Available online at www.sciencedirect.com
ScienceDirect
Journal of the European Ceramic Society 31 (2011) 715–721
www.elsevier.com/locate/jeurceramsoc

Corrosion behavior of ZrO_2–SiO_2–Al_2O_3 refractories in lead silicate glass melts

Rafi Ali Rahimi [a,*], Ali Ahmadi [a], Saeid Kakooei [a], S.K. Sadrnezhaad [b]

[a] Material Research School, Nuclear Science & Technology Research Institute (NSTIR), Atomic Energy Organization of Iran, Rajaei Shahr, Karaj 31485-498, Iran
[b] Department of Materials Science and Engineering, Sharif University of Technology, P.O. Box 11365-9466, Tehran, Iran

Received 3 November 2010; accepted 24 November 2010
Available online 21 December 2010

Abstract

High-temperature (1200–1350 °C) corrosion of fused-cast ZrO_2–Al_2O_3–SiO_2 (ZAS) refractory contacting lead silicate glass melt (LSG) containing 68.5 wt% PbO was investigated by scanning electron microscopy (SEM), energy dispersive spectroscopy (EDS), differential scanning calorimetry (DSC), x-ray diffraction (XRD), thickness measurement and Archimedes density measurement. ZAS durability was improved by baddeliyete content and deteriorated with open porosity proportion, corundum percentage and eutectic mixture presence. Diffusion of lead resulted in fusion-temperature lowering of the glassy layers embedded within the ZAS particles. Heating caused viscosity drop across the interface, loosening the inter-connected refractory particles and disrupted the crystalline particles residing adjacent to the refractory exterior. Among three ZAS refractories tested in this research, the most durable material was the one with the utmost baddeliyete amount, the least open porosity and the minimum eutectic mixture.

Keywords: ZAS refractory; Corrosion; Lead silicate glass; Diffusion; Glassy phase

1. Introduction

Glass melting tanks require durable refractories resistant to corrosive attack, thermal shock and creep conditions together with small thermal conductivity and controllable thermal expansion coefficient.[1–7] The rate of corrosion reactions that may occur between the refractory and the liquid phase depends on the temperature of the glass melting tank, composition of the melt and porosity of the solid phase. Fused cast ZrO_2–Al_2O_3–SiO_2 (ZAS) refractories are superior because of low porosity, interconnected corundum–baddeleyite particles and interstitial glassy phase.

Lead silicate glass (LSG) has versatile applications in different areas from radiation protection, video-screen manufacturing and glass electrode production to the ophthalmic biotechnology and life science. The lead content of the glass increases the fluidity of the melt and the corrosion rate of the refractory. Difference in constituent chemical potentials of the LSG and the ZAS embedded glass layers produces the driving force for migration of the elements to achieve equilibrium. The migration rate depends on the chemical potential gradient and the binding strength of the elements to their neighbors. Alkali, lead and alkaline earth elements have, for example, small obstacle to the migration. Diffusion of these elements across the interface produces a glassy layer which differs in composition with the ZAS glassy phase and slows down the migration of the diffusing elements.[5–11]

Corrosive effect of the lead silicate glass on refractories has been the subject of many investigations. Pavlovskii et al.,[12] for example, have studied the corrosion of corundum, mullite–corundum and mullite in different lead silicate melts. Corundum offered highest resistance to corrosion in all glass melts; while enhancement of silica decreased the resistance. Duvierre et al.[2] investigated the significance of using the ZAS refractories for production of lead crystal glass. They compared the quality of the glasses produced using both alumina–silicate and the ZAS and found that the ZAS met the present and the future quality requirements of the crystal manufacture. Sedlacek

* Corresponding author. Tel.: +98 261 4464088; fax: +98 261 4464088.
E-mail addresses: rrahimi@nrcam.org (R.A. Rahimi), aahmadi@nrcam.org (A. Ahmadi), skakooei@nrcam.org (S. Kakooei), sadrnezh@sharif.edu (S.K. Sadrnezhaad).

0955-2219/$ – see front matter © 2010 Elsevier Ltd. All rights reserved.
doi:10.1016/j.jeurceramsoc.2010.11.022