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Study of the viscosity behaviour of glasses obtained from urban wastewater treatment sludges from Egypt using hot stage microscopy

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The volume of sludge produced in wastewater treatment plants in Egypt is becoming more important; this paper studied the chemical composition of sludge from four treatment plants located around Nile delta and valley: El-Sadat City (E-01), Alexandria (E-02), Abo-Rawash (E-03) and Minufiya (E-04), and is suggested as a possible solution, the vitrification of these sludges. Another important objective for obtaining correct this glass is to know the viscosity temperature curve, including developing a prototype of hot stage microscopy (HSM) and development of software suitable for the analysis of images. Each image has different morphology related to different viscosity, can that way determine the viscosity at the temperature of heating.

The chemical composition of these sludges is close to a basalt rock except that the phosphorus content is higher, and sometimes with a certain proportion of heavy metals. Cr, Zn and Pb exceeds the limit allowed to be used in agriculture, this is one of the solutions actually used. In general, major oxides to sludges ranging from: SiO_2 (36-48 wt %), $Al2O_3$ (9-16 wt %), CaO (5-25 wt %), P2O5 (1.5-11 wt %) and $Fe2O_3$ ($\sim$ 9 wt %), this composition. Since of them are formulated and prepared by four different glasses, in some cases being necessary to incorporate a quantity of raw materials. The sludge combustion heat, the thermal evolution, vitreous transition temperature (Tg) and crystal growth temperature of the glasses were obtained by carrying out a differential thermal analysis. Tg of the four glasses vary between 650 and 725 ºC and the growth occurs between 938 and 1033 °C. The vitreous transition temperature was also determined with a dilatometer. Each original glass has been characterized mineralogically by X-ray diffraction: quartz, plagioclase, K-feldspar and calcite. Two samples contained gypsum and some clay mineral traces. We also obtained the viscosity - temperature curves with the aid of the hot stage microscopy that has allowed us to determine the working temperatures of the four glasses, ranging from 926 and to 1419 °C, depending on the type of forming process used.

In all glass samples the viscosity-temperature curves have similar characteristics, but for higher viscosities a separation among the different viscosity-temperature curves occurs. This different behaviour is associated to chemical composition: Ca-rich silica aluminum melt, present low viscosity at low temperatures, > P2O5 content, the nucleation of a more refractory phosphate phase occurs. In order to obtain the original glasses working conditions (necessary for possible industrial applications) are used the Vogel-Fulcher-Tammann equation: a) upper and lower annealing temperatures of the samples are similar for the different glasses and ranging between 595-641 ºC and 671-701 ºC respectively; b) working temperature range from 917-1307 ºC for the sample E-02, and 925-1503 ºC for the sample E-04, depending on the conformation system used. Finally, the forming and melting temperatures of the samples vary between 1307-1403 ºC (E-02) and 1503-1550 ºC (E-04).

The results confirm that HSM is a good technique for studying the sludge vitrification process, and could provide important information for the possible industrial application.

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