

# Glass

Mesopotamia is thought to be the cradle of glass making. A site approximately 3,500 years old has yielded the earliest glass fragments known. Glass is a silica based material with a amorphous structure. Ideally glass contains approximately sand or silica ( $\text{SiO}_2$ ), alkali oxides soda ( $\text{Na}_2\text{O}$ ) or potash ( $\text{K}_2\text{O}$ ) (potassium carbonate in the past derived from wood ash) and a flux an alkaline earth such as lime ( $\text{CaO}$ ). Soda-lime glass has been the most common glass throughout history. The higher the silica contents the higher the melting-point, therefore harder to work with, it is very hard and resists high temperatures (1,000–1,500 °C). An increase of soda or potash disrupts the silica network and lowers the working temperature.

Antique glass containing sodium or potassium can be susceptible to humidity. Sodium and potassium exposed on the surface can react with carbon dioxide from the atmosphere and turn into sodium carbonate and potassium carbonate, both of which are extremely hygroscopic. At a relative humidity of 40 % and above, drops of moisture appear on the glass (weeping glass) leaching out the sodium and potassium and leaving behind only the hydrated and porous silica. This can result in the glass having an iridescent, crazed, pitted or flaking surface. In glass produced after the 18th century, this effect is not commonly encountered.

## Handling

Glass with an iridescent or fragile surface should not be handled with cotton gloves, since the fibres can entangle with the surface and cause more damage. It is best to handle this kind of glass with non-powdered nitrile gloves.

It is also pertinent to remove rings and watches, since the hard metal can chip, scratch or crack some ancient glass.

As tempting as it is, do not handle objects by projecting elements such as spouts, handles or rims. These areas are very vulnerable and should there be a previous restoration, the likelihood of weak bonds failing catastrophically is high.

In cases of inappropriate handling, small faults such as hairline cracks can open further and cause disintegration of the artwork. Always use both hands, and then only hand-carry pieces over short distances, place them in padded boxes and use trolleys whenever possible.

## Display

Effective illumination of glass objects is notoriously difficult. When lighting glass, the light source should not heat up the glass. Old restorations usually done with epoxy resins might discolour due to high light exposure.

The relative humidity of the showcase should not exceed 40 % when the glass shows signs of crazing (crizzling) or iridescence. Archaeological glass is best kept at a stable relative humidity 40–50 %.

## Maintenance

The surface of modern glass can be dusted with a longhaired brush. It has to be ensured that the metal ferrule around the base of the bristles is protected with masking tape, so as not to risk scratching the surface of the glass.

It has sometimes been recommended to use compressed air from an aerosol-can; however, like the brushing; this has to be done with caution, since it can easily dislodge loose fragments on antique and damaged glass.

Dusting of antique glass with a cloth is not recommended. The cloth can catch on parts of damaged glass or chips and further harm the surface.

Washing of glass should be left to an experienced conservator. Since the acidity of some waters can cause problems with antique glass surfaces.

## Packing and Storage

Packaging for transit or storage is best done by professional art-handlers. The packing materials need to be inert to prevent damage due to off-gassing of harmful substances such as acids. The acid can damage the alkaline in the surface of an antique glass.

To ensure safe transport, always check the condition of the glass in advance.

Then acid-free paper is wrapped around the body. No tape is to be used in the first layer of wrapping. Then a double layer of bubble wrap is to be wrapped

around the body. The bubbles have to face each other, to minimise the pressure points. The piece is then placed into a crate (one made of inert plastic is best). The crate is padded with shock absorbent polyethylene foam to secure the object against shock.

Old and antique glass is best stored in a relative humidity under 40 %. Modern glass can be stored at a relative humidity of 45–55 %. Temperature of storage should not exceed 20–25 °C. Higher temperatures will accelerate the ageing of old restorations.

## **Conservation and Restoration**

Glass can be easily damaged during handling and transport. In the past cyanoacrylates and nitrocellulose adhesives have been used to repair the damage; however these adhesives do more damage than good. They can creep into cracks or crazes and cannot be removed any more. Due to ageing, they diminish in coherence and yellow.

Today, a conservator will use specially developed epoxy resins to join the fragments or fill the missing areas. These epoxies are less susceptible to yellowing than earlier adhesives. The resins are usually colour matched with pigments and the resulting restoration is usually hardly visible. However, it has to be added that an adhesive such as an epoxy in a crack or in a porous or delaminating surface, cannot be reversed. Therefore acrylics are more suitable for archaeological materials. Surfaces that delaminate should never be impregnated with any kind of synthetic material by a non-specialist, since it is very difficult if not impossible to remove these materials (Figs. 1, 2 and 3).

## **Testing and Analytical Methods**

### **Microscopy:**

Low-power microscopic observation can show inconsistencies in wear and tear, plus any old or new damage.

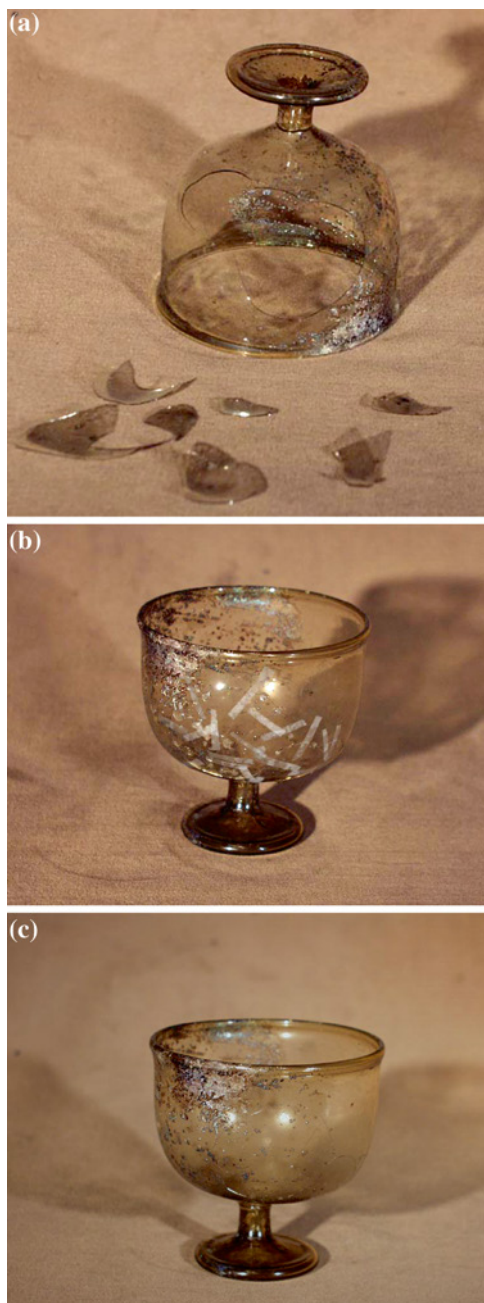
### **Ultraviolet Light (UV) and Infrared light (IR):**

This can show up variations in materials, as well as old and modern additions, and in some cases traces of old decorations.

### **Chemical Spot Tests:**

Various chemicals are applied in small areas to detect inconsistencies in the surface materials and perhaps the application of modern coatings to improve the appearance of the object.

**Fig. 1** **a** This Roman glass has a very interesting impact fracture that clearly shows that it is recent damage, since all the fragments are present and the edges are very sharply defined. **b** The fragments were taped into place using masking tape. Small strips allow the pieces to be placed and adjusted without damaging the surface of the glass. **c** The gaps and fractures were filled with an epoxy resin that was originally developed for the aircraft industry to join large glass panels in windscreens without leaving bubbles or visual traces in-between the panels. The fluidity and refractive index of the resin allows all the cracks in the glass to be filled and effectively disappear Faltermeier (2012) [www.faltermeier.biz](http://www.faltermeier.biz)

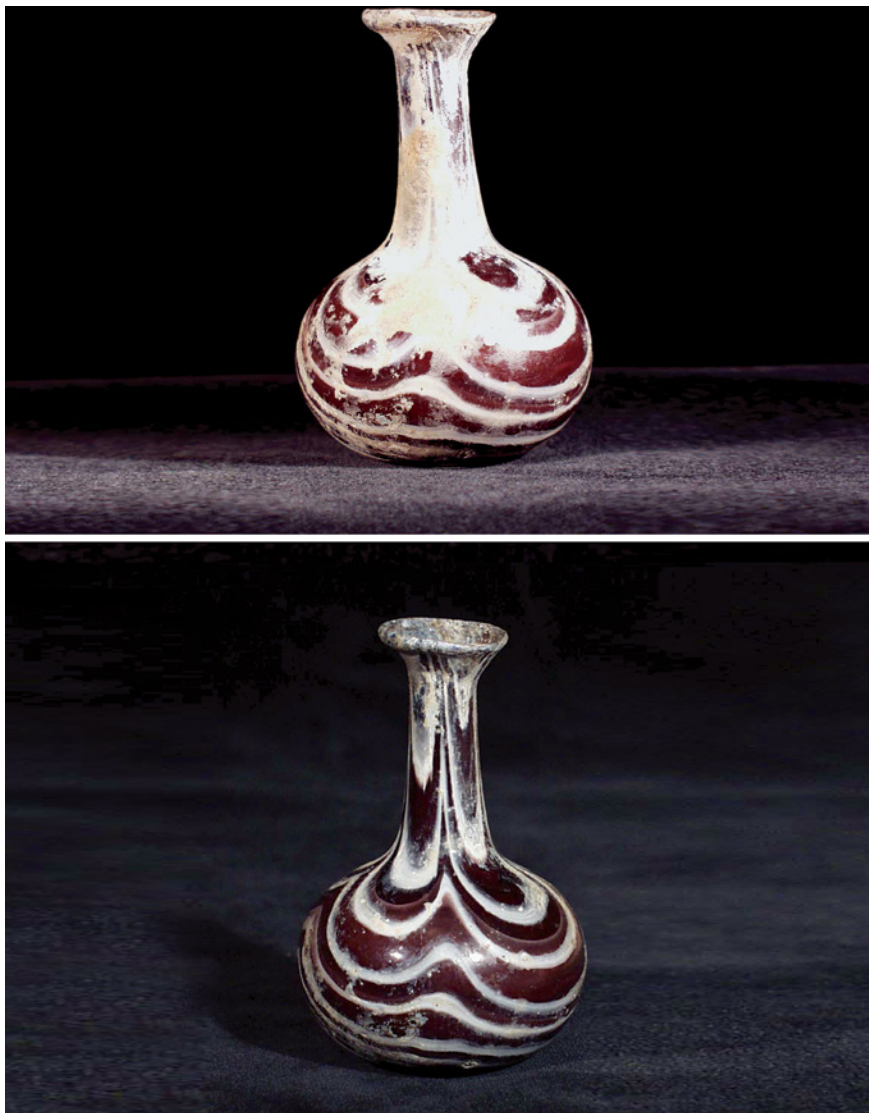




**Fig. 2** Above is a *dark green*, Roman glass dish before and after conservation. The fragments were joined with an acrylic resin. This procedure is almost completely reversible. Notice how in the calcareous deposit only a small hairline crack is visible

#### X-ray Fluorescence:

This technique looks at the surface composition of the glass and might indicate a modern reproduction. It is non-destructive.



**Fig. 3** This ancient aubergine coloured glass vase was covered in calcareous deposits that disfigured and obscured the white decoration flowing through the coloured glass matrix. The deposit was removed with a complexing agent that did not attack the fragile glass surface. At the end of the treatment the glass surface was smooth and reflective again. The deposit was *left* on the inside and near the rim

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Collections

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