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BOT-500
Irradiated Antique Bottles

Why do the Irradiated Glass Bottles turn Purple?

Glass manufacturers often need to produce a clear glass or maintain a consistent tint in their glass. One of the raw materials used to make glass is sand (SiO_2 source), which can contain up to 0.1% Fe_20_3. Iron imparts a color to glass depending on the oxidization state. Ferrous iron (Fe^{2+}) produces a blue color of high molar absorptivity whereas ferric iron (Fe^{3+}) produces a low intensity yellow-green. Iron in glass at standard glass production temperatures will be approximately 80% Fe^{3+} and 20% Fe^{2+}. Glass manufacturers reduce the high intensity ferrous iron blue color by using chemical or physical decolorizing methods. Chemical decolorizing agents such as manganese, cerium, and arsenic oxidize the Fe^{2+} to Fe^{3+}. Physical decolorizing agents such as selenium, cobalt, nickel, and neodymium produce a complimentary color to neutralize the iron color.

Manganese was the preferred decolorizing agent for early glass manufacture but has been replaced by other decolorizing agents. Since manganese removes the dirty color of iron, it was called "glassmakers soap". It is common to find clear class that has turned purple by exposure to sunlight (solarization) in antique bottles and glass insulators. Now let's look at the chemical reactions involving manganese and iron in glass. First you need to know that Mn^{3+} produces a violet or purple color in glass and Mn^{2+} is non-coloring or clear. In the decolorizing process Fe^{2+} is oxidized by Mn^{2+}: $Fe^{2+} + Mn^{3+} \rightarrow Fe^{3+} + Mn^{2+}$. The following occurs during solarization: (1) $Mn^{2+} + h\nu \rightarrow Mn^{3+} + e^-$ (2) $Fe^{3+} + e^- \rightarrow Fe^{2+}$ where $h\nu$ is energy supplied by sunlight or irradiation. In theory, heating the glass to temperatures near the glass softening point (~500 °C) can reverse the solarization process.

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