Fabrication of glass-based products as remediation alternative for contaminated urban soils of Barcelona

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Introduction

Contaminated soils from Barcelona city (Catalonia, Spain) from an area previously occupied by a metal smelting industry were used as raw material for making glass. The aim of this research is to evaluate the sustainability of vitrification from the view of energy efficiency and land reuse in highly contaminated soils where other techniques, as phytoremediation or organic amendments stabilization, are not possible. The main pollutants are Cu, Pb and Zn with soil total concentrations in the first 50 cm about 930, 1330 and 5379 mg·kg-1, respectively.
The methodology followed is shown in Fig. 2. A representative sample of the polluted soil was used to prepare the glass.

Figure 1. Sampling of the polluted urban soil.

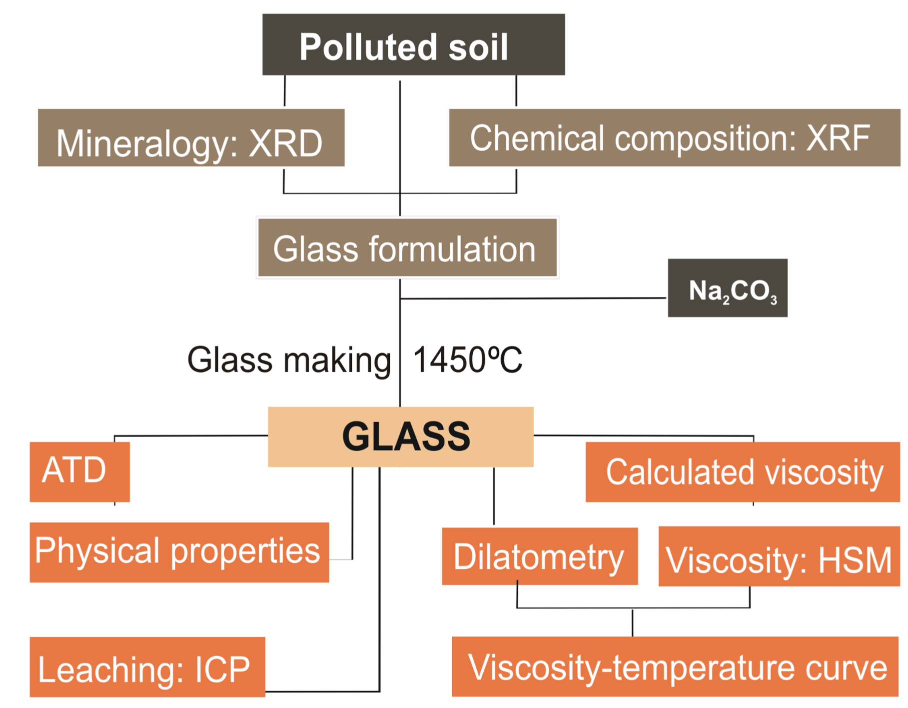

Figure 2. Methodology.

Results & Discussion

Minerals of the soil raw materials are mainly quartz, calcite, albite and illite. The chemical composition of the soil and the formulated glass is in Table 1.

Table 1. Chemical composition, Wt %, of soil (WS9 and glass (G).

	SiO_2	Al_2O_3	CaO	K_2O	Na_2O	Fe_2O_3	MgO	MnO	P_2O_5	ZnO	PbO	LOI
S	40.26	7.16	10.64	1.36	0.58	11.37	1.05	0.10	0.49	0.39	0.13	26.25
G	47.76	8.50	12.62	1.62	13.45	13.49	1.24	0.10	0.59	0.46	0.15	

The DTA of the glass shows the Tg, two exothermic peaks and an endothermic peak (Fig. 3). Mineral phases of glass treated at the peaks temperature are in Fig. 4 and Table 2.

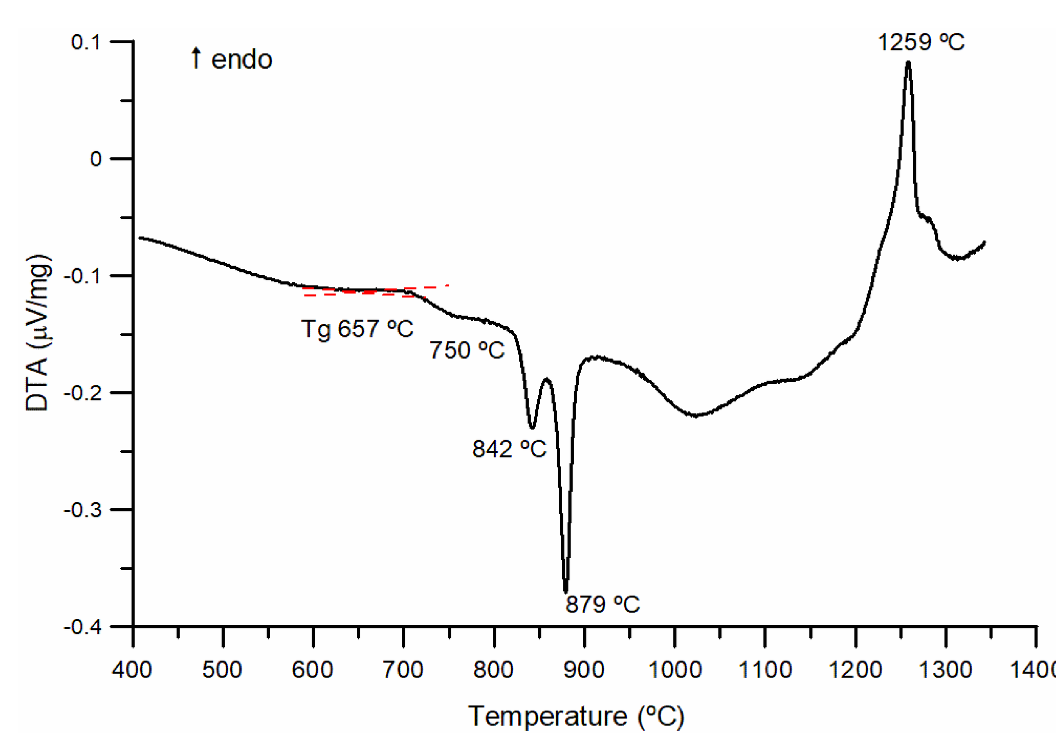

Figure 3. DTA of obtained glass.

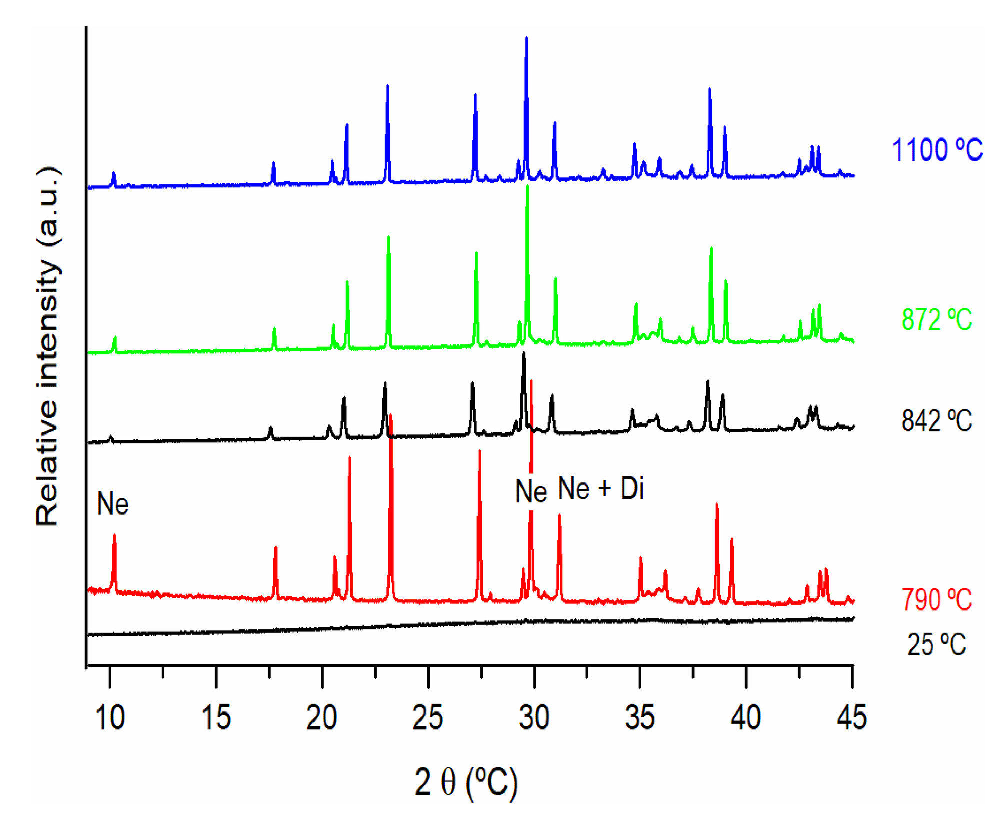

Figure 4. XRD of the glass treated at the temperatures of the DTA peaks.

The dilatometric analysis of glass yielded a Tg and The dilatometric softening point, Td (Fig. 5).

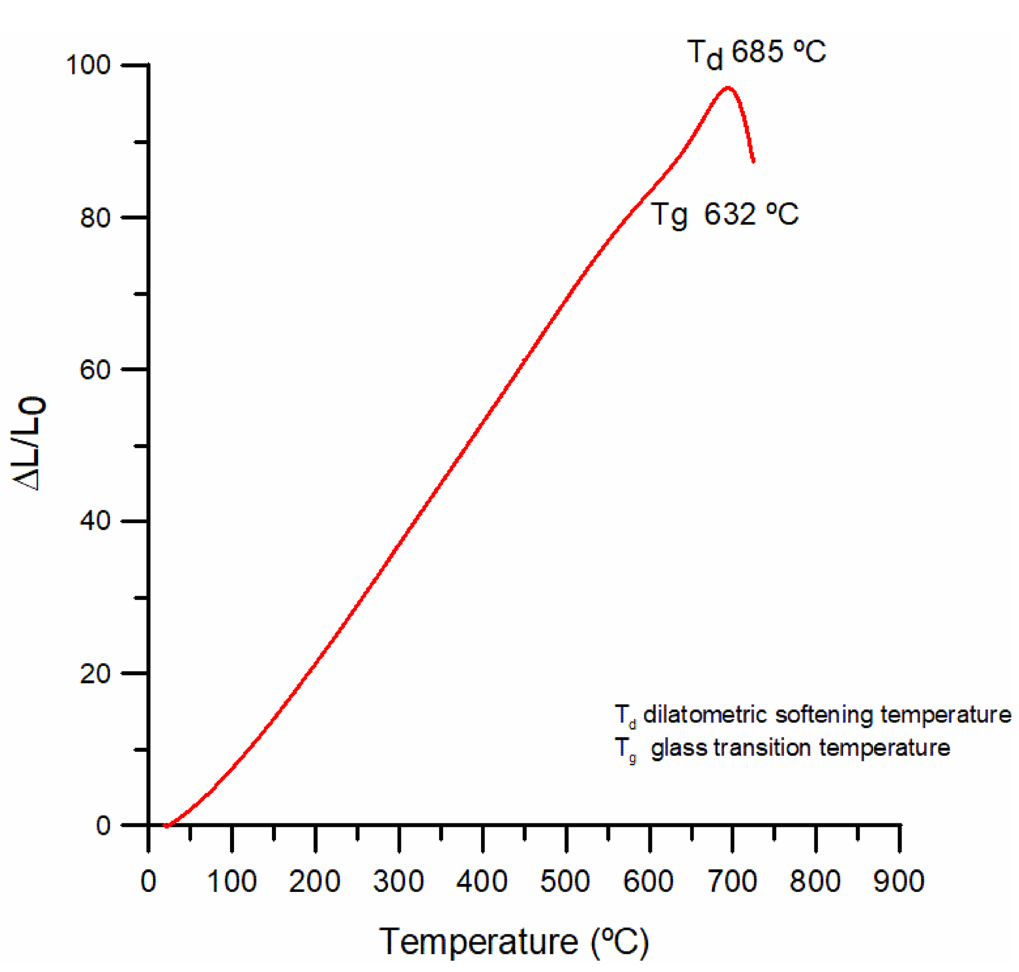

Figure 5. Thermal expansion plot.

The viscosity-temperature curves (Fig. 6) were drawn from HSM results and from the correlation between the fixed points of the known viscosity, the Tg obtained by a dilatometer corresponding to a viscosity of $10^{12.3}$ Pa·s and the Vogel–Fulcher–Tammann eq.

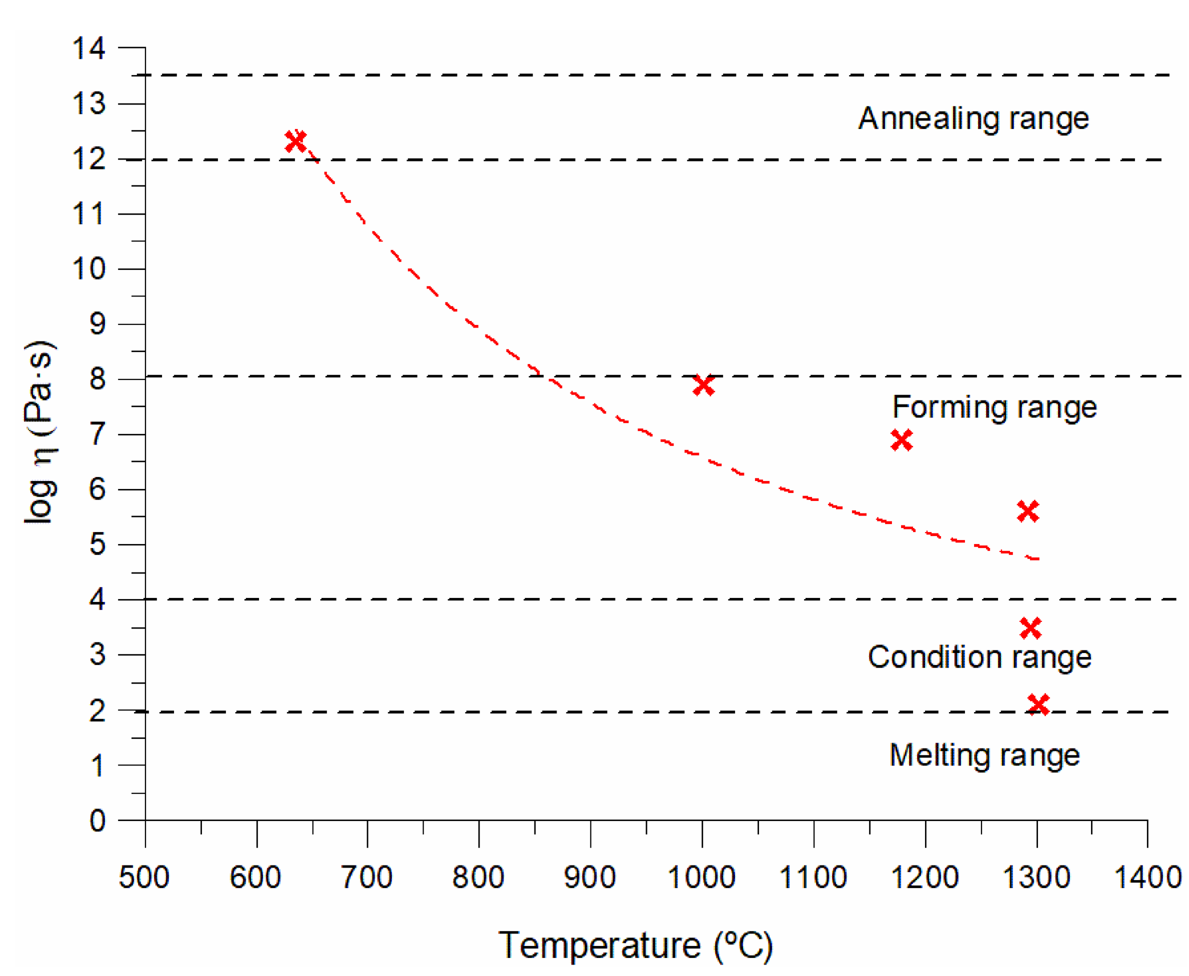

Figure 6. viscosity-temperature curves.

Table 2. Mineral phases of thermal treated glass. Rhönite is $Ca_4[Mg_8Fe^{3+}{}_2Ti_2]O_4\ [Si_6Al_6O_{36}]$.

Treatment	Nepheline	Diopside	Rhönite
790 °C	87	13	
842 °C	82	18	
879 °C	76	6	15
1100 °C	76		24

Some physical properties of the glass are shown in Table 3.

Table 3. Glass physical properties.

Density	2.7 g·cm^{-3}
Refractive index	1.586
Refractometric spectra	Absorption in dark yellow, red and blue
CIELab parameters	L=45, a*= 0, b*=1

The test of leachability of potentially toxic elements from the obtained glasses, determined using the DIN 38414-S4 standard, shows that the concentration of metals is always under the threshold limits established in the standard (Table 4).

Table 4. Chemical composition, in ppm, of glasses, their leachates, and threshold limits (TL) according to the DIN 38414-S4 standard.

	Cu	Zn	Pb	As	Cr	Ni	Cd	Hg
Glass	744	4303	1064	-	96	53	5	-
Leachate	0.006	0	0.0005	0.0001	0.0001	0	0	0.0001
TL leachate	2.00	4.00	0.50	0.50	0.50	0.40	0.04	0.01

Conclusions

The contents of the elements leached from the glass are well below the limits established by the European legislation. Thus, a commercially glass suitable for retaining the contaminants from the polluted soil used was obtained.