Chemical Composition of Container Glass

Material: Recycled Glass

Issue: *Understanding the chemical composition of container glass is critical to recycling for a number of reasons. First, the chemistry has significant implications for managing the behavior of molten glass in any remelt application, from large-scale container manufacturing down to cottage-industry pressed glass. Second, the composition has important implications for evaluating health concerns related to glass handling, such as free silica content (see* Analysis of Glass Dusts *Best Practice). In addition, product manufacturers are required to produce Material Safety Data Sheets (MSDS) which describe chemical composition and special handling precautions. Finally, the chemistry is important in determining the compatibility of glass with new and novel secondary uses.*

Best Practice: More than 95% of all manufactured glass is made from sodium oxide, calcium oxide, and silicon dioxide, commonly referred to as a soda-lime-silica composition. Due to universal similarities in manufacturing techniques for glass containers, particularly the viscosity requirements of high-speed "press and blow" production equipment, the chemical formulations of glass food and beverage containers have relative uniformity and compatibility. Container glass is formulated to set up quickly and to hold its shape when mechanically blown into molds. A random mix of container glasses is anticipated to be relatively homogenous, provided there are no significant contamination levels.

The principle element of container glass, silica, refers to a naturally occurring mineral consisting of silicon dioxide (SiO_2). The majority of silica occurs as quartz, a crystalline form of SiO_2. Crystalline forms of silica, also known as "free" silica can contribute to causing certain lung diseases under conditions of prolonged exposure to airborne particles. While SiO_2 is a primary ingredient in the manufacturing of bottle glass, when glass is formed, the crystalline structure is changed to an amorphous structure and the SiO_2 is no longer considered crystalline.

Table: Typical Chemical Composition of Container Glass:

Oxide	Weight % Range	+ / -
SiO_2	66-88	1.00
Al_2O_3	0-7	0.50
CaO	0-15	0.50
MgO	0-5	0.50
Na_2O	8-18	0.50
K_2O	0-4	0.50
Fe_2O_3	< 0.5	0.05
Cr_2O_3	< 0.1	0.02
SO_3	< 0.2	0.02
All other oxides	< 0.1	0.02
C	< 0.1	0.02

Source: CBOT Recyclables Exchange

The function of soda ash content in container glass formulations is to lower the fusion point of the silica sand and improve workability of the glass at moderate furnace temperatures. Lime is included in an amount sufficient to adjust the viscosity and increase durability of the finished glass. With the development of increasingly rapid manufacturing machinery, soda content has been lowered and lime increased, as shorter working times are required. There has also been economic motivation to reduce soda contents, as it is the most expensive major ingredient in glass.

The addition of post-consumer cullet to raw materials promotes rapid melting of the batch, lowering energy requirements. However, after one or more reheatings, the dissolved gases and the volatile alkalis in the cullet are driven off, making it necessary to add chemicals to the mix in order to reinstate lower viscosity and improve working characteristics.

Coloring agents are a minor constituent in container glass, but can effect chemical compatibility and furnace performance during remelting. Amber bottle glass is produced with a sulfur-iron colloidal solution, under reducing conditions. Green and clear glass are produced in oxidizing reactions with small amounts of Cr_2O_3 dissolved in the glass. These are general guidelines. Of domestic container production, 63% is clear, 23% is amber and 13% is green, but varies significantly geographically and seasonally.

Implementation: While major variations in the chemical formulations of container glass are not anticipated, the composition of specific post-consumer sources of container glass should be periodically tested to confirm the actual chemical composition. It is especially important to understand the chemical nature of soda-lime container glass during the development of alternative uses.

Benefits: For many uses of recycled glass, including remelt applications and abrasive blasting grit, knowledge of the chemical composition of the post-consumer glass cullet is critical to accessing end-use markets. In remelt applications, this information provides the basis for evaluating color modification potential (see *Color Modification of Post-Consumer Recycled Glass* Best Practice). In industrial mineral applications, this information is important to assess glass's compatibility with the chemistry of the industrial process.

Application Sites: Glass beneficiation facilities, glass container and fiberglass insulation manufacturing facilities, studio glass shops.

Contact: For more information about this Best Practice, contact CWC, (206) 443-7746, e-mail info@cwc.org.

References:

CBOT Methods for Sampling and Testing Glass Cullet, Clean Washington Center, 1996.
CBOT Recyclables Exchange Literature, www.cbot-recycle.com, September 1996. *Post-Consumer Glass Cullet Remelting Process Assessment*, Clean Washington Center, 1996.
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