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Evaluation of behavior of fining agents in glass melting process

Masataka Kawaguchi

Nippon Electric Glass Co., Ltd., 7-1, Seiran 2-Chome, Otsu, Shiga 520-8639 Japan

mkawaguchi@neg.co.jp

Glass defects such as bubbles, stones and cords are sometimes found in glass products and they lead toan increase ofthe rejection rate. Accordingly, it is very important to know the origin of them and how to remove them from glass to keep making the glass productswith high quality.

The process that bubbles are removed from molten glass is called "fining". Generally in the fining process, bubbles rise in molten glass to the surface according to Stokes' law and burst at the surface. Since growth of the bubbles is very effective to facilitate the fining, a small amount of chemicals called "fining agent"isusually added to glass forming batch.Several fining agents are known, such as sodium sulfate, redox oxide and sodium chloride. The common function of them is to release fining gas during the fining process and to expand the bubbles.

There are three general mechanisms ofthe fining agent behavior as shown in Table 1. Sodium sulfate decomposes and releases sulfur dioxide and oxygen upon heating. It is popularly used for soda-lime silicate glasses. Redox oxides including As_2O_3, Sb_2O_3 and SnO_2 release oxygen upon heating through the reduction reaction.Theyare used mainly for specialty glasses. Sodium chloride vaporizes upon heating and itis used especially for borosilicate glasses.In each case,understanding the temperature range where each fining reaction takes place and reflecting the temperature range on a practical production are very important. Some investigations were carried outfor the understanding, using gas analysis, voltammetry, redox titration, in-situ observation of molten glass, and so on. The evaluation methods and the results are shown in this paper.

Table 1. Fining agents used for glass manufacturing

Mechanism	Fining agent	Reaction	Temp. [°C]
Thermal decomposition	Na_2SO_4	$Na_2SO_4 \rightarrow Na_2O + SO_2\uparrow + 1/2 \cdot O_2\uparrow$	1400～
Reduction reaction	Sb_2O_3	$Sb_2O_5 \rightarrow Sb_2O_3 + O_2\uparrow$	～1400
	As_2O_3	$As_2O_5 \rightarrow As_2O_3 + O_2\uparrow$	1200～1700
	SnO_2	$SnO_2 \rightarrow SnO + 1/2 \cdot O_2\uparrow$	1500～
Vaporization	NaCl	NaCl in melt → NaCl (gas)↑	1420～