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CHARACTERISATION OF PAKISTANI SHEET GLASSES

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A number of glass industries in Pakistan are manufacturing sheet glass. Most of these industries are lacking adequate R&D facilities. Hence no data is available for physicochemical characterisation of their products. In the present study we attempt to characterise three different sheet glasses by determining their viscosities at different temperatures, running differential thermal analysis and analysing the chemical compositions, both by wet and energy dispersive spectrometric analyses.

Key words: Characterisation, Sheet glasses, Viscosity.

Introduction

Like all other industries in Pakistan, glass industry has not appreciated the necessity for creating research and development facilities. Consequently, there is hardly available data for either glass compositions, characteristic temperatures or viscosity-temperature relationships. There may be a number of reasons for the industry that it does not pay attention to them, however, it is doubtless that no improvement in quality can be expected without R&D activities.

In glasses, viscosity-temperature curves play an important role and give many useful information. Firstly, it is helpful for determining characteristic temperatures, such as strain point, annealing point, glass transition, softening and fiber drawing points etc. The viscosity temperature curves also indicate the ease or difficulty with which the process of shaping of glass articles could be carried out.

Differential thermal analysis is another important tool for characterisation of glasses. It is useful for determining the glass transition, crystallisation and liquidus temperatures. Combined with viscosity data (these mutually support and supplement) it is useful for better understanding of the thermal behaviour of glasses.

Chemical analysis of glasses is quite a laborious and time-consuming job besides the hazards of using hydrofluoric acid. Now-a-days, a number of techniques are available which are safe, time saving and easier than the classical method. Energy dispersive spectrometric analysis is one of them.

Experimental

Three sheet glass samples designated as Glass 1 (colourless), Glass 2 (Ambre glass) and Glass 3 (colourless) were collected from the local market. Glass 1 and 2 were produced by Khawaja Glass Industries Ltd., Hasanabdal while Glass 3 was the product of Nowshera Sheet Glass Ltd., Nowshera.

Viscosity measurements. Viscosity measurements were made with Chyo balance a penetration type viscosity apparatus [1]. The instrument has viscosity measuring range of 10^5-10^{14} poises. 1mm diameter penetration needle was used. Temperature range for the viscosity measurement was 600-700°. Appropriate loads on the needle at 600° and 700° were 5kg and 50g, respectively.

Differential thermal analysis (DTA). Differential thermal analysis were carried out with a Shimadzu's DT-40 type apparatus. About 20mg glass powder sample was used. DTA trace was obtained from 20-1000° at a heating rate of 10°/min.

Energy dispersive spectrometric (EDS) analysis. Hitachi S-2700 type scanning electron microscope equipped with Noran EDS was used for the analysis. Bulk glass samples (3x3x10mm) were coated with platinum and analysed by acquiring X-ray spectrum at 25KV accelerating voltage and 12mm working distance. Noran EDS (using beryllium detector) can detect sodium and all other elements heavier than sodium.

Wet analysis. 0.5-1 Gram of powder sample was fused with sodium carbonate and SiO_2, R_2O_3 (R stand for Al, Fe), TiO_2, CaO. MgO were determined gravimetrically according to ASTM [2] and Fe_2O_3 by colour comparison method [3]. Alkalies were estimated separately by flame photometry [4].

Results and Discussion

All the present sheet glasses are basically a soda-lime--silica glass, in which Al_2O_3 and MgO are added to strengthen and to increase thermal tolerance of the glass, respectively. Chemical and EDS analyses of the glasses under investigation are given in Table 1, which shows that Glass 1 and 2 have similar compositions. Also there is not much difference in composition except for higher Fe_2O_3 content in Glass 2. Glass 3 has higher silica, lime and soda content than Glass 1 and 2, however, its alumina content is lower than Glass 1 and 2. Table 1 shows that EDS analyses well agree with wet chemical analyses. A typical EDS spectrum is shown in Fig. 1. (The major peaks are automatically labelled while the minor peaks can be labelled manually).

Figure 2 shows the viscosities of the glasses between 600-700°. The dotted line is drawn from the data taken from the literature [5]. Glass 3 shows the higher viscosity than Glass 1 and 2. Glass 2 possesses the lowest viscosity. The difference of viscosities between Glass 2 and Glass 3 is about an order of magnitude which persists throughout the viscosity range studied. The difference in viscosities may be due to difference in compositions. The higher value of viscosity of Glass 3 may be due to its higher silica and lime content. Low lime content in Glass 2 is probably responsible for its low viscosity.

DTA curves of the three glasses are shown in Fig. 3. The present glasses are expected to be very stable glasses, hence the glass transition points of soda lime glasses are normally difficult to determine from DTA curves because the endothermic peak is not so sharp compared with certain non-silicate glasses [6,7]. Glass 3, however, exhibits quite sharp Tg at 565° which is probably due to some annealing problem.

The main characteristic in the DTA traces is the endothermic peak which starts at about the same temperature (i.e. 660°) for all the three glasses. The effect may be due to the softening of the glass. The downward trend of the DTA curves continued as the temperature ramp up. Evidently, the heat taken up by the glass is used for lowering of the viscosity. Just before the start of this steep downward (endothermic) phenomenon there is a broad exothermic peak in each curve. This may correspond to improved contact of the glass sample to the holder, thus, giving better heat transfer. The first liquidus (T_{L1})

TABLE 1. WET AND EDS ANALYSIS OF PAKISTANI SHEET GLASSES.

	Glass 1		Glass 2		Glass 3	
	Wet	EDS	Wet	EDS	Wet	EDS
SiO_2	70.89	70.75	70.69	70.52	71.64	71.56
Al_2O_3	3.95	4.00	3.84	3.89	1.58	1.62
Fe_2O_3	0.20	0.22	0.35	0.36	0.27	0.26
CaO	6.84	6.79	5.79	5.74	7.59	7.68
MgO	3.90	3.92	4.07	4.17	2.16	2.20
Na_2O	14.20	14.22	14.85	14.88	16.45	16.50
K_2O	0.12	0.10	0.41	0.38	0.19	0.18

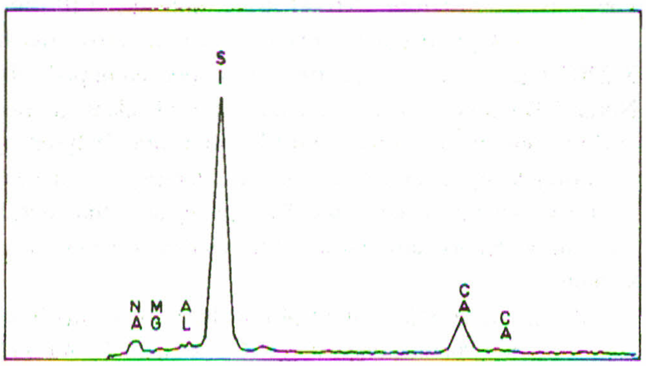

Fig. 1. EXEC (7-D) Glass 3.

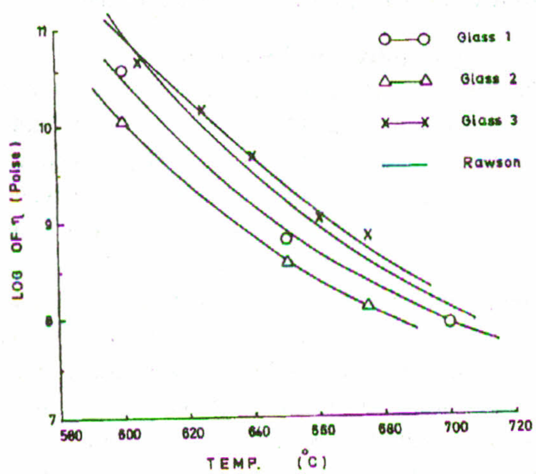

Fig. 2. Viscosity temperature relationship of different Pakistani sheet glasses.

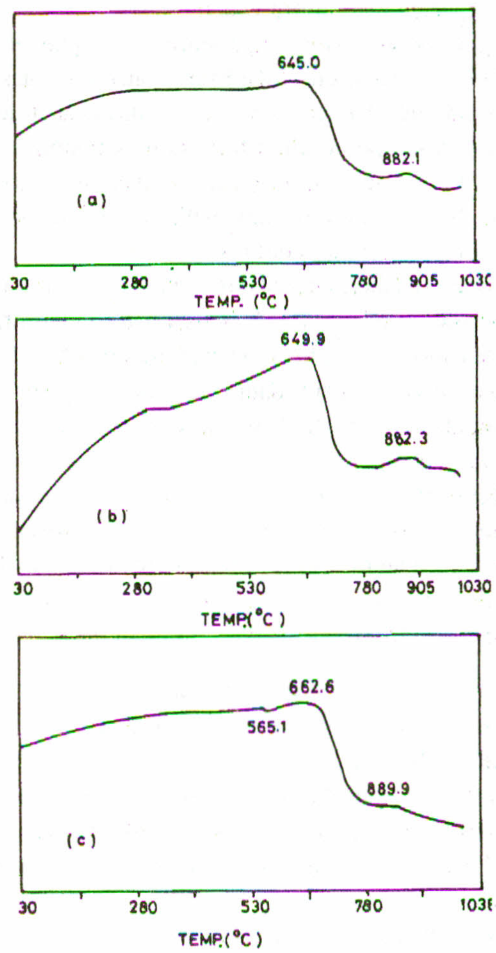

Fig. 3.

in Glass 2 lies at about 800° whereas in Glass 1 and 3 it lies at 834 and 840°. Except for Glass 3, other two glasses show another exothermic peak at 882°. At about 980° there is another minima in the curve for Glass 1, which may be regarded as second liquidus (T_{L2}). Same trend can be seen in Glass 2, however, the minima may be observed at higher temperature (over 1000°). No such trend is observed in Glass 3. As DTA temperature range was restricted up to 1000° it is difficult to determine the true liquidus temperature, however, keeping in view the compositions of the glasses it should not be far from T_{L2}.

Data in Fig. 2 is also used to determine the activation energy of viscosity for these glasses by using Arrhenius equation. Due to small range of temperature it was possible to obtain straight lines. The activation energy for viscosity for Glass 2 and 3 are about 100 Kcal/mol while for Glass 1 it is about 116 Kcal/mol. These values are comparable with the literature value [8].

Conclusion

Three sheet glass samples were characterised by using viscosity apparatus, DTA, SEM equipped with EDS and wet chemical analyses. It was found that:

(i) Glass 1 and 2 have similar compositions, and difference in viscosities. This may be due to the thermal history of the glasses.

(ii) Glass 3 has higher silica, lime and soda content than Glass 1 and 2 while alumina content of the former is much less than the later.

(iii) Glass 3 has higher viscosities than Glass 1 and 2 (closer to literature value), however, it has sharp T_g which indicates some annealing problems.

(iv) Without characterisation of materials, it is difficult to guarantee the quality of products. Early realisation of this important aspect will not only improve the quality but also help the industry to meet the challenges of 21st century. Fortunately facilities are available in the country to undertake such studies.

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