EVALUATION OF THE APPLICABILITY OF SLAG AND MINING WASTES FOR PRODUCING GLASS FIBRE

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Introduction

The recycling and management of the by-products of smelting and mining wastes have been received environmental concerns. Australian researchers ranked the sulphide tailing and bauxite residue as firstly and secondly important wastes requiring urgent treatment.[1] Owing to the depletion of high grade gold ore, minable gold concentration in the gold ore has been decreasing. The current concentration of gold in minable gold ore is approximately 3 - 4 ppm,[2] and minable concentration of gold is expected to be lowered in a few decades. The sulphide form in gold ore and the mineralisation of gold tailing result in environmental contamination by releasing of acidic effluents and leaching of cyanide complexes. During the Bayer process, the alumina in bauxite reacts with caustic soda forming soluble sodium aluminate. After filtration, the solid impurities remain as slurry form, and the filtered fine particle is called red mud. The disposed red mud is expected to be increased by three billion tons in 2015.[3] Due to its high alkalinity and heavy metal concentration, the disposal of red mud results in soil and water contamination.

In order to reduce the disposal of mining waste and bauxite residue, various utilising methods have been proposed. Production of raw material for construction and glass-ceramic production have practically succeeded. However, most of the previous studies were focused on the utilisation of each waste. For this reason, the composition and further optimisation of physical properties were limited.

For the flexible compositional optimisation and treating various wastes, four types of mining waste and smelting by-products were utilised in the present study. The ferronickel slag and waste limestone are considered along with gold tailing and bauxite residue for the optimisation of chemical composition in terms of MgO and CaO, respectively. By mixing those four mining wastes and smelting by-products, a novel process for glass fibre production was proposed. In order to verify its applicability, the drawing temperature was determined by viscosity measurements. In addition, the mechanical properties were examined following the standard test

method. Finally, 2-dimensional micromorphology of the glass fibre was investigated by an aid of scanning electron microscope (SEM).

Experimental

The red mud, gold tailing, waste limestone and ferronickel slag were respectively mixed in an appropriate weight ratio. The mixture was ground in an agate mortar in order to obtain the homogeneous mixture.

The viscosity of present system was measured by using the rotating cylinder method. For determining the temperature dependency of the viscosity, the measurement was carried out at every 50 K by decreasing the temperature from 1773 K to liquidus temperature at 5 K/min. After determination of the drawing temperature, the glass fibre was obtained by a drawing process. The physical property of the obtained non-crystalline glass fibre was analysed following the standard test method (ASTM C1557 – 03: standard test method for tensile strength and Young's modulus of fibres). After the measurement of the mechanical properties, the micromorphology of the glass fibre was investigated using SEM.

Results and discussion

Figure 1 shows the viscosity of present molten mixture of various wastes. A negative temperature dependence of the viscosity was observed and the drawing temperature where its viscosity is log 2.5 to 3.0 dPa·s was determined by using the VFT (Vogel-Fulcher-Tammann) equation.[4] The corresponding viscosity in the present study was observed in the temperature range between 1475 and 1525 K.

Following the standard test method, the tensile strength (σ) and Young's modulus (E) were measured. Figure 2 shows the cross-sectional SEM image of the obtained glass fibre following the tensile strength test. By an aid of image processing software, the cross-sectional area was analysed and its tensile strength and Young's modulus were calculated. Table 1 shows the average tensile strength and Young's modulus of the present system.

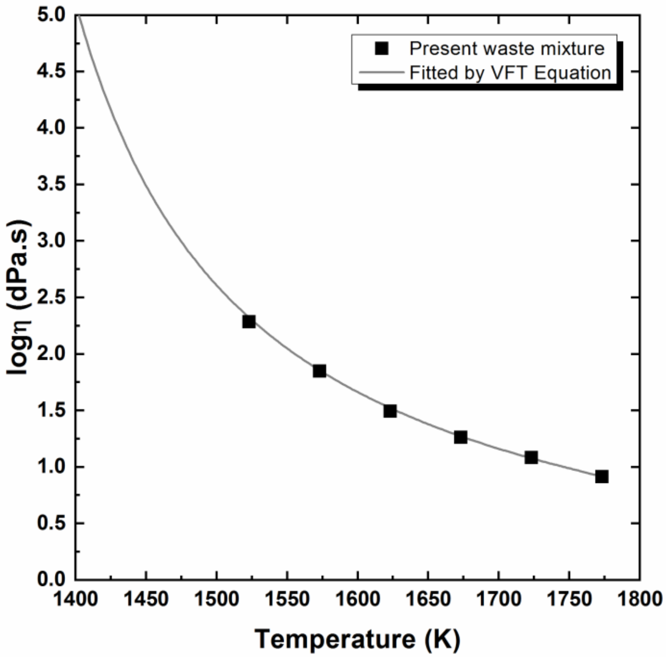

Figure 1: Temperature dependence of the viscosity in the present system and VFT fitting

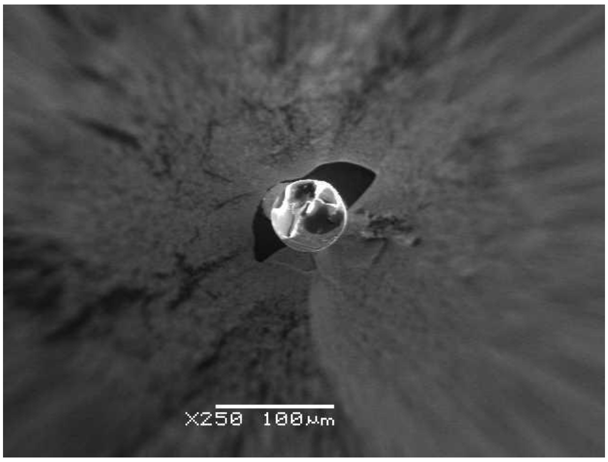

Figure 2: SEM image of the cross-section of the glass fibre surface

Table 1: The average diameter (µm), tensile strength (MPa) and Young's modulus (GPa) of the present glass fibre

	Diameter (µm)	Tensile strength (MPa)	Young's modulus (GPa)
Present system	62.4	447.2	70.7

Although the present tensile strength is much lower than the reported tensile strength of basalt fibre[5], similar Young's modulus[6] was obtained. Considering that the tensile strength is mainly affected by the diameter of the fibre, relatively slow drawing speed in the present study results in the low tensile strength. However, since Young's modulus is not affected by the diameter of the fibre but mainly affected by material characteristics, similar Young's modulus indicates the applicability of the present system for glass fibre.

Conclusions

The utilisation of mining wastes and smelting by-products was suggested for producing glass fibre having similar physical properties as that of continuous basalt fibre. By using rotating cylinder method, the fibre-forming temperature was determined for adopting the down-drawing process. Similar Young's modulus to that of conventional basalt fibre indicates the applicability of present system for continuous glass fibre production.

References

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