to be significantly different to the current waste feed in both their chemical composition and physical properties. For example, molybdenum-containing solids are known to have formed in the storage tanks over time, which will challenge the current waste loading limits of the glass composition used for vitrification. Hence, a number of R&D programmes have been undertaken in order to understand the challenges that these new waste streams will present to WVP. These include the development of a novel glass frit composition with an improves molybdenum tolerance, and high sodium glass formulations for treating a potential sodium carbonate wash-out waste stream.

Keywords

Nuclear waste, current challengues in UK

Synthesis, structure and properties of glass-ceramic by Fe-Ni wastes

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ABSTRACT

Hazardous residues from ferronickel smelting plant (70 wt %) are mixed with glass cullet (30 wt %) and vitrified at moderate temperature of 1400 °C. The optimal heat-treatment regime for transformation of obtained glass into glass-ceramic is evaluated by fast non-traditional methods: the nucleation step is estimated by DTA analysis, while the crystallization step – by pycnometric measurements. The results highlight that a low cost heat-treatment (45-60 min nucleation at 650 °C and 30-45 min crystallization at 750 °C) can be applied.

The evolution of crystallization process and the development of glass-ceramic structure are studied in detail by XRD, SEM, EDS and TEM. Additional information about the morphology of final glass-ceramics is obtained by FEG-SEM.

It is highlighted that, due to the presence of 1.5 wt.% chromium oxides and high amounts of iron and magnesium oxides in the parent glass, the crystallization process is peculiar. It starts during the melt cooling with the precipitation of preliminary Fe-Mg-Cr spinel crystals, which then act as centres for epitaxial growth of pyroxene phase. At the same time, due to liquid-liquid immiscibility, the main amorphous phase is characterized by a nonhomogeneous binodal structure, which becomes finer after the nucleation treatment. As a result, pyroxenes with sizes below 1 μm are formed as main crystal phase during the crystallization step. The total crystallinity of this complex structure is estimated at about 55-60 wt. %.

Notwithstanding of the high amount of harmful wastes in the batch, the obtained glass shows a high chemical durability and the resulting glass-ceramic is characterized by attractive mechanical characteristics: bending strength - 120 MPa, Vickers hardness - 9 GPa and fracture toughness – 1.6 MPa $m^{1/2}$.

Keywords

waste vitrification, heat-treatment optimisation, structure, mechanical properties

Geopolymer matrices for the immobilisation of toxic wastes

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ABSTRACT

Geopolymer technology has been recognised to be effective in the immobilisation of toxic wastes since long time ago.

In this paper, after supplying a brief and general overview of the inertization techniques applied to wastes, a wide description is carried out on the effect of alkali activation process (geopolymerization reactions) on different metals fixation

Lead, Arsenic, Chromiun, Mercury, Boron, Cesium, are some of the elements which have been investigated in relation to the leaching capacity within some different geopolymer matrices.

Additionally, some wastes like ashes from an urban incinerator or some mining tailings have also been studied when inertized with geopolymer matrices.

As a general rule, geopolymer matrices, due to the fact that they are formed under strong alkaline conditions, generate an optimal chemical environment for the precipitation of very insoluble phases. Additionally, many low porosity geopolymer matrices can be developed. These two circumstances efficiently help to impede the leaching of many toxic metals when trapped into the geopolymer matrix.

Keywords

Geopolomer matrices, immobilisation, toxic wastes.

Waste-based lightweight geopolymers for novel applications

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ABSTRACT

The production of lightweight geopolymers has become a hot topic in recent years, due to the increasing awareness regarding the unsustainability of Portland cement. The geopolymers potential for structural applications has long been recognized, yet they present other interesting properties (e.g. high temperature stability, heavy metal adsorption capacity) that may allow their use in innovative applications. Environmental applications ranging from pH buffering and wastewater treatment are forecasted in this work. Porous geopolymers were produced, by playing with the composition and by adding blowing agents. Biomass fly-ash and dregs generated by the cellulose industry, Al-anodizing sludge, and red mud were the wastes tried in this work.

Keywords

Porous geopolymers; environmental applications; wastes recycling.

SESSION POSTERS

Vitrification

Palmtree biomass and sewage sludge vitrification

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ABSTRACT

Since decades, it has been demonstrated that vitrification of a wide range of industrial wastes is possible by an adequate design of composition and processing parameters. Even the post-desvitrification by following a controlled crystallization process in two stages: nucleation and crystal growth can be incorporated in the waste vitrification process, allowing the obtention of materials or products with useful applications. Until now, some composted sewage sludge from Alicante area have been proposed as biosolids for soil remediation and even for the compositional design of rustic tiles and technosols. However, up to now the vitrification capabilities of this residue combined with abundant local biomass, such as the palmtree residues has not been investigated. Thus, this is the first research focused about the possible vitrification of biomass wastes from the Elche palmtree orchards and the sewage sludge from the treatment of wastewater in order to reduce this type of wastes and to explode the capability of these residues for the production of construction materials. Here, the analysis by XRF and the HSM (Heating Stage Microscopy) of the starting wastes for evaluate these wastes for vitrification and production of new materials are shown. In order to design new compositions able to vitrified easily, these first experimental results are discussed to the view of the composition phase diagrams.

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Keywords

Palmtree biomass, sewage sludge, vitrification.

Manufacture of sustainable clay bricks valuing ash from burning of wastes from orujillo olive

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ABSTRACT

Currently, the main sources of energy used worldwide are fossil fuels, coal and oil, which are very easy and economical to obtain and transport [1]. The environmental problems and degradation caused by greenhouse gas emissions from the use of this type of fuels make it continue to investigate other types of renewable energy sources friendlier with the environment. Biomass are the most important renewable energy source in the world.

The generation of energy by the burning of biomass produces a series of residues or by-products that cannot be re-integrated within the same manufacturing process, so it is necessary to look for new developments to avoid their disposal on landfill. One of the possibilities for the valorization of these wastes is their use in the manufacture of construction elements. Ceramic products may tolerate considerable amounts of wastes through the inertization and neutralization by encapsulating in the ceramic matrix [2-4].

In this case, the development of clay bricks has been studied with the incorporation of fly ash from the burning of the orujillo olive waste, which is produced in the industry La Loma, located in Villanueva del Arzobispo (Jaén). The incorporation in different dosages of 0 mass%, 5 mass%, 10 mass%, 15 mass%, 20 mass% and 25 mass% has been studied, with a mixture of clays of 40 mass% of black clay, 30 mass% of red clay and 30 mass% of yellow clay. The waste and the different types of clay have been investigated by XRD and XRF. Absorption, suction, compressive strength, ICP-mass, SEM, FTIR and absorption and desorption of nitrogen values of the fired samples were investigated.

Keywords

Clay brick; Orujillo; Olive waste; Fly ash

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Aluminium dust ashes as raw material in ceramic industry

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ABSTRACT

Global demand of aluminium increases continuously and annual production of aluminium exceeds 49 million tons worldwide as of 2014 [1].

Aluminium dust ash, produced by the secondary aluminium industry, and another wastes and by-products that became from aluminium industry has been used in different industrial fields [2].

Some researchers have studied recycling different wastes to produce ceramic bricks [3,4]. The construction industry, due to great need for raw materials can absorb much of the wastes. As it was received at laboratory, raw materials, clay and ashes, were analyzed by XRF and XRD.

The main objective of this study is to investigate the effects of aluminium dust ash addition on the properties of fired clay bricks for building construction. Aluminium dust ash was substituted (5, 10, 15, 20 and 25% in weight) in clay to produce bricks with a grain size below than 100 µm. In order to obtain comparable results a series without the residue was also prepared.

The prepared mixtures were compacted in laboratory press under a pressure of 2.5 MPa for rectangular shaped (30 mm x 60 mm x 10 mm), dried at 100ºC and then fired at different temperatures (850-950-1050-1150 and 1250ºC). For the purpose to examine the technological and physical properties of prepared samples were subjected to several assays: absorption and suction of water, linear shrinkage, firing loss weight and compressive strength. Furthermore the microstructure obtained was observed by SEM-EDS and the lixiviation of heavy metals was explored by ICP-M.

Keywords

Ceramic materials; Valorization; Aluminum dust ash

Acknowledgement

This work has been funded by the Project “Valuation of various types of ash for the obtaining of new sustainable ceramic materials” (UJA2014/06/13), Own Plan University of Jaen, sponsored by Caja Rural of Jaen

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Assessment of electric steel black slags for the manufacture of ceramic materials

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ABSTRACT

Ceramic materials are suitable to achieve the inerting and neutralization of industrial waste by inerting and encapsulating them in its matrix [1]. This is because ceramic materials once conformed and sintered, hardly leaching to environment pollutants, so if you are able to enter any amount of waste within the ceramic matrix, however small it may be, it will be getting inert within in it [2].

During the steel fusion manufacturing process by electric arc furnace process gets liquid steel and swimming on the surface, black slag. In the present work, for the manufacture of ceramic pieces clay coming from the quarries of the ceramic industry of Bailén (Jaén) and slag black industry steel in percentages ranging from 5% to 25% by weight were used as raw materials. The ceramic samples were subjected to a firing process to a 950 °C.

The results indicate values lower linear shrinkage, and starting from 10% even expansiveness, and greater values of water absorption and water suction capacity but complying with the rules as that does not exceed the values permitted by standard [3]. Compressive strength although it decreases substantially continue complying with the legislation that serves as a reference [3], converting them into a suitable material to be used in construction.

Keywords

Ceramic materials; Steel furnace slag;Inertization

Acknowledgement

This work has been funded by the Project “Valuation of various types of ash for the obtaining of new sustainable ceramic materials” (UJA2014/06/13), Own Plan University of Jaen, sponsored by Caja Rural of Jaen

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[3] EN 772-1: 2011

Mullite and mullite-based ceramic composites from kaolinite and sericite clays, wastes and by-products of mining

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ABSTRACT

Mullite is one of the most commonly crystalline phases found in advanced ceramics with applications as structural material in high-temperature engineering applications. Mullite shows excellent properties: low thermal expansion coefficient, high-temperature strength, creep resistance, good chemical and thermal stability and stability in oxidative atmospheres [1].

Formation of mullite can be reached by thermal decomposition of aluminosilicates (kyanite, andalousite or sillimanite), hydroxyaluminosilicates (kaolinite, pyrophyllite or sericite) and raw clays containing mixtures of these silicates and by thermal reaction of pure silica and alumina mixtures [2].

The use of kaolinite and sericite clays containing Si and Al, wastes with high Al content and by-products of mining with high-kaolinite content, is an attractive way for mullite preparation and processing at relatively low cost [3]. The present communication is a part of a wide investigation on processing of mullite and mullite-based ceramic composites from these precursors.

The basic features of mullite fabrication of own investigations from all these precursors are presented, compared and overviewed [4, 5]. The methods have implications for the recovery and recycling of Al wastes and use of waste by-products of mining as valuable raw materials. After wet processing of the mullite precursors at the laboratory, thermal treatments using pressed cylindrical samples at 500 MPa from 1200-1600 ºC were performed. The resultant materials were studied by XRD, SEM-EDS, thermal analysis, mechanical strength and porosimetry.

It can be concluded that the thermal behavior of some mullite precursors was influenced by the presence of impurities in the raw materials. However, the presence of these impurities originates a progressive and enhanced sintering because some liquid phase is produced. For instance, porous mullite-based composites, with values of 52-45 vol. % can be obtained by firing some precursors at 1500-1600 ºC for 30 minutes. In particular, the use of sericite clays as raw material was very interesting according to the present and precedent results at laboratory level.

Keywords

Mullite; Ceramic composites; Kaolinite; By-products; Sericites clays

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Dissolution kinetics of apatites in borosilicate glass melt

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ABSTRACT

In France, High-Level radioactive Wastes (HLW) coming from nuclear spent fuel treatment are contained in a homogeneous sodium-borosilicate glass at the La Hague reprocessing plant. High Level Waste vitrification consists in the incorporation of fission products and minor actinides in a borosilicate glass melt at high temperature. In order to obtain the glass homogeneity, crystallized phases formed at different stages of the melting process have to be dissolved before pouring the glass in the canister. Nucleation and growth of these phases have already been studied (Delattre 2013, Orlhac 2001, Fillet 1997) but, to date, few studies on their dissolution in nuclear glass melt have been performed.

The presented study focuses on dissolution kinetics of apatites ($Ca_2Nd_8(SiO_4)_6O_2$ type) in two types of simplified sodium-borosilicate glass melts: a simplified UOx glass and a Nd-enriched glass. Because of the volatility of B and Na at high temperature, experiments were made in closed systems using platinum capsules. Crystals features (size, number, morphology, composition) are followed as a function of time at different temperatures around liquidus temperature, by SEM coupled with image analysis and microprobe. Influence of initial crystallized state (size particles, crystallization fraction, crystals morphologies…) on dissolution kinetics is also studied. Results on dissolution kinetics and influence of the above parameters on these kinetics will be presented.

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Keywords

Apatities, borosilicate glass.

Inertization of galvanic sludge waste containing Chromium and Copper in a vitreous matrix

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ABSTRACT

There is some approaches to inertization of industrial sludges produced by the physico-chemical treatment of wastewaters generated by electroplating operations, one of them have been incorporated it to ceramic matrixes to produce ceramics materials [1,2]. This paper presents the results of an investigation of the stabilization of sludge waste (SW) in a glass matrix. SW is a solid waste that is generated by the treatment of wastewaters encountered in galvanic coating process. Chemical analysis of SW reveals that it is mainly composed by heavy metals, such as Cr, Cu and Fe. Different levels of the dried sludge waste were mixed with a crushed glass matrix and then the mixtures were melted at 1400 °C. Optical characterization of the obtained glasses stabilized waste; determined by UV-Visible spectroscopy, reveal the appearance of two new bands at 445 and 650 nm characteristic of Cr^{3+} and non presence of Cr^{6+} characteristic bands. The CIE L*a*b* color measurements show that clarity (from L* = 91.96 to 29.71 with 5 wt % of waste) is inversely proportional to the amount of the immobilized waste. However a pronounced greenish color characteristic of Cr^{6+} ions and a significant increase in a* parameter values in comparison with b* is noticed. (a* = -13.12 and b*= 8.6 with 2 wt % of waste). Chemical durability tests reveal that in both acid and alkaline solutions (HCl, HF and NaOH); increasing stabilized waste amount produces the reduction of the elaborated stabilizing glasses chemical durability. Electron paramagnetic resonance spectroscopy EPR showed an increase in Fe^{3+} and Cr^{3+} peak intensities with increasing W immobilized amount. Environmental risks associated with the W stabilization, evaluated by leaching tests reveal that pH values of the immersion waters were alkaline. After 20 days conductivity waters values are stabilized.

Keywords:

Sludge waste; glass matrix; stabilization; UV-Visible transmission; Color; Chemical durability.

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Phase composition and properties of glass-ceramic tiles obtained using granitic screenings and basaltic tuffs

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ABSTRACT

Granitic screenings ((%) 54.0 – 65.30 SiO2, 0.62 – 0.89 TiO2, 15.01 – 17.3 Al2O3, 5.37 – 8.61 (Fe2O3+ FeO), 2.09 – 3.23 MgO, 3.40 – 6.43 CaO, 3.41 – 3.98 Na2O, 2.96 – 3.69 K2O, and 1.29 – 2.60 other) are formed during the production of road stone and acted as a fluxing agent. Basaltic tuff is represented,%: 8-10 CaO; 3-5 MgO; 12-15 Al2O3; 11-14 (Fe2O3 + FeO); 2-4 (Na2O + K2O); 49-51 SiO2; 2-3 TiO2; 3-5 SPT and is produced in small amount together with basaltic rocks.

The purpose of this work is to determine the fluxing potential of granitic screenings and basaltic tuffs in a glass-ceramic tile composition. It has been established that the increases of granitic screenings and especially basaltic tuffs in the iron-rich mass composition leads to decrease in the amount of silicon and aluminum oxides and an increase in the content of iron oxides and alkali oxides in the resulting liquid phase, which contribute to the decrease in viscosity of the system [1] and thus determine the firing temperature and pyroplastic deformation of tiles. The almost complete sintering of glass-ceramic tiles leading to sample without open porosity, occurs at 1150±5 ^{o}C [2].

Investigations have shown that it is possible to produce glass-ceramic tiles with enhanced physical-chemical properties using granitic screenings and basaltic tuffs.

Keywords

Glass-ceramic tile; Granitic screenings; Basaltic tuffs; Sintering.

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Development of a glass-ceramic glaze formulated from industrial residues to improve the mechanical properties of the porcelain stoneware tiles.

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ABSTRACT

Nowadays, in the framework of the circular economy, the revalorization of industrial wastes is the key to remaining competitive in the global marked. In this research recycled soda-lime glass and ashes from a coal power thermal station have been reused to produce a glass-ceramic glaze to be applied on the porcelain stoneware tile. In order to facilitate the application of the suspension of the glaze on the porcelain surface, 7%wt kaolin and 1%wt carboxymethyl cellulose have been added by Dr. Blade method to the precursor frit, based on a 90%wt of industrial residues: recycled glass and ashes from the coal power thermal station, melted previously at 1500ºC for 1h. The tested pieces have been fired by a conventional porcelain cycle at 1180ºC of maximum temperature. The X-ray diffraction, X-ray fluorescence, scanning electron microscope have been the instrumental techniques used to characterize the final piece. Besides these tests, some technological properties such as the flexural strength and the Vickers microhardness have been measured. Finally, a glass-ceramic glaze on porcelain ceramic tile has been produced, exhibiting two crystalline phases, one from the plagioclase feldspar system and the other from the pyroxene system. Both phases ensure a high flexural strength (around 965 kg/cm^2) and a significant Vickers microhardness of 2500 when a 1N-force is applied to the glass-ceramic glaze for 30 seconds, improving the mechanical properties of a conventional porcelain ceramic tile.

Keywords
Circular economy, Revalorization of industrial waste, Glass-ceramic glaze, Porcelain stoneware, Mechanical properties

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Manufacturing new ceramic materials from clay and chamotte derived from the structural ceramic industry

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ABSTRACT

The construction industry is an excellent industry for the absorption of large quantities of solid residues, already is as they appear or once submitted to a certain process of adequacy [1]. The ceramic products and principally bricks and tiles, they are very heterogeneous on having been formed by clay by wide margin of composition [2]. Due to this, these materials can tolerate the presence of different types of residues in considerable quantity [3,4], which can help to reduce the costs in construction. The chamotte is a by-product of the industry of manufacture of ceramic tile and of porcelanic gres.

The aim of this study was to take advantage of the ceramic pieces that are rejected for the sale during the process of production for having one or more faults to introduce them, once taken to a size of suitable grain, inside the ceramic counterfoil to elaborate a new ceramic product and to know the physical and mechanical characteristics of the same ones.

The raw materials were supplied by Gres de Vilches, S.L., in the chamotte case and Arcillas Bailén, S.L., for the clay.

For the present work, raw materials were characterized by XRD, XRF, plastic behaviour of ceramic paste, calcimetry and thermal analysis. The ceramic samples were made with different proportions of clay and chamotte which were subjected to different studies such as absorption, suction, compression strength, thermical conductivity, density and microstructural study SEM.

Keywords

Ceramic inertization; Chamotte; Ceramic tile wastes

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Sintering parameters optimization during inertization bauxite tailing in ceramic products

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ABSTRACT

Red mud is an industrial byproduct from the bauxite ore to obtain metallic aluminum by the Bayer process. It is a difficult material to manage due to its high pH, presence of polluting chemical elements and with physical characteristics close similar to clay.

The production of ceramic materials has so far not been the only one, but the main feasible material for the valorization of these residues [1], although many works has also been done using it as an additive in the manufacture of cement clinker [2] as well as geopolymer raw material [3]. According to Spanish law 22/2011 of waste and contaminated soils, the use of red mud to manufacture ceramic materials is considered as a type IV recovery operation since it is a recycling or recovery of metals and metal compounds.

For the present work 60x30 mm ceramic samples were made with different proportions of clay and red mud which were subjected to different studies such as the properties necessary to understand plasticity of the ceramic pastes by means of Plasticity indexes, pH study and dilatometric analysis, as well as environmental analysis of leachate by means of ICP-M. To do this, the quantity of red mud added was optimized to later find the most suitable firing temperature of the manufactured samples by studying a series of physical variables such as suction and water absorption, compressive strength, weight loss and linear shrinkage, as well as the soaking time at the optimum temperature. Microstructure was studied using SEM-EDS and the formation of new mineralogical phases formed by the effect of temperature was analyzed using the mapping technique.

Keywords

Red mud; Ceramics; New formation compounds; Leachate analysis; Firing optimization

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Development of new ecological porcelain ceramic tiles by the addition of recycled soda-lime glass and ceramic chamotte

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ABSTRACT

In the last few years the concept of Circular Economy has become the worldwide attention as a procedure to optimize the natural resources, energy and waste with special focus on urban and industrial residues [1]. The following research work shows the results of the introduction of wastes generated by the ceramic industry in the stoneware porcelain formulation, such as the calcined clay from fired porcelain of stoneware (chamotte) and residues from other sectors like the recycled glass [2, 3]. Five compositions have been developed using the conventional ball clays and adding 5%wt of porcelain chamotte and recycled soda-lime glass in a range from 0%wt to 20%wt .Besides, all these compositions contain Spanish sodium-potassium feldspar, which is not commonly used in the ceramic bodies formulation due to it has a higher melting temperature than the conventional sodium feldspar from Turkey. So, this substitution aims to improve the Spanish mining market, while the recycled soda-lime glass can reduce the sintering temperature of the composition to save thermal energy. As a result, an ecological porcelain ceramic tile with 20%wt of waste, exhibiting low porosity (<1%wt) and higher mechanical resistance than standard porcelain stoneware tiles has been obtained, fired at 20ºC less than the conventional porcelain tiles.

Keywords

Circular economy, Recycled waste, Porcelain stoneware tile, Mechanical resistance

Acknowledgement

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Evaluation of the ability of a sewage sludge-like matrix to inertize industrial wastes

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ABSTRACT

Vitrification is a well-established technique in the inertization of hazardous waste. Its strengths lie on a reduction of the volume of the waste and their ability to bind potentially toxic elements in the glass structure. Sewage sludge (SS) is a high volume and potentially hazardous waste, with a bulk composition similar to basalt, that can be inertized by vitrification [1]. This work focuses on the design of a glassy matrix analogous to sewage sludge using basalt doped with phosphorus and calcium. The similarity with basalt makes the sludge potentially favorable to vitrification because it ensures both low bulk viscosity and a low melting point. However, phosphorus and calcium play a major role in the modification of the macroscopic properties of the glass. The addition of phosphorus causes an unmixing process over 4 wt% P_2O_5, whereas calcium causes a disproportionate increase in viscosity over 20 wt% CaO.

The new matrix analogous to SS (basalt with 4 wt% P_2O_5 and 20 wt% CaO) can be used to inertize potentially toxic elements (PTE) found in industrial wastes. The addition of metal cations (such as alkaline-earths or transition metals) influences the glass-formation ability and may induce the nucleation and growth of crystalline phases upon saturation in the melt, which will lead to further inertization when these phases are stable. The chemical resistance of the obtained materials then depends on the fractionation of each PTE between the glass and the crystals, and on the stability of the newly formed minerals. This stability is assessed by analyzing the compositions of the leachates [2].

Keywords

Vitrification; Sewage sludge; Inertization matrix; Leachate;

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Recycling tungsten tailings for making glass

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ABSTRACT

Tungsten is a critical material for the Europe and several mines are opening in Spain. Their tailings can constitute an environmental problem. W occurs mainly in deposits with granitic or calc-silicate compositions. The glass formulation and thermal treatments are different using tailings of both deposit types. In this work tailings from different W deposit types were used as raw material to obtain commercial glass. Minerals, determined by X-ray diffraction, from granitic deposits are mainly quartz, albite, K-feldspar, and muscovite, and minor hematite and kaolinite. Glass was formulated by adding 29 wt.% of $CaCO_3$ and 14 wt.% of Na_2CO_3. The skarn deposit has quartz, plagioclase, hornblende, vesuvianite, epidote, apatite, biotite and grossular. Ca content is relatively high, then only 15 wt.% of $CaCO_3$ and 15 wt.% of Na_2CO_3 were added to make glass.

Mixtures were molten at 1450 ºC. Glass transition temperature, determined by dilatometry, is 569-644 ºC; temperatures of the fixed viscosity points, obtained from hot stage microscopy, are first shrinkage (796-854 ºC), maximum shrinkage (895-987 ºC), softening (996-1179 ºC), half ball (1153-1253 ºC) and flow (1198-1344 ºC). Viscosity-temperature curves have been obtained, and used to calculate the relevant temperatures for the process. In all cases the lower temperature corresponds to calc-silicate compositions. In granitic materials, a small exothermic peak at 875 ºC and another, more prominent, at 1022 ºC corresponds to crystallization temperatures of nepheline and wollastonite and the endothermic peak, 1200 ºC, is the melting point. In calc-silicate materials, the main exothermal event occurs at 933 ºC and the main endothermic, linked to melting, appear at 1180 ºC. The obtained crystalline phases are gehlenite, nepheline and wollastonite. In both cases, a commercially glass is obtained suitable for retaining the contaminants from the raw material used.

Keywords
Recycling; Tailings; Wolfram; Glass

Manufacture of bricks based on sludge from mine tailings.

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ABSTRACT

The search for sustainable applications for gold residues in the Ecuadorian rainforest has led to the development of the present research, which involves the use of mine tailings to develop a technologically improved brick from environmentally friendly alkaline (geopolymerization), present good physical and mechanical characteristics, and high durability over time. To accomplish this objective, three stages were developed: characterization of the raw material, selection of the activating solution and factors to be intervened in the process (temperature, molar concentration, solution content) for further analysis and mechanical characterization of disks made by combinations of the factors selected through the use of the diametrical compression test using the Brazilian Test (BT) this test allowed to optimize time and resources in the development of normal sized bricks. The results show that the solution content, the molar concentration and the curing temperature are key factors for the development of the chemical process, because they provide the element with a satisfactory mechanical behavior. A molar concentration of 15, a solution content of 26% and a temperature of 120 ° C, proved to be the optimum blend for the manufacture of bricks making mine tailings a potential candidate for the manufacture of eco-friendly bricks.

Keywords

Ecuadorian rainforest; Geopolymerization; Brazilian test; Molar concentration

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Assessment of solar panel waste glass in the manufacture of sepiolite based clay bricks

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ABSTRACT

The renewal of the photovoltaic installations generates a considerable volume of silicon residues derived from the solar panels siliceous glass. Glass-ceramic materials are a potential solution for the recycling of by-products to reduce environmental impact [1]. The structural, compositional and physical characteristics of sepiolite render this clay mineral a suitable ceramic material. High sepiolite content promotes faster sintering at lower temperatures, sintered materials with lower porosity and higher toughness and strength [2,3]. In this study, solar panel waste glass was used in clay brick production based on sepiolite. Two siliceous materials were used as degreaser: diatomaceous earth and waste glass from solar panels. The mixtures were fired at 975, 1025 and 1075 ºC and analysed with the help of X-Ray Diffraction and Scanning Electron Microscopy. The technical properties of the glass-ceramic samples were also determined. The siliceous materials reduce the plasticity of the sepiolite, provide strength and render these glass-ceramics an interesting material from the industrial point of view.

Keywords

Solar panel waste glass; Sepiolite; Clay bricks; Glass-ceramic

Acknowledgement

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Developing CIGS solar cells on glass ceramic substrates.

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ABSTRACT

$Cu(In,Ga)Se_2$ (CIGS) is a p-type semiconductor material and an attractive absorber for thin films solar cells due to its unique optical and electrical properties [1, 2]. The low cost of this technology is based on its application on cheap substrates (glass, ceramic or glass-ceramic materials), effective uses of raw materials and lower thickness of the film (range from 1.5 to 3 μm) [3]. In this work, a glass-ceramic substrate has been developed using industrial wastes materials (recycled glass, bottom ash and fly ash from a thermal power plant). The CIGS absorber has been synthesized by an easy and low-cost way of preparation using the co-precipitation method. The solar cell device has been completed and fully characterized. The obtained films were characterized by X-Ray diffraction (XRD), scanning electron microscope (SEM) and electrical characterization. The short circuit current (Jsc), open circuit voltage (Voc), fill factor (FF), and total area power conversion efficiency (Eff.) of the device are 8,11 mA/cm^2, 168,2 mV, 27,6% and 0,4% respectively.

Keywords

Glass-ceramic, Industrial wastes, CIGS solar cell, Co-precipitation synthesis

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Red mud as a stable pigment for ceramic glazes

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ABSTRACT

The valorisation of residues has gained increasing momentum in the last decades due to environmental concerns and the recognition that natural resources are limited. One residue implicated in both matters is red mud (RM), a highly alkaline iron oxide rich sludge obtained during alumina production. The environmental and economic issues posed by its management are considerable since RM is retained by lagooning or stacked in landfills. Without any industrial applications consuming the huge amount of RM produced annually (□120 Mt), the accumulation of RM residues worldwide will reach estimated values of □3.9 billion tons in 2017.[1] In the literature some applications for RM were considered, ranging from environmental and agronomic uses, to construction and chemical applications.[2] However RM remains mostly as an non-exploitable waste.[2] The production of pigments from RM is one of the most interesting approaches, due to the expected high added value, with examples of its use in city furniture, ceramic glazes, heavy-clay ceramics and glass-ceramics.[3]

In this work, a stable RM inorganic pigment for colouring commercial ceramic glazes (transparent, opaque and matte) was developed. RM powders were sintered at different temperatures (1100-1350ºC) and characterized by XRD, UV-Vis, DTA-TG, CIELab and SEM/EDS techniques. The pigments sintered at 1300ºC (RM_1300ºC) yielded the best results, producing a stable brownish hue on the glazes.

Keywords

Red mud; Pigments; Waste valorisation; Ceramic glazes.

Acknowledgement

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Obtaining a glass-ceramic material from industrial wastes which improves the technological properties of the porcelain stoneware

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ABSTRACT

As a life example of the revalorization of industrial waste by the glass-ceramic process, inside of the new production concept of the circular economy, this work has been focused on the synthesis of a new manufactured material by the sinter-crystallisation method and from industrial waste: recycled soda-lime glass and ashes from a coal power thermal station. The typical instrumental techniques (X-ray diffraction, X-ray fluorescence, scanning electron microscope) have been used in order to characterize the glass-ceramic composition, in parallel to the some technological properties such as the bulk density, the flexural strength, the linear shrinkage and the water absorption. The fritted material (50% recycled soda-lime glass, 25 % bottom ash, 15% fly ash and 10% $CaCO_3$) has originated two main phases: the sodium anorthite and the hedenbergite when it has been fired over 850ºC during minutes of residence time, that is a manufacturing cycle much environmentally friendly that the conventional ceramic firing at 1200ºC. Then, while its shrinkage is a third, the water absorption of this glass-ceramic material is similar to the porcelain (less than 1% wt), being the apparent density a bit higher than the one corresponding to this ceramic product (2.6 g/ml instead of 2.4 g/ml). In addition, the flexural strength is almost twice that of the ceramic product (around 950 kg/cm^2 instead of 550 kg/cm^2).

Keywords

Circular economy, Revalorization of industrial waste, Glass-ceramic process, Porcelain stoneware, Technological properties

Acknowledgement

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Sintering of glass matrix composites: A non-isothermal kinetic model

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ABSTRACT

This report sets out the results obtained on studying the sintering process of glass and glass–zircon composites. Test pieces were formed by slip casting and pressing and were subjected to constant-rate heating (at rates ranging from 0.5 to 60K/min) in a laboratory kiln and in a hot stage microscope.The fired test pieces were characterised by mercury porosimetry, scanning electron microscopy (SEM) (with EDS and image analysis), and X-ray diffraction to monitor the development of the textural and microstructural characteristics of the different materials with sintering progress and to study the zircon solution–reprecipitation process. The sintering of composites with moderate zircon contents only developed via particle rearrangement by viscous flow. In contrast, at high zircon contents, the zircon solution–reprecipitation process was also required. The kinetics of the former mechanism were perfectly described by the Avrami–Erofeev model. The values of the Avrami power index, "n", and the pre-exponential factor, A, which were verified to be independent of the type of thermal treatment, were related to the zircon content and to the zircon and glass volume average sizes. In contrast, the effect of temperature on the process rate was the same as that of glass viscosity and was, consequently, independent of all test operating variables. Finally, a kinetic model was developed and validated that describes very well the effect of all the studied operating variables (heating rate, component particle size distribution, and zircon content) on the composite degree of non-isothermal sintering progress associated with particle rearrangement by viscous flow.

Keywords

Glass Matrix Composites; Sintering; Kinetic Model; Glass viscosity

Inertization of pyritic mine tailings by encapsulation in glass- ceramics with the addition of Brazil Nut shell ashes

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ABSTRACT

The majority of mining environmental liabilities (MEL) in Bolivia consist mainly of high pyrite contents with heavy metals. These MELs cause irreversible damage to human health, flora and fauna by contaminating air and ground-water with particulate matter containing heavy metals. This research work shows that the inertization of the pyritic material is possible by incorporation into a plastic mass of clay for the production of glass-ceramics. The acid formation produced during the preparation of the ceramic paste with water is possible to control with the addition of alkaline Brazil nut shell ash. The optimum determined amount of pyrite for incorporation into the clay is 20% weight. The obtained glass ceramics have an apparent density of 1.44 g/cm^3, water absorption of 22.49% and compressive strength of 14 MPa. The last value is better and superior to the limit established by the European Standard (UNE-EN 772-1) applied to building bricks. Finally, it is found that the Brazil nut shell ash (20% weight) incorporated into the clay and pyrite plays an important role in obtaining a glass ceramic free of cracks and neutralization of any acid formed in the ceramic paste.

Keywords

Glass ceramics, Pyrite, Brazil nut shell ash.

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RASCHIG RINGS GLASS- CERAMICS WITH NANOSILVER PARTICLES

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ABSTRACT

In the present work, we have used raw material obtained from the bolivian valleys clay bentonite, phosphoric rock and recycled organic matter of bone meal from the waste of a livestock industry. Homogeneous mixtures of the same were made; By means of two firing techniques was possible to obtain glass- ceramics, with the formation of acicular crystals at nanoscale and nanopores. The first mixture was brought to a heating process at 500 oC for one hour to submerge it in an $AgNO_3$ solution and immediately to continue cooking the ceramic until reaching temperatures of 1000oC. The second mixture was immersed in the $AgNO_3$ solution and brought to direct heating until 1000oC, both in a reducing medium with wood chips in order to obtain silver nanoparticles in the ceramics. These glass ceramic (Rashing rings) filters will be used in the treatment of wastewater, removal of heavy metals and elimination of microorganisms. The characterization of glass ceramic samples was performed by determinations of chemical analysis, electron microscopy and differential scanning calorimetry of each compound of the mixtures. The electron microscopy images show small crystals (1micros average size) with acicular shape in both compostions, as well as the formation of nanopores (400nm average size) in the second mixture.

Keywords
Ceramic filters, nanopores, nanosilver, water treatment

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INTRODUCTION OF Cr/Ni/Cu WASTES FROM GALVANIZING SLUDGES AS CERAMIC PIGMENTS

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ABSTRACT

The galvanizing sludge from the non-ferrous metal industry such as Cr/Ni/Cu plating produces acid wastes which are usually neutralized with lime slurry in batch processes and the resulting waste is dewatered by vacuum filtration or filter-pressing. Dewatered sludges contain calcium sulphate ($CaSO_4$), product of the neutralization, as well as Cr, Ni and Cu. In this communication two galvanizing sludge wastes from Cr/Ni/Cu plating have been dried (110ºC) and fired (1100ºC), and both dried (gray coloured) and fired (black coloured) powders have been characterized by DTA-TG, XRD and SEM-EDX techniques. XRD shows only quartz crystallization in dried samples, while in fired powders the crystallization of spinel chromite $NiCr_2O_4$ and NiO periclase are detected, along with $CaSO_4$ anhydrite and $CaSiO_3$ wollastonite. The powders have been introduced as ceramic pigments into three different conventional glazes: a) a lead bisilicate ($PbO.2SiO_2$) double fire frit (1000ºC), b) a double fire frit with low lead content (1000ºC) and, c) a double fire frit without lead (1050ºC). Glazed samples were characterized by UV-vis-NIR (diffuse reflectance) and CIEL*a*b* (colour parameters). Dried powder produce glaze defects (pin-holing and crawling), but fired powders did not show these faults giving gray to pure black coloured glazes.

Keywords

Galvanizing waste; Ceramic pigment; Ceramic glaze; Periclase

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Immobilization of heavy metals on celsian lattice by ceramization: reusing as ceramic pigments

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ABSTRACT

Heavy metals are naturally occurring elements that have a high atomic weight and a density at least 5 g/l, and their toxicity depends on several factors including the dose, route of exposure, and chemical species. There has been an increasing ecological and global public health concern associated with environmental contamination by these metals. Celsian $BaAl_2Si_2O_8$ (monoclinic, space group I 21 / c), is a feldspar, although its symmetry is somewhat different: the order in the celsian is simple, each tetrahedron AlO_4 is surrounded by four SiO_4 tetrahedra and vice versa, while Ba shows an irregular configuration with 10 equidistant neighbours. This disorder induces a low symmetry and increases the kinetic barrier of nucleation. In fact, the celsian structure has a metastable polymorph, the hexacelsian or hexagonal celsian, composed of a double and alternating sheet of tetrahedra $(AlSi)O_4$. In this communication the immobilization of several heavy metals such as M=Cr, Fe, Co, Ni in celsian system has been studied by sintering up to 1500ºC of its oxides with $BaCO_3 Al(OH)_3$ and SiO_2 in order to obtain $(Ba_{1-X}M_x)Al_2Si_2O_8$ solid solutions. Cr^{3+} enters in solid solution forming cationic vacancies up to x=0.5 (both celsian and hexacelsian coexist), Fe^{3+} and Co^{2+} only up to x=0.1 (both celsian and hexacelsian coexist), melting at higher x values, while Ni only forms solid solution at low x (0.02), coexisting hexacelsian and celsian and crystallizing $NiAl_2O_4$ spinel at higher x. However, the use of glass-forming mineralizers such as borates (boric acid or sodium perborate) increases reactivity, and monophasic celsian is obtained in the case of Co-celsian solid solution (adding 10wt% of glass-forming agent) at only 1000ºC/3h of sintering temperature. Powders have been reused as ceramic pigments and leachate tests performed in order to classify the resulting solid solutions for its landfill disposal (Council Directive 1999/31/EC on waste landfill).

Keywords

Heavy metals; Solid solution; Celsian; Ceramic pigment

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Thermal plasma vitrification process as the effective technology for hospital incineration fly ash immobilization

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ABSTRACT

The aim of our studies was to use a thermal plasma treatment process to transform the hospital incineration fly ash into the glassy products called vitrificates that can be stored on the land without a harmful environmental effects.

This was achieved by: (i) optimization of temperature and energy used adjust accordingly at process minimum cost and (ii) stabilization of vitrificates for different composition of waste mixture. The chemical stabilization of final products was examined by heavy metals leachability tests. Hardness tests were done to verify the physical stabilization of vitrificates. We also checked if the reinforce of raw material by various pigments as well as the chemical compounds influenced the stability of the final products.

The thermal plasma treatment is an effective method which can be used to convert hazardous waste into less toxic or inert glassy products. The chemical composition of raw materials influenced the chemical and physical properties of the vitrificates and decided about their internal structures.

Keywords

thermal plasma treatment process; hospital incineration fly ash; hazardous waste utilization;

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Thermal treatment of asbestos containing materials (ACM) by mixing with Na_2CO_3 and special clays for vitrifying waste

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ABSTRACT

Asbestos has been widely used in the past decades due to its favorable properties as raw materials in the production of asbestos cements, which are the one of the most significant asbestos containing materials (ACM) hazardous wastes. The term “asbestos” defines a group of fibrous silicates including commonly chrysotile which is a hydrated magnesium silicate. Nowadays, these materials are considered extremely hazardous due to their carcinogenic activity when there is a risk of exposure though fibres inhalation [1]. This study reports the thermochemical conversion achieved by partial fusion and recrystallization of ACM. The benefit of this process derives from the irreversible transformation of the asbestos fibrous structure, when added to a glass-forming mixture [2], and the potential recycling of the waste. In our case, the process has been carried out by adding a mixture of sodium carbonate and special clays (bentonite or sepiolite), as fluxing agents at 1100 and 1200 ºC, leading to the formation of a partial melt. The resulting quenched materials were characterized by X-ray Diffraction and Scanning Electron Microscopy. Fibrous morphologies are completely destroyed at 1200 ºC forming CS larnite, CMS bredigite and periclase, together with glassy materials. The obtained products are susceptible to have hydraulic properties serving as components of eco sustainable cements [3].

Keywords

Asbestos; Special Clays; Vitrification;

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Sintering and phase formation of ceramics based on huge amount of MSWA

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ABSTRACT

The opportunity for a total removal of the traditional fluxes in new tiling ceramics is studied by the synthesise of original batches, based on 60 wt% bottom ashes from municipal solid waste incinerator (MSWA) and 40 wt% industrial clays. Two fractions of pre-treated MSWA (above and under 2 mm), having different chemical compositions, are milled and mixed with three various industrial clays. Thus obtained six ceramics are characterized by equal amounts of CaO (12-14 wt%) and with Al_2O_3/SiO_2 ratio (in wt%) which varies from 16/58 to 26/42.

The sintering behaviours and the phase transformations of these ceramic batches are studied by contactless optical dilatometry and DTA-TG, whereas the final phase compositions and the structures of obtained ceramics are elucidated by XRD and SEM-EDS.

It is demonstrated that, at lower Al_2O_3/SiO_2 ratio, the sintering temperature is inferior but the sintering interval is very narrow. Contrary, at higher Al_2O_3/SiO_2 ratio, the sintering temperature increases but the sintering interval becomes wider and more technological. This densification behaviour, as well as the final phase compositions and morphologies of the new ceramics, are explained by their locations in the $CaO-Al_2O_3-SiO_2$ phase diagram.

It was also highlighted that, due to the formation of high amount of anorthite solid solution during the sintering and cooling steps, the samples with high Al_2O_3/SiO_2 ratio are characterized by structures and properties close to ones of the traditional glass-ceramics by industrial wastes, which however are manufactured at significantly higher cost price.

Keywords

MSWA, ceramics, sintering, structure

Vitrification of mining wastes containing the magnesium hydrous phyllosilicate mineral vermiculite with derived lithium glass-ceramics

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ABSTRACT

The mineral magnesium magnesium hydrous phyllosilicate known as vermiculite is located in several deposits in Spain, for instance near Santa Olalla del Cala in Andalucia, Spain, being mined in the past as isolation material. Nowadays , these deposits are abandoned and wastes containing important proportions of MgO combined in mica-vermiculite interstratified residues. The waste vitrification for these abandoned open sky deposits has been considered by combining with a natural phosphate mineral residue from Caceres, Spain. It have been melted three compositions in the system:
Li_2O-MgO-Al_2O_3-P_2O_5-SiO_2 which include also Fe_2O_3 in around 3 to 4.5 wt% and Fluoride between 0.5- 1.5 wt%. The resulting glasses are transparent and smooth green colour giving rise after TTT treatments to several opal, opaque glass- ceramics with a common surface showing iridescence. Full characterization has been carried out by XRD and electron microscopy with EDS, as well as by XPS spectroscopies, concluding that the main crystalline phases formed in these vitrified materials were: cordierite and ß-spodumene, being the surface enriched in Fe_2O_3 with respect the average composition. Toughness for final glass- ceramic was higher than the original glasses reaching values higher than conventional mullite ceramics.

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Keywords

Vermiculite, lithium, glass-ceramics.

Vitrification of U_3O_8 in iron aluminium phosphate matrices including Cs_2O, Bi_2O_3, PbO and MoO_3

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ABSTRACT

In order to encapsulate nuclear wastes enriched in Uranium, they have been designed and obtained vitrified bases of iron aluminum phosphates and substitution of U by Bi. The thermal behavior has been investigated by DTA /TG analysis and structure by Infrared, Raman and Mossbauer spectroscopies. Likewise, the leaching and thermal expansion has been also considered, as well as the XRD determination of phases and identification of some phases such as Fe(PO)4 and TEM/EDS and SEM/ EBSD. Iron phosphate glasses are based in depolymerizing the 3D structure of vitreous P_2O_5 (O/P=2.5; ultraphosphate) by the addition of other components such as: Fe_2O_3, Al_2O_3, Na_2O, Cs_2O, UO_2, Bi_2O_3, PbO, MoO_3 which subsequently they add oxygens (O/ P=3, metaphosphate); (O/P=3.5; pyrophosphate); (O/P=4; orthophosphate;) to the network and distributing the cations as modifiers of the vitreous structure. These glasses have been designed and obtained formulating all from the starting binary composition: 40Fe2O3–60P2O5, where the Fe/ P=0.67. The vitrified structures are difficult to crystallize as is the case of the Fe +U contents in the range of 0.5 per P atom. They depict a reasonable chemical stability and corrosion resistance to the attack by water due to the high percentage of P-O-Fe-O bonds and the presence of U(4+ to 6+) giving rise to a strong bonding between PO_4 chains and the Fe^{3+} tetra or octahedric coordinations with the oxygens. Lately, the calcination of simulated miniplates of Si_2U_3 / Al and adding UO_2 to dilute this Uranium enriched in MTR combustible (Material Testing Reactor) has been also investigated.

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Keywords

Nuclear waste, matrices.

SESSION POSTERS

Geoplymeration

Biomass bottom ash and aluminium industry slags-based geopolymers

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ABSTRACT

Geopolymers are a class of alkali activated materials that using an aluminosilicate source producing a cementitious binder. Chemically it is comprised by tetrahedral alumina and silica units condensed at room temperature yielding a three-dimensional network structure is generated a reaction product namely N-A-S-H gel [1]. Since the 90's, alkali activation research has grown dramatically in all corners of the globe [2] but too much research has been focused on the development of geopolymers as Portland cement substitute from coal fly ashes, slags and another industrial wastes [3] while investigations regarding the production of geopolymers using biomass ashes are scarce.

In this work pre-treated bottom ash is geopolymerized using metakaolin, filter powder from aluminium secondary industry, NaOH solution and sodium silicate (water glass) solution. As precursor of aluminosilicates biomass bottom ash (as source of silica) and aluminium secondary industry waste (as source of alumina) were activated with a sodium silicate and sodium hydroxide solution. The bottom ash used in this study was obtained from "Aldebarán Energía" plant renewable energy generation from biomass dispersed of the pruning of the olive grove, from performances in the mountain (forest biomass) and energy crops. The geopolymers obtained were curing for 7, 14 and 28 days at room temperature. The samples were subjected to characterization assays by attenuated total reflectance (ATR), X-ray Diffraction (XRD), and compressive strength testing after 7, 14, 21 and 28 days, finally samples were subjected to SEM and ICP-M after 28 days.

Keywords

Porous geopolymers; Alkali-activation; bottom ash; Aluminum industry waste

Acknowledgement

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Alkali activation of biomass and aluminium industry filter dust in metakaolin-based porous inorganic polymers: microstructural analysis

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ABSTRACT

The metal aluminum recycling industry produces filter powders, it is a by-product of the casting of solid aluminum, composed mainly of aluminum oxide in a percentage between 60-70%, 8% of calcium oxide, almost 15% of sodium chloride and between 5-10% of potassium chloride. It is a by-product with which some tests are currently being carried out for use as a road cracking sealant and in certain steel applications. From the point of view of its reuse it is an ideal candidate to be used as a cementing material due to its high content of aluminum compounds which allows modifying its The addition to regulate the S/Al ratio, fundamental in the design of the geopolymer. valorization of forest residues by combustion is a common practice. Nonetheless, this procedure generates substantial amounts of ash (bottom and fly). Common methodologies for their management, such as addition to forest soils and their incorporation in cement production, have environmental and technical limitations [1]. Fly ash-based geopolymer usually show mechanical strength and durability nearly comparable to hydrated Portland cement and can be used as a class of green cement with natural resource efficiency [2].

The geopolymers provides a new solution for the valoration of the fly ash that can serve to secure toxic metallic elements [3]. This study synthesized geopolymers from fly ash, aluminium secundary industry waste and metakaolin. As precursor of aluminosilicates biomass fly ash (as source of silica) and grinding dust from aluminium secundary industry waste (as source of alumina) were activated with a sodium silicate and sodium hydroxide solution. Geopolymer specimens were prepared with the following molar oxide ratios: $SiO2/Al2O3$: 1.9, 2.0, 2.2, and 2.3.

The geopolymers obtained were curing for 7, 14 and 28 days at room temperature, after that the samples were subjected to characterization assays of attenuated total reflectance (ATR), X-ray Diffraction (XRD) and compressive strength testing after 7, 14, 21 and 28 days and to SEM/EDS and ICP-M after 28 days.

Keywords

Aluminium filter dust; Geopolymer; Alkali activation; Fly ash

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Inorganic polymers synthesized using biomass ashes-red mud as precursors based on clay-kaolinite system

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ABSTRACT

Inorganic or geopolymer polymers constitute a new class of materials synthesized from materials of aluminosilicate nature (clays and kaolin) and an alkaline activator to be used in multiple applications ranging from its use as a cementitious material [1] until its use as a catalytic support [2] and even as a reinforcing matrix for composite materials with fibers [3]. For the synthesis of geopolymers the chemical reaction between amorphous silica and alumina in combination with a highly alkaline environment at or slightly elevated temperature is used to form a three-dimensional polymer gel of Si-O-Al-O-Si [4]. Residues and by-products from various industrial fields, such as rice husk ash (rich in amorphous SiO2) and red mud (rich in aluminum oxides and hydroxides) were used as well as the dehydroxylated clay and kaolinite system a heating at 800°C.

The raw materials were characterized by XRD and XRF and ground to a particle size of 0.1-0.2 mm. The mixtures were made to achieve a Si/Al molar ratio between 2.2 and 2.6 using sodium silicate and sodium hydroxide as activating agents, the samples were subsequently cured at 70°C for 24 hours and then assays were performed to determine the evolution and progress of the polymerization reaction at ages of 1, 7, 14 and 28 days by ATR, in addition to this the mechanical properties, the crystalline species present by XRD, the microstructure formed by SEM/EDS and the leaching of the metals by ICP-M were studied.

Keywords

Red mud; Rice husk ash; Inorganic polymers; Microstructure

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Stabilization of flotation rejects resulting from the treatment of Pb/Zn ore based on geopolymers

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ABSTRACT

Geopolymers are amorphous aluminosilicate binder material. The main objective of this study was the stabilization of two heavy metals Pb and Zn solid wastes resulting from the treatment by flotation process of Pb/Zn ore. The lead-zinc deposit in Amizour (South of Bejaia, Algeria) is considered as the largest poly metallic deposit in Algeria. The wastes were first characterized by physico-chemical methods as XRD, XRF, and SEM. The Pb/Zn rejects were encapsulated in Na-geopolymer based on metakaolin of Algerian kaolin. However, various amount (0, 5, 10 and 15 wt %) of rejects were introduced within the paste of Na-geopolymers. There are not previously barely works that provide information about immobilization of Zn in geopolymers [1] although lead has been profusely studied [2]. According to El-Eswed [3] the best approach to reduce the mobility of heavy metal species by stabilization/solidification (S/S) techniques. The physico-chemical characterization and durability of the samples in the alkaline, acid and neutral solutions were studied. The samples was subjected to leaching test and measured by ICP-M and the results showed that the heavy metals were effectively immobilized in the Na-geopolymer, which is attributed to the incorporation of Pb and Zn in the geopolymer network. The results of the IR spectroscopy showed that not change were produced in the basic structure of geopolymers when 10 wt % of reject was added, this involve the resistance of these materials to the various attack solutions. The results indicated a successful stabilization/immobilization of the Pb/Zn rejects into the Na-Geopolymers.

Keywords

Geopolymer; Pb/Zn rejects; Stabilization; Durability; Environment

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Solidification and Stabilization of heavy metals by using coal fly ash aluminate geopolymers

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ABSTRACT

The stabilization/solidification (S/S) of a simulated waste containing hazardous metals such as Pb, Cd, or Ni by means of geopolymerization technology using sodium aluminate is described in this paper. Sodium aluminate has been used as an activator in geopolymers [1, 2]. However, evaluation of solidification and immobilization during geopolymerization using aluminate activators is limited [3, 4]. In the present study, a waste aluminate solution from the anodizing industry was used to synthesize coal fly ash-based geopolymers as metal-immobilizing matrixes. Different alkali-activating agents such as sodium hydroxide and sodium silicate have also been used. Mixtures of simulated waste with these kinds of geopolymeric materials and class F coal fly ash used as geopolymer precursor have been processed to study the potential of geopolymers as waste immobilizing agents. To this end, the effects of curing conditions and composition on the compressive strength, microstructure and leachability (including TCLP, UNE-EN 12457-4 and NEN 7375 tests) have been tested to assess the results obtained and to evaluate the heavy metal immobilization efficiency. Compressive strength values in the range 1–10 MPa were easily obtained at 7 and 28 days. Concentrations of the metals leached from S/S products were strongly pH dependent, showing that the leachate pH was an important variable for the immobilization of metals. Comparison with other fly ash-based geopolymer systems used in S/S technology has also been accomplished.

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Keywords

Heavy metals, coal fly ash.

Effect of temperature on the clinkerization of low energy belite cements using by-products from the ceramic industry as raw material

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ABSTRACT

The cement production industry has a high environmental footprint, accounting for approximately 5-7% of the worldwide CO_2 emissions [1,2]. The main reason for these emissions is the result of the fuels used to generate the necessary energy, which is estimated at 0.37 kg/kg clinker, and in the decarbonation of limestone during the cement production process, estimated at 0.53 kg/kg of clinker CO_2 [1]. Belite cements contains a higher percentage of belite (C_2S) than Ordinary Portland Cements and the necessary burning temperature could be reduced by 6-10%. Consequently, levels of emitted CO_2 and NO_x could fall [3].

In this study, chamotte from the structural ceramic industry, limestone and clay were used for the production and characterisation of four types of belite cements: pure belite cement as reference with 0 wt.% chamotte, one with 2.5wt.% chamotte, one with 5wt.% chamotte and one with 10wt.% chamotte. The design of the raw mixes was based on the compositional indices lime saturation factor, alumina ratio and silica ratio.

The clinkering temperature was studied for the range 1300-1390 ºC. To stabilize the α’- and β-C_2S polymorphic forms, the clinker was cooled fast by the simultaneous application of blown air and crushing by means of a hammer [4].

For the study of the new formulations of belite cement clinker, a characterization of the raw materials and chamotte was carried out. Specifically a mineralogical analysis was carried out using XRD and the determination of its chemical composition by FRX. Analysis of the clinkers was done by optical microscopy, SEM and XRD.

Keywords

Belite cements; Chamotte; Low energy cements; Ceramic industry wastes

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Influence of carbon fiber waste on properties of blast furnace slag geopolymers

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ABSTRACT

The main objective of this work was the study of properties of geopolymers based on blast furnace slag (BFS) with additions of a mud-powder of carbon fiber originated from the aeronautical industry (PPFC). Two parameters have been analysed: BFS/PPFC ratio (100/0, 80/20 and 60/40) and the activating solution (NaOH 8M and Sodium silicate). Samples were cured at 60 ºC. Different tests were carried out in order to analyse the physical and mechanical properties: open porosity, density, compressive strength and Shore hardness. Geopolymers were also subjected to an acid attack test. In addition, the evolution of the compressive strength with the temperature (105 ºC, 300 ºC, 500 ºC and 700 ºC) was evaluated too. A reduction of porosities and an increment of compressive strengths were observed as PPFC content in the geopolymer increases. Geopolymers activated with silicate were less porous and more resistant than those activated with hydroxides [1]. A positive effect of PPFC waste (regardless of activating solution) on the acid attack results was observed since a higher acid attack resistant was obtained as PPFC content increased in the geopolymer. Although the PPFC produced more porous geopolymers, they showed more chemical stability [2]. Geopolymers withous PPFC showed an increase of compressive strength with the temperature in the range of 105–300 °C and a decrease in the range from 300 to 700 °C [3]. However, geopolymers with PPFC showed a progressive reduction of the compressive strength after exposure to high temperatures [4].

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Keywords

Blast furnace slag, aeronautical industry.

Old Kingdom Pyramids, constructive hypothesis with geopolymers: a brief review

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ABSTRACT

The rediscovery of ancient technical acumen from a scientific perspective has both started off present research lines and attracted media attention which, otherwise and in spite of its many benefits, technologies such as geopolymerization could not attract on their own. The present article reviews the current state of French chemist Joseph Davidovits's (1979) heterodox hypothesis, still not accepted by most Egyptologists. Such hypothesis, the construction of the Old Kingdom pyramids with conglomerate stones bound together by means of a geopolymer binder, is analyzed from the point of view of the construction material itself.

Keywords

Old Kingdom Pyramids; Geopolymer binder; Limestone

Synthesis of ceramic materials from alternative geopolymer precursors

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ABSTRACT

Alternative geopolymer materials were produced using alkaline activators based on potassium hydroxide (KOH) and rice husk ash (RHA), as reference material was used an alkaline activator based on commercial potassium silicate. The optimized matrix in terms of their compressive strength were used to design composite materials, those were designed by incorporation refractory brick particles which were obtained by milling in ball mills. Microstructural monitoring was performed with instrumental techniques such as X-Ray Diffraction, TGA/DSC and SEM from room temperature until after exposure to high temperatures. The effects of different sources of silica and reinforcing particles were evaluated on the mechanical and thermal-physical properties (thermal conductivity and heat transfer). The use of RHA as silica source to produce alternative alkaline activators produces geopolymer materials with mechanical properties similar. The exposure of geopolymer pastes to high temperatures was found these keeping their integrity, the residual compression strength after exposure to 600 °C reaches 50 MPa and at 1200 °C the residual compression strength was 110 MPa. The particle-reinforced composites with 20 % reached residual compression strength was 180 MPa. Based on the results of the mechanical and microstructural characterization, it was possible to conclude: the thermal stability and high residual compression strength shown in the composite materials after exposure to high temperature is due to sintering processes, structural rearrangement and formation of crystalline phases such as leucite and mullite. The materials were tested up to 1500 °C, at which point no evidence of melting or melting processes was observed.

Keywords

Wastes; Metakaolin; Rice husk ash; Leucite; Geopolymer; Crystallization

Building elements produced by the geopolymerization of debris from the construction sector

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ABSTRACT

The objective of this research was to demonstrate the feasibility of recycling red clay brick wastes (RCBW), concrete wastes (CW) and glass wastes (GW) derived from construction and demolition activities by using alkaline activation technique to obtain alternative cementitious materials suitable for be used in the manufacture of building elements. The residues were selected and separated from an actual sample of debris and subsequently crushed and milled separately to obtain a size smaller than 50 µm. Alkaline activators as sodium hydroxide (NaOH) and mixtures of NaOH + sodium silicate (Na_2SiO_3) were used. The curing temperature was between 25 and 70 °C. Additions of Portland Cement (OPC), less than 30% by weight of the waste (RCBW; CW; GW), were used to obtain hybrid type cements cured at room temperature (25°C). Alkaline activated cements based on the brick, concrete and glass wastes gained a maximum compressive strength of 102, 33 and 57 MPa at 28 days, respectively. Optimal cements were characterized by techniques such as FTIR and SEM. The mechanical performance of these materials allowed the production of building elements such blocks, pavers and tiles; it is highlighted that the above applications comply the standards and specifications established in the building field and the manufacture method. This recycling process is considered as a feasible alternative to reuse the mentioned wastes, due to the high impact to the environmental sustainability and taking into account their high volumes of generation and the demand of building elements at global level.

Keywords

Geopolimerization; Alkali-activated materials; Construction and demolition wastes; Ceramic wastes; Recycling;

Acknowledgement

The authors thank the Universidad del Valle (Cali, Colombia) and the Administrative Department of Science, Technology and Innovation (Colciencias) for the support received in the framework of the project, “Construction of prototype at the scale of rural housing using innovative materials with low carbon footprint,” Contract 096-2016, within which this research was conducted.

Synthesis hydrothermal of hydrotalcite-type material employing bauxite residues from Juruti (Amazon Region, Brazil)

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ABSTRACT

The synthesis of hydrotalcite-type material from bauxite residues from Juruti mine (Pará State, northern Brazil) is presented. The residues and the final product were characterized by X-Ray Diffraction (XRD), Thermogravimetric analysis and Scanning Electron Microscopy (SEM). According to the results obtained, although residues have been employed as starting material, pure hydrotalcite could be synthesized with rhombohedral (R3-m) structure-like and 7,68 Å interlayer spacing. The unit cell parameters were obtained as a=3.130(7), c=23.47(6), as well as size crystal (31 nm) by Scherrer Equation. The thermal behavior of hydrotalcite could be divided into four main decomposition steps (TG-DTA curves) related to the loss of interlamellar water, decomposition of OH^- groups and collapse of the hydrotalcite structure. The material exhibited morphology in the form of plates and small agglomerates.

Keywords

bauxite residues; hydrotalcite; amazon region.

Preparation of lithium birnessite-type material employing Mn residues from Carajás Mineral Province (Pará State, Brazil)

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ABSTRACT

This work describes the synthesis of octahedral layered birnessite-type manganese oxide with Li^+ as interlayer cation (Li-OL-1), using manganese residues at mining site from Carajás Mineral Province (Pará State, northern Brazil). The preparation method involved dissolution of Mn_2O_3 followed by reprecipitation of the layer-phase sodium birnessite, which was ion exchanged with an aqueous solution of Li^+ at room temperature while stirring overnight. The X-ray diffraction patterns clearly indicated the transformation of Mn residues into birnessite with basal spacing around 7Å. The TG-DTA curves permitted to verify the thermal behaviour of Li-OL-1, which revealed a stability up to 600 ºC. FT-Raman spectra of the product showed intense bands around 280, 405 and 637 cm^{-1} and could be assigned to the layered framework structure. These results indicated that, Mn residues can be excellent raw materials for the synthesis of layered structures type birnessite.

Keywords

Mn oxides; Residues; Synthesis; Li-birnessite; Carajás Mineral Province

Processing of cellular geopolymers by direct foaming of alkali-activated ceramic clays and metallurgical slags

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ABSTRACT

Since geopolymers display both good engineering properties and reduced CO_2 emissions during their manufacturing, they are currently attracting great interest in improving the environmental performance of traditional building materials. Additionally, these materials also show a huge potential to utilize industrial wastes as an alternative to conventional raw materials [1].

On the other hand, foamed inorganic materials such as ceramics or concrete can provide a perfect combination of mechanical strength and low mass due to their porous microstructure and thus, a wide number of applications have been described, ranging from filter or catalyst support to thermal insulators [2]. In particular, geopolymer foams have been proposed from different kind of alkaline activated aluminosilicates coming from industrial waste, calcined clays or their mixtures and by using several types of foam precursors in order to improve materials features [3,4].

In the present study the starting materials were an illite-smecttite clay mixture from Bailén (Southern Spain) and kaolinite clay from Portugal, both used in the manufacture of common building ceramics and pottery, and with the intention of covering different rheological behaviour. The waste used in order to obtain geopolymers and fit the Si/Al and Si/Na ratios was metallurgical slags. From these raw materials, it is proposed the development of foams by using direct foaming of casting slips through the addition of two kinds of surfactants: sodium dodecyl sulphate (SDS) and sodium lauryl sulphate (SLS), followed by air injection by mechanical stirring and subsequent hardening. Thus, final porosity is mainly controlled through stirring speed and surfactant concentration.

The main properties examined were bulk density, porosity, thermal conductivity and fracture modulus. These properties were analysed and discussed in terms of microstructure and processing parameters. Thus, the present work contributes to a feasibility study on the technical implantation and repercussion of this material processing method for different building applications.

Keywords

Clay; Metallurgical Slags; Geopolymer; Foam; Porosity;

Acknowledgement

The authors acknowledge the support from Consejería de Economía y Conocimiento, Junta de Andalucía, through the EFIWALL Project PI12/1920.

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Low thermal expansion geopolymers fabricated from waste borosilicate glass and its use as photocatalysts support

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ABSTRACT

Nowadays waste glass materials represent one of the most serious environmental problems in our planet, for that reason its reutilization is necessary to contribute to the sustainable development. Among the options for reutilization of waste glass materials it can be mentioned its use as raw material to get alternative cementitious binders [1] by means of alkaline mechanochemical milling, a method commonly used to treat industrial waste such as slag, glass or fly ash. The alternative cementitious materials, called geopolymers [2], can be used in various advanced applications to reduce the environmental impact of the construction industry. In that sense, in this work it was carried out the fabrication of geopolymers from waste borosilicate glass (WBG) by alkaline mechanochemical milling method using NaOH (8.0 M), 10 wt.% of portland cement, and in order to control thermal expansion of geopolymers it was added 10 wt.% of Eucriptite ($LiAlSiO_4$). Results indicated that waste borosilicate glass is reacting with the NaOH forming the geopolymer, but also cement and $LiAlSiO_4$ are partially reacting. During the alkaline activation reaction of WBG it is formed the sodium aluminosilicate hydrate gel (N-A-S-H), which was detected by Raman spectroscopy. On the other hand, thermal expansion coefficient of geopolymers was measured by dilatometric analysis and results showed values close to $3.0x10^{-6}$/K; it means that the presence of Eucriptite favors the control of this property allowing the fabrication of low thermal expansion geopolymers. Additionally, the fabricated materials were used as support of $SiC-TiO_2$ photocatalyst and after 3 hours of reaction under UV-light it was reached more than 95% of Rodamine B discolored.

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Porous geopolymers obtained from rice husk ash and aluminum industry waste.

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ABSTRACT

Geopolymers (GPs) are inorganic aluminosilicate polymers synthesized by alkali activation of Si- and Al-rich materials at near ambient temperatures [1]. Porous geopolymers are also of great interest due to the search for new applications such as cellular concrete, catalyst support, gas filtration and insulation materials. Sustainable materials are considered in which industrial by-products can be used as raw material in a process of low energy cost. In this work, porous geopolymeric materials synthesized from wastes were studied. As precursor of aluminosilicates rice husk ash (as source of silica) and aluminum secondary industry waste (as source of alumina) were activated with a sodium silicate and sodium hydroxide solution. The influence of the Si/Al ratio (4-7) and the curing time were determined by keeping the Si/Na = 0.7 M molar ratio constant and the concentration of sodium hydroxide in the activating solution = 8.5 M. The porous geopolymers obtained were characterized by Fourier Transform Infrared (FTIR), X-ray Diffraction (XRD), Absorption-Desorption of N_2 and Thermogravimetric and Differential Thermal Analysis (TG-DTA). The results indicated that bulk density decreased, water absorption, apparent porosity and compressive strength increased when Si/Al ratio was raised from 4 to 7 at 7 curing days. However this tendency is not maintained for higher curing times (28 days). The bulk density decreased, water absorption and apparent porosity increased in higher proportions however compressive strength is maintained for Si/Al molar ratio of 4 and 5. Geopolymers exhibited a compressive strength of 1.8 MPa and a bulk density of 716 kg/m^3 were obtained, with a Si/Al molar ratio of 7 after 28 days of cured at room temperature.

Keywords

Porous geopolymers; Alkali-activation; Rice husk ash; Aluminum industry waste

Acknowledgement

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Green geopolymer-based mortars from paper pulp industry wastes for sustainable construction

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ABSTRACT

Sustainability in construction is a major concern worldwide as far as its intensive industry, with a special attention to cement production, has been found to be a major source for carbon dioxide emissions. Furthermore, the global industrial system has also reached high levels of unsustainability due to the large amount of wastes that are being released in the atmosphere. Valorisation and reuse of industrial by-products along with a valid alternative to ordinary Portland cement make geopolymers a solid and sustainable via to be followed. Fly ash-based geopolymer concrete/mortar is an environmentally-friendly structural material made from alkali activated alumino-silicate and aggregates. They show a better or at least comparable strength and durability, along with a high chemical resistance, in comparison to traditional cements. Moreover geopolymers are highly cost-effective and easy to prepare.

In this work the use of a green geopolymer-based mortar is evaluated for sustainable construction and environmental applications. In the pursuit of a sustainable construction material, regional wastes derived from paper pulp industry are exploited as a base for material processing. A simple, reproducible, ambient temperature, and low cost manufacture is followed. Workability, mechanical performance, microstructure, along with water absorption and the main physical properties are investigated. Preliminary laboratory tests indicate that such a geopolymer mortars are a viable environmentally friendly solution for conventional Portland concrete replacement that may help in reducing the environmental footprint associated with waste disposal.

Keywords

Geopolymers; Biomass fly ash; Green mortar; Construction; Mechanical performance; Industrial waste valorisation.

Geopolymers incorporating soda lime glass waste

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ABSTRACT

Geopolymers were primarily developed for the construction industry as non-Portland cements due to the fact that about 5-8% of the global CO_2 emissions is generated from Portland production, it is in fact estimated that for each ton of cement 1 ton of CO_2 is generated [1].

Geopolymers can provide comparable or better performance to traditional construction materials, with the advantage of greenhouse emissions reduction, thanks to the capability to harden at room temperature [2].

The aim of this work is to evaluate the possibility to create geopolymers using glass waste as source of silica instead of water glass normally used as alkaline activator. This waste can be valorized to minimize energy demand and CO_2 emissions associated with sodium silicate production, where temperature around 1300 °C is required. In this study fly ash, a residual generated by coal combustion in thermal power plants, and soda lime glass waste are used as alluminosilicate raw materials activated by sodium hydroxide.

Mechanical performance of the new materials was assessed by compressive strength test after 28 days of air cooling. Spectra have been acquired through Fourier transform infrared spectroscopy (FTIR) and crystalline phases have been detected by X-ray diffraction (XRD) analysis. Helium pycnometry and microstructural characterization, including pore size and crack distribution analyses by scanning electron microscopy (SEM), were carried out. Moreover final leaching tests were conducted to assess the stability and sustainability of the geopolymers.

Keywords

Glass waste, sodium hydroxide.

Acknowledgement

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Use of residual diatomaceous earth as a silica source in geopolymers production

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ABSTRACT

In recent years, using alternative construction binders to Portland cement has gained importance. Among them, geopolymeric binder, developed by a reaction between an aluminosilicate precursor and a high alkalinity solution, is highlighted. The activating solution generally comprises sodium silicate (waterglass) and sodium hydroxide. Since waterglass is the most expensive material with a high environmental impact, using alternative silica sources will lead to more sustainable binders. Previous studies have successfully used silica-rich waste materials, e.g., rice husk ash (RHA) or waste glass as a silica source. The mechanical properties of the geopolymers developed with these alternative solutions were similar to those obtained with commercial solutions.

Diatomaceous earth (also called diatomite or kieselgur) is a sedimentary rock with high amorphous silica contents formed by fossilized diatom remains (a type of hard-shelled algae). This research aimed to assess the possibility of using diatomaceous earth as a silica source for the alkali-activating solution in geopolymers production. Fluid cracking catalyst residue (FCC) was used as a precursor and six different activating solution types were prepared, one with commercial products ($NaOH/Na_2SiO_3$) and five with NaOH and silica obtained from silica-rich materials: RHA, commercial diatomite (CDE), residual diatomite from a beer company (BDE) and two residual diatomite types from a wine company, one calcined and one non-calcined (WCDE and WDE, respectively).

Microstructural and compressive strength developments were investigated in pastes and mortars cured at room temperature for 7 and 28 days. The compressive strength results of diatomite mortars were slightly lower than those of mortars prepared with RHA or commercial solutions. This opens up a new possible way to reuse and recover diatomaceous earth residue, a significant waste material.

Keywords
Diatomaceous earth, geopolymer, waste materials, FCC, RHA

Calcined Clays for low carbon cement: Rheological behaviour in Portland cement pastes

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ABSTRACT

In this paper, the rheological behavior of pastes of Portland cement and different calcined clays additions were analyzed. For this purpose, two Portland cements with different mineralogical composition (low C_3A and high C_3S content and low C_3S and high C_3A content) combined with different replacement percentages of three minerals additions of aluminic nature (quartz as control, and two metakaolins) are used. Mineral admixtures have different crystallinity and morphology: the quartz is fully crystalline; metakaolins are vitreous with a small fraction crystalline. The vitreous phase gives to the calcined clays, pozzolanic properties. All determinations were performed on Haake Roto Visco at 25°C, just on the latency period of hydration. The results show that paste of Portland cement with low C_3A content and high C_3S content presents a great shear strength and the replacement by calcined clays addition affects the rheological behavior of pastes depending on the pozzolanic nature and the reactivity of addition.

Keywords

Calcined clays; Pozzolanic and non pozzolanic additions; Portland cement pastes; Rheology

LATE POSTERS

USE OF CLAYS IN ALKALINE HYBRID CEMENT PREPARATION. THE ROLE OF BENTONITES

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Hybrid alkaline cements (the last generation of alkaline cements) are cementintious materials consisting in mixtures of high proportions of SCMs (commonly fly ashes or blast furnace slags (BFS)) and low contents of PC. These systems, in presence of a soft alkaline activator, set and harden developing materials with excellent engineering properties, comparable an even higher than a traditional PC cement. This work seeks to study the effect of using clays as a new aluminosilicates source, in the preparation of hybrid alkaline cements. The clay chosen is bentonite.

Pastes consisting in different proportions of Portland cement (PC) and de-hydroxylated Bentonite (BT) were prepared: 100% PC, 100% BT, 80% BT:20% PC, 70% BT:30% PC y 60% BT:40% PC (weight percentage). All systems were hydrated with water in presence and in absence of a solid alkaline activator (5% Na_2SO_4) and cured at ambient temperature for 28 days. The mechanical strength behaviour was analyse after 2 and 28 days. The reaction products were characterised by XRD and FTIR. The hydration kinetics was also analysed by Isothermal Conduction Calorimetry.

All systems (except 100% BT) set and harden showing cementitious properties. The presence of alkaline activator accelerated the precipitation of the reaction products favouring the mechanical strength development. Alkali activated system containing 60% of Bentonite achieved 53 MPa after 28 d (1.5 times more than the same system only water hydrated). The hydration in presence of the alkaline activator does not modify the type of the secondary reaction products formed (basically portlandite and ettringite). The main reaction product in these alkali activated systems consists in a mixture of amorphous gels: C-A-S-H + N-A-S-H, which proportion will be highly dependent on the initial CaO content.

Keywords

Alkaline activation, geopolymer, hybrid cements, mechanical strenghts, Bentonites

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