**Innovative glass recipes containing industrial waste materials**

**Introduction**

Industrial waste management is a fundamental question in a society that faces a growing industrial production. The crescent population, urbanization and wealthiness cause an increase of the global production of solid waste. Factors like population and *per capita gross domestic product* (GDP) are utilized to measure the total global *municipal solid waste* (MSW) production [1]. Some predictions about the world population suggest that it will reach the highest point during this century.

The waste production rates per capita usually grows with the wealthiness, despite the fact that there is a tendency toward the dematerialization in the wealthiest countries. The junction of these aspects points to a scenario in which over the next decades the global waste generation could probably peak [1].

About 5 to 7% of the whole global greenhouse gas emission is originated from the manufacture of the *ordinary Portland cement* (OPC), constituting a latent question for the global environment [2]. Geopolymer is a promising technology, an ecological binding material that works as an alternative binder to Portland cement. Usually, the geopolymer is composed by the reaction of an geologically generated aluminosilicate compound, like clay and metakaolin, or industrial by-products, like fly ash and ground granulated blast furnace slag with an alkaline solution [3]. The two principal environmental advantages coming from the use of the geopolymer binder instead of the Portland cement are the significant decreasing of greenhouse gases emissions and the application of industrial by-products to develop building materials.

The use of slag cements or ground granulated blast furnace slag (GGBS) is another manner to develop building materials using waste products. As an additive, the slag add many benefits to the concrete properties. For instance, a high durability as a result of the low capillary porosity, protection against alkali silica reaction and a low risk of thermal cracking (EUROSLAG Technical Leaflet No. 1, 2003). These properties support the utilization of slag cements in exceptional environments, for instance waterproof basements, maritime structures and bridges.

The generation of 1t Portland cement originates in Europe about 1.2t of CO2 on average. At the same time, the production of 1t blast-furnace slag cement composed of 50 wt.% GGBS brings only 0.54t CO2 (EUROSLAG Technical Leaflet No. 1, 2003).

In 2016, the concentrations of CO2 in the Earth's atmosphere reached a record. According to the *World Meteorological Organization* (WMO), the record increase in the annual mean from 2015 to 2016 was 50% higher than the average of the past 10 years [4].

Hence, future emission reductions is necessary. The use of slag is a very efficient and economic manner to reduce the CO2-emissions and the energy, utilized intrinsic in the manufacture of the cement.

Other applications of slag include road construction and as porous asphalt. Despite the large number of products developed from waste materials, most of them consist of non-transparent materials. One of the reasons is due the fact that it is a challenge to get transparent materials in reasonable temperatures from these waste products.

Slag and fly ash contain many elements which are also present in typical glass formulas. For instance, the elements found in higher amounts at chemical systems of standard silicate glasses are: SiO2, Na2O, CaO, K2O, MgO, Al2O3, Fe2O3 [5]. All those elements are found both in slag as in fly ash compositions. Some of those elements are high refractory and their presence in complex compositions leads to a high tendency to crystallization and high working temperatures. The glass is a material that allows large amounts of various elements in solution, being suitable to assimilate the complex materials in its compositions.

In this work, we aimed to get new glass recipes incorporating waste materials in their compositions. At the same time, keeping the transparency and relatively low working temperatures. To reach these conditions, the elements amount as well as the melting conditions were optimized. The optical, mechanical and thermal properties of the samples were measured and compared to the standard borosilicate and soda-lime glasses. The potential application of these new compositions as building materials was evaluated.

**References**

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