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STUDY OF LEAD GLASS TABLEWARE COMPOSITIONS FOR HIGH SPEED OPERATING MACHINES

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Lead glass batches Nos. 2 and 3 containing 7-14.8 PbO% are fit for automatic machine production. These can yield high productivity at a lower cost. Glass No. 1 containing 29% PbO because of slow setting is suitable for pot melting. Properties such as density, refractive index, specific heat and the temperature corresponding to viscosity value 10^{13} poise have also been studied.

INTRODUCTION

The glass which is defined as a material of infinite relaxation time finds use in every walk of life. Its artistic nature has been accepted from times immemorial. The first tableware articles were made from soda-lime-silica glass. The colour of these tablewares due to over-decolourisation and presence of excessive iron was dull. Slowly low melting lead glasses, produced in clay pots, became very popular in the tableware industry. The cut pieces of the old Bohemian lead glass earned a name for themselves. The tablewares made from the Czechoslovakia crystal glass had no match the world over. Due to their very long setting rate these crystal glasses could not be produced on automatic plants. In the present study two low lead compositions and one similar to the Bohemian glass composition are investigated and their properties are also determined.

EXPERIMENTAL

Melting of glasses. The chemical contents of washed graded silica sand and limestone used in the present studies [1] are given in Table 1. Soda ash, lead oxide, potash and other chemicals were almost free of iron oxide. The glasses were melted in malachite clay pots specially prepared for melting lead containing glasses. Glass melting temperature was kept at 1400^{o}. The proofs were taken from time to time till the glass was free of seeds. The temperature was then gradually lowered to 1100^{o} and small rods were fabricated for the measurement of thermal expansion, density, refractive index and the temperatures corresponding to viscosity values of 10^{13} poise. The glass rods were annealed at 535^{o}C in an electric furnace. The annealing was checked by a strain viewer using polorized light. The rest of the glass in the pot was left in the furnace to cool down to room temperature. The clay crucible was broken and the annealed solidified glass was cut to make prisms of various sizes.

Determination of the Properties of Lead Glasses. The density of the glass was determined by the Archimedes principle. The specific heat of all the glasses studied was calculated by the equation [2] $C = (t\ \Sigma a_i\ P_i + \Sigma C_i\ P_i)/(0.00146\ t+1)$ where P_i is the weight fraction of oxide in the glass and a_i and c_i are known as coefficients in the temperature range, 0-t . The refractive index was determined by the immersion method [3] and the temperature corresponding to viscosity 10^{13} poise calculated by plotting $\frac{\Delta \ell}{\ell}$ against temperature where $\Delta\ell$ is change in length of a glass rod ℓ is the original length of glass rod as used in the thermal expansion determination.

RESULTS AND DISCUSSION

The results of the chemical analysis of the Daudkhel sand and Pampokha limestone are given in Table 1. The iron contents of sand and limestone samples are 0.025 and 0.07 % respectively. Percentages move than 0.045 % of Fe_2O_3 of lead glasses produce a yellowish green tint in them. The materials selected fall within the limit and the clear white product is obtained by their incorporation in glass batches [3].

Selective batch composition of three lead glasses is given in Table 2. The chemical analysis of glass No. 1 as calculated from the batch is SiO_2, 56.2; PbO, 29; CaO, 2.0%; K_2O, 13.0? and AS_2O_3, 0.3 (wt%). This is a typical composition of modern crystal glass suited to Pakistan raw materials. The above composition also resembles the old Bohemian lead glass which was known for its transparency,

Table 1. Chemical composition and physical characteristics of commercially exploited glass sand and limestone

Chemical constituents (wt%)	Sand (Daudkhel) 100-500 microns	Lime-stone Pampokha-Swat)
I/L	0.20	44.00
SiO_2	99.56	0.18
Al_2O_3	0.24	0.14
Fe_2O_3	0.25	0.007
CaO	0.05	55.60
MgO	0.02	0.23
% Retained on Tayler mesh No. 100-500	85 %	-
Bulk density lb/ft^3	103	-
Colour	-	White with patches of grey colour.
Texture	-	Medium to fine grained
Minerals	--	Traces of apatite and quartz.

brilliancy and dispersion. The chemical composition of Bohemian glass was SiO_2, 53.5; PbO, 34.49; and K_2O, 12.02 (wt%). Chemically this is a lead potash glass and produces a peculiar ring when struck. It can be seen that the percentage of PbO in the old Bohemian glass is 5% higher than that of glass No. 1. The replacement of 5% PbO in the old Bohemian glass by SiO_2 and CaO reduces the cost of production of modern crystal glasses.

Glass containing 29% PbO can be fabricated without crystallisation to any intricate shape. Due to its low specific heat and slow setting nature it cannot be produced mechanically on fast operating machines. Heavy demand for crystal glasses, labour unrest, air pollution, escape of volatilised PbO along with flue gases into the atmosphere, and other factors have forced the crystal industry to research for the alternative. Nowadays better methods of beneficiation of raw materials have simplified the task of the glass chemist to modify glass compositions according to requirements. Brilliancy and freedom from colour are also now achieved by increasing silica ($Fe_2O_3 \leqslant 0.025$) at the expense of PbO. Glass batches No. 2 and 3 shown in Table 2 have been developed by increasing silica and soda ash at the expense of lead oxide and potash. This replacement not only decreases the cost but also makes the glasses to melt congruently and worked on the automatic machines. The chemical contents of glass No. 2 given in Table 2 are SiO_2, 67.2%; PbO, 14.8; CaO, 0.9; Na_2O, 9.5; K_2O, 7.1; and AS_2O_3, 0.5 (wt%). The lead contents of this particular glass places this glass between lead and soda lime container glasses. This glass has good brilliancy as lead potash crystal glasses and because of its increased specific heat can be worked on automatic machines. These facts are supported by the results given in Table 3. Glass No. 2 has as good a brilliancy and transparency as glass No. 1 containing 29%.

Table 2. Batch compositions of lead glasses

Material specifications	1	2	3
Sand	1000	1000	1000
Red lead	507	226	100
Limestone	–	24	49
Soda ash	47	231	288
Potash	282	155	93
Sodium nitrate	15	13	12
Arsenic	8.5	7.4	7.0

Further increase of silica and soda ash at the expense of lead oxide and potash yields glass No. 3 is as given in Table 2. The percentage lead oxide of this glass is only 7%. This glass has good shine and brilliancy. This is better than soda lime silica container and slightly lacks the shine of glass Nos. 1 and 2. This can be overcome by the proper adjustment of decolourisers. The results of the density, refractive index, specific heat and the temperature corresponding to a viscosity values of 10^{13} poise of glass No. 1 are given in Table 3. The density and refractive index values

Table 3. Properties of the lead crystal glasses as a function of composition

	1	2	3
Lead oxide (%)	29.0	14.2	7.0
Density g/cm^3	3.0998	2.5990	2.5472
Refractive index	1.558	1.534	1.520
Specific heat (Cal $g^{-1}C^{o-1}$) Temperature 0-600^o (^{o}C)	.2417	0.2722	0.38104
Temperature corresponding to viscosity value 10^{13} poise	470	480	510
Visual examination	Colourless brilliant shine	Colourless brilliant shine	Colourless brilliant shine.

of 3.0998 g/cm^3 and 1.588 respectively show that this is a particular composition of cut crystal glass and conforms to the British Standard Specifications [5]. The low values of specific heat (0.2417) and the temperature corresponding to viscosity value of 10^{13} poise indicate that this is a long working range glass and loses its heat contents very slowly. In view of the low specific heat, the glass can be worked manually. Glass No. 2 because of its high specific heat can be worked on fast operating machines.

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