Corrosion Characteristics of SiO_2-Al_2O_3-CaO-MgO Glasses

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Introduction.—Preliminary to the recent work on the rock wool resources of Illinois carried out in the Geological Survey laboratories[1], a series of four component (SiO_2-Al_2O_3-CaO-MgO) silicate melts were prepared, utilizing the pot fusion method of Peddle[2]. An accurate investigation of glass, as shown by Morey[3] and others[4], requires the use of platinum apparatus, but the work is slow because only one sample can be prepared at a time. Peddle has demonstrated, however, that much useful information on glass characteristics can be obtained from glasses prepared by fusion of batch mixtures in clay pots[2]. As an initial step toward a more thorough and accurate investigation, the clay pot fusion method can be said to embrace practical advantages, as it is possible by such means to prepare more glasses simultaneously, and these in larger quantities, than is allowed by the high cost of large platinum ware, and the small size of crucibles usually available.

The chief difficulty encountered in the pot fusion method is the corrosive effect of certain batch compositions on the pot, a condition which of course disturbs radically the original composition in the finished melt. Pot corrosion is a function principally of three interrelated factors: (1) phase equilibrium relationship involving the components in the batch and pot; (2) viscosity of the melt of the original batch composition and the change in viscosity with change in melt composition due to corrosion, and (3) the duration of time that the melt is kept in a fluid condition. The porosity of the pot and surface tension of the melt are additional factors in the corrosion process. Our data can be discussed to only a limited extent on a basis of above factors because phase equilibrium data on the four-component system under discussion are not as yet complete in the literature, and all the melts were prepared under the same conditions and hence depart from true equilibrium in different degrees. Some observation on a basis of viscosity is afforded, however, as some of the original batch compositions studied were similar to the composition of certain basic slags utilized in viscosity studies by McCaffery[5] and his co-workers.

We have found, as a result of preparing a great number of silicate melts of the system cited, that batches containing in excess of 70 per cent $SiO_2 + Al_2O_3$, or in excess of 1.15-1.20 gram mols $SiO_2 + Al_2O_3$ per 100 gm. batch, can be melted in fireclay pots without excessive corrosion.

Experimental procedure.—Batch compositions were compounded from the raw materials (silica, aluminum hydroxide, calcium carbonate and magnesium carbonate) to give one kilogram of raw material per sample. Following thorough mixing, the samples were moistened with distilled water and packed tightly into fireclay crucibles (3 ½″ top diameter by 5 ½″ high), excess sample being discarded. After drying, the crucibles were transferred to a gas-fired kiln, fired to 1375° C, which temperature was maintained constant for two hours. After cooling for 20 hours the kiln was opened, the crucibles were drawn, and the melts were examined visually and analyzed quantitatively.

Experimental results.—Chemical analyses revealed that corrosion was excessive only in those samples containing less than 70 per cent silica-plus-alumina and that the corrosion varied fairly regularly with the silica-plus-alumina content (Table I).

TABLE I.—CRUCIBLE CORROSION AS A FUNCTION OF BATCH CONTENT OF SILICA-PLUS-ALUMINA

Batch content $SiO_2 + Al_2O_3$ per cent	Analyzed content $SiO_2 + Al_2O_3$ per cent	A. D. of analyzed $SiO_2 + Al_2O_3$ content per cent	Number of samples analyzed
70	71.7	± 0.9	17
65	68.1	1.3	19
60	65.8	2.0	19
55	65.3	3.1	15
50	64.7	2.3	7
45	65.9	3.4	6
40	68.4	...	1

Expressing extent of corrosion as a function of batch silica-plus-alumina on a mol basis indicated that samples containing in excess of 1.15-1.20 gram mols per 100 gms. of melt can be prepared by the pot fusion method without disturbing the originally desired composition radically.

Some few of the glasses prepared were of such composition that the viscosity both of the melt of batch composition and the melt of changed composition due to corrosion could be compared in a general way on a basis of the viscosity studies of basic slags by McCaffery and co-workers[5].

Such a comparison taking into consideration the other factors influencing corrosion, indicated the nature of the influence of viscosity. A low viscosity for a particular batch composition does not necessarily imply that excessive corrosion will take place; if that particular glass composition is saturated with those components which it might dissolve from the pot, it can exhibit a low viscosity and still be comparatively non-corrosive. It is in those instances in which the original glass is unsaturated with respect to components of the pot that viscosity and time are factors of great magnitude. If in such a case the viscosity of the original melt is low and the duration of fusion long, corrosion approaching thermal equilibrium for the components of the pot and melt at the temperature employed will take place.

In conclusion it should be pointed out that while the use of platinum ware is certainly essential to the accurate investigation of such glasses, the batch process, utilizing fireclay pots for melting is of definite worth in the preliminary evaluation of silica-alumina-lime-magnesia glasses of certain restricted compositions as herein described.

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