University of Belgrade
Technical Faculty in Bor and
Mining and Metallurgy Institue Bor

51st International October Conference on Mining and Metallurgy

PROCEEDINGS

Editors:

Prof. dr Srba Mladenović
Prof. dr Čedomir Maluckov

Bor Lake, Serbia,
October 16-19, 2019

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DISSOLUTION OF COAL FLY ASH GLASS IN DIFFERENT MEDIA

Veljko Savić[1], Vladimir Topalović[1], Jelena Nikolić[1], Srđan Matijašević[1], Marija Đošić[1], Snežana Grujić[2]

[1]Institute for Technology of Nuclear and Other Mineral Raw Materials, Franchet d' Esperey 86,11000, Belgrade, Serbia

[2]Faculty of Technology and Metallurgy, Karnegy 4, 11000, Belgrade, Serbia

Abstract

The increasing production of fly ashes from carbon combustion in thermal power plants has compounded environmental problems worldwide. As one of promising solution the vitrification of fly ashes could be considered. For potential application chemical durability of material should be known. Dissolution of coal fly ash glass grain samples was studied. The glass was obtained by melting a mixture of coal fly ash, Na_2CO_3 and $CaCO_3$ at T= *1500 ^oC and quenching the melt in air. The chemical durability of the glass was determined by dissolution test in distilled water, HCl and NaOH at T = 95^0C for t =2h. It was shown that dissolution rate of glass in distillated water and NaOH is negligible, while in HCl solution was shown significant mass loss.*

Keywords*: glass, coal fly ash, dissolution*

1. INTRODUCTION

Coal fly ash, generated during the combustion of coal, is an industrial by-product whose current annual production is estimated to be more than 500 million tons [1], a number that continues to increase to account for the growth in power demand. This large amount industrial waste can cause significant environmental and ecological problems if not treated properly. Only parts of the enormous waste residue are utilized, primarily in cement industry and building materials field. The residual coal fly ash is generally disposed in ponds or landfill without any treatment, which not only occupies vast land but also results in serious environmental pollution. For example, potentially toxic substances in coal fly ash could leach into soils and groundwater and accumulate in the food chain [2]. Because the coal fly ash contains large amount of SiO_2 and Al_2O_3, which are main glass network formers, it is feasible to use coal fly ash as a raw material to develop glass [3]. Vitrification of hazardous wastes into glass provide an alternative way to waste treatment or landfilling. Glasses and glass-ceramics, obtained from solid waste materials, like coal fly ash, are used as construction and architectural components; thermal, sound and electric insulators, wall tiles, tile glazes, filtering and wear-resistant parts, etc [4]. The produced materials seem promising, not only because of their outstanding properties, but also since the hazardous wastes can be successfully converted into glassy products as non-hazardous materials. Recycling of hazardous wastes in glass production results in many advantages; the use of „free“ raw material, the conservation of natural resources, the elimination of the waste with the protection of the environment, etc [5]. This paper reports the results of vitrfication of waste fly ash collected from the open pit near the TPS „Nikola Tesla" – Republic of Serbia and its dissolution behavior.

2. EXPERIMENTAL

The raw sample of fly ash was collected from the open pit near the TPS „Nikola Tesla", dried in oven and then analyzed. To determine chemical composition of fly ash and obtained glass a wet chemical method and AAS (Perkin Elmer 703) were employed. The phase composition was defined by the XRD - Philips PW-1710 automated diffractometer with a Cu K_α radiation tube operating at 40 kV and 32 mA. Na_2CO_3 and $CaCO_3$ were used as raw materials for Na_2O and CaO sources to lower viscosity of glass batch. The glass was prepared by melting a homogeneous mixture of 75% fly ash, 15% CaO and 10% Na_2O in zirconium silicate crucible at T=1500 °C during t=1 h in electric furnace. The chemical durability (as wt.% loss) was estimated in distialted water, 0.01 M HCl and 0.01 M NaOH, respectively. In these experiments 2 g grained samples with sizes from 0.3 to 0.5 mm were placed in contact with 70 ml solution for 2 h at T=95 °C [6].

3. RESULTS AND DISCUSSION

The chemical composition of the fly ash sample is shown in Table 1. Due to low concentration of glass network modifier cations viscosity of melted fly ash is very high, and it is imposible to pour it. In order to make melt pourable chemical composition of batch should be altered introducing modifier cations in the batch.

Table 1. Chemical composition of the fly ash sample

oxides	SiO_2	Al_2O_3	CaO	MgO	Na_2O	K_2O	Fe_2O_3	TiO_2	L.o.i
mass%	55.33	25.11	6.26	1.42	0.32	1.23	7.08	0.50	2.52

The XRD analyses showed in Figure 1. revealed a complex phase composition of fly ash.

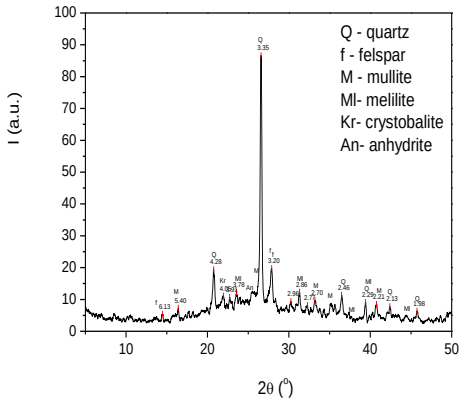

Figure 1. XRD patterns of the fly ash sample

As can be seen from the XRD patterns (Figure 1), the crystalline phases determined in the sample are: quartz, feldspar, mullite, melilite, crystoballite and anhydrite.

The homogenous black glass was obtained by melt casting on steel plate. XRD patterns are shown in Figure 2. No crystalline phase was found which confirms that obtained material is amorphous. The chemical composition of the glass sample is shown in Table 2. Obtained glass

has high concentration of glass network modifier cations which enabled low viscosity and good flowability of melt.

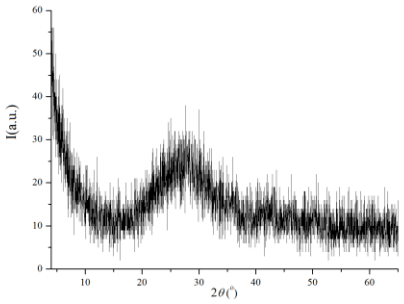

Figure 2. XRD patterns of the obtained glass sample

Table 2. Chemical composition of the glass sample

oxides	SiO_2	Al_2O_3	CaO	MgO	Na_2O	K_2O	Fe_2O_3	TiO_2
mass%	42.63	19.34	19.67	1.09	10.15	1.03	5.45	0.39

The results of dissolution test are shown in table 3.

Table 3. Dissolution test of fly ash glass

Solution	Weight loss (%)
Distillated water	negligible
0.01 M NaOH	negligible
0.01 M HCl	43.80

The dissolution of glass matrix is a complex process with several characteristic steps. In alkaline media the dissolution of the Si-glass network by which the glass dissolves directly into the solution take place. In neutral and acid media the initial dissolution is characterized by ion exchange processes between protons in solution and glass network modifier cations, resulting in the formation of a hydrated layer, through which the aqueous species diffuse. At the same time, the glass network composed of network forming tetrahedral hydrolyzes, causing the release of cations into solution. Because of high concentration of glass network modifier cations and high concentration of protons in acid solution glass shows significant mass loss and great dissolubility, while, on the other side, doesn't dissolve in neutral and alkali media at high temperatures. This excludes possibility for use as anticorrosive container lining.

4. CONCLUSION

The glass was successfully obtained using coal fly ash, Na_2CO_3 and $CaCO_3$ as raw materials. The results of laboratory experiments have shown that the vitrification process can be considered as promising solution for waste management. The results of dissolution test revealed a high durability in distilled water and in alkali solution of the grained glass samples. Weight loss determined after dissolution in HCl solution has shown a poor acid durability of the samples

due to ion exchange processes between glass network modifier cations and acid solution. Obtained glass can find potential application as thermal and sound insulator, construction materials and wall tiles.

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