Synthesis and Characterization of Geopolymers by the Alkali Activation of Natural Ecuadorian Zeolites: The Use of Geopolymers as Potential Thermal Insulating Materials and Reaction Kinetics of the Geopolymerization' Reaction.

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ABSTRACT

This work presents the synthesis of geopolymers by the alkali activation of natural Ecuadorian zeolite and their mechanical and thermal characterization. The main goal of this study is to determine the geopolymers' thermal, mechanical and geopolymerization reaction properties. The reaction kinetics will be determined by using X-Ray Diffraction (XRD) technique in order to know the reduction of the crystalline structures in time. The expected compressive strength for non-foamed geopolymer may be consistent with the requirements of the construction industry. The thermal conductivity of foam type geopolymers is expected to be sufficiently low to be used as thermal insulating material.

INTRODUCTION

Worldwide, two of the most important problems that have been related to climate changes are energy waste and CO_2 generation by all the productive processes. The energy required in households and industry for condition the internal environment of the structures has been increasing and every year reaches new digits. In both cases thermal insulation with different materials have been solutions to keep the conditions as required. Depending of the proposal or the use the engineers gives to these materials; they have to count with properties as high mechanical strength resistance and low thermal conductivity without suffering changes in their structure and chemical composition when they are exposed to these conditions (Vaou et al., 2010).

The main source of industrial and residential insulation through the 19th and 20th centuries was asbestos. Then, after some years, asbestos has been classified as a known human carcinogen by the Department of Health and Human Services of the United States, by the Environmental Protection Agency and the International Agency for Research on Cancer. According to research, exposure to asbestos can increase the risk of lung cancer and mesothelioma (Department of Health and Human Services, USA). In the specific area of constructions, it's well known that the process of calcination of Portland cement release Carbon Dioxide to the atmosphere, this gas is one of the reasons of global warming (Environmental Protection Agency, USA). Approximately, the carbon dioxide makes a contribution around 65% for global warming, and 6% of CO_2 emmitions comes from the cement industry. The production of one ton of Portland cement emits approximately one ton of CO_2 into the atmosphere (McCaffrey, 2002). A solution under study is the use of aluminosilicate entities to form geopolymer and its variations, which may have the

right characteristics and properties to use it as thermal insulating materials (Sakulich et al., 2009). Geopolymers are a solution for this problem if they were used as alternative binder to the Portland cement, reducing up to 80 % of the emissions inflicted by cement and aggregates industries (Davidovits, 1994).

The study´s objective is to synthesize and characterize samples of geopolymer formed by alkaline activation of Ecuadorian zeolite, through measuring the mechanical properties, thermal conductivity and reaction kinetics of geopolymerization process.

MATERIALS AND METHODS

The methodology of this study consists four phases. The first phase is preparation of zeolite, which includes grinding and drying process, verification of organic traces in the zeolite using Fourier Transform Infrared Spectroscopy technique analysis, heating process to remove organic compounds if it is needed and particle size distribution analysis. Second and third phases are preparation of samples and essays, respectively. The optimum Sodium Hydroxide molar concentration for alkali activator will be studied. Samples will be molded using 5 cm ASTM cube molds. Mechanical compressive strength test will be the indicator used to determine the best sodium hydroxide molar concentration. In order to get better results curing temperature will be studied with the best concentration. Thermal conductivity will be determined in foam type geopolymers. The foamed geopolymer will be heated; temperatures in cold and hot sides will be determined using thermocouples. With the temperatures and dimensions the thermal conductivity will be calculated. To finish third phase, determination of kinetics properties by In-Situ X-ray Diffraction (XRD) will be carried out: Reaction order, kinetic constant and variation of reaction rate. Finally, the fourth phase is the analyses of results and conclusions.

RESULTS AND DISCUSSION

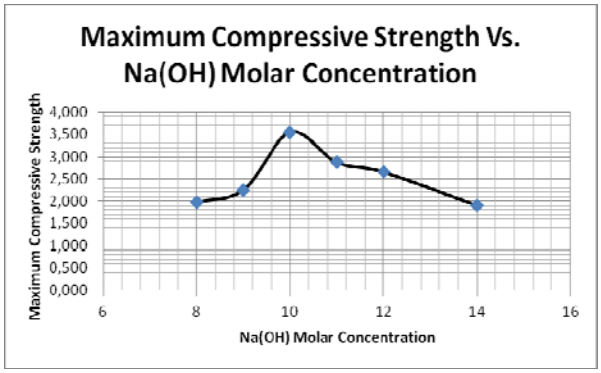

Figure 1: Maximum Compressive Strength Vs. Na(OH) Molar Concentration

Figure 1 shows the correlation between the maximum compressive strength reached with the differents molar concentrations of sodium hydroxide. The compressive strength tests were carried out in the early age of the geopolymer. All cubes, were cured 24 hours at a curing temperature of 60 °C. In the figure 1, it can be appreciated that the compressive strength increases as the sodium hydroxide molar concentration increase until 10 Molar. After this concentration, the maximum compressive strength for 11, 12 and 14 molar show a considerably decrease. Sodium Silicate/Sodium Hydroxide ratio was 2.5 and Calcium Hydroxide was added in 1% of zeolite mass. The best molar concentration for the alkali activator is 10 Molar.

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