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RAW MATERIALS AND GLASSMAKING TECHNOLOGY IN NINETEENTH-CENTURY MURANO GLASSWORKS

Introduction

Murano glass production went through a period of severe crisis in the first half of the nineteenth century. Some timid signs of recovery appeared in the 1830s, partly due to the Venetian antiquarian Sanquirico, who had copies of Renaissance glass made, particularly in filigree. But the real rebirth of artistic blown glass production began in Murano with Fratelli Toso (1854) and Salviati & C. (1866, specialising also in the production of mosaic glass tesserae), and with the opening of the Glass Museum by Abbot Vincenzo Zanetti and Mayor Antonio Colleoni in the second half of the century.

One of the innovations in nineteenth-century Murano was the founding of big factories producing window panes using the cylinder blown technique, bottles in low cost dark glass (Vetreria Marietti), crystal tableware (Società Anonima Vetreria Veneziana) and beads (Società Veneziana per l'Industria delle Conterie, which brought together seventeen small craft companies for the production of beads). This led among other things to a rationalisation of production, a reduction in costs, the introduction of new, more efficient furnaces and new raw materials.

This paper aims to discuss the raw materials and the types of glass used in nineteenth-century production in Murano. The research makes use of some publications on the history of Murano glass[1], some studies by Paolo Zecchin of documents concerning the relation

[1] Cecchetti *et al.* 1874; Santi 1914.

between glass production and economic data[2] and commentaries by Cesare Moretti, Tullio Toninato and Paolo Zecchin on about thirty unpublished Murano recipe books of the nineteenth century (manuscripts), in which the glassmakers noted the raw materials and their ratio in the preparation of the glass batch)[3]. Information has also been taken from the few published chemical analyses of nineteenth-century glass.

Raw materials

The glass used in Murano up until the end of the seventeenth century was mainly a soda-lime-silica glass, regardless of the type of product made. It was obtained by mixing two raw materials: silica in the form of quartz pebbles (from the Ticino and Adige rivers), reduced to powder as the vitrifying compound, and the ash of halophyte plants grown in a saline environment, such as Salsola kali, Salicornia, etc. containing sodium carbonate (fluxer) and calcium carbonate (stabiliser). Soda ash was imported from the Eastern Mediterranean and Spain.

The glass compositions underwent profound changes between the end of the seventeenth century and the start of the eighteenth with the use of new raw materials like potassium nitrate and arsenic. In this period lead-potash-silica glass was also produced in Murano in imitation of English and Bohemian glass. Furthermore, while on one hand the composition of the glass became more and more specific for the type of product (blown items, beads, industrial glass, mosaics), on the other hand glass of different composition was also used to make the same products.

There were further important changes in the type and sources of supply of glass raw materials and in the composition of the batch in the nineteenth century. Silica sands were used almost exclusively as the vitrifier, while the Ticino pebbles, already little used in the eighteenth century, appear only in rare recipes. The most widely

[2] Zecchin 2007 and 2010.

[3] Zecchin 1998; Toninato 2001; Moretti 1999 and 2001.

used was sand from Pula and Lissa (Croatia), already in use in the eighteenth century, gradually replaced from 1887 with a high purity sand known as *Fontainebleau* (origin: France and Belgium), which is still used today. Other sources of supply cited more rarely are the low quality sands of Lazio and Sicily. The use of feldspars (aluminium-silicate minerals also containing minor amounts of lime, potassium and sodium) also appeared at the end of the nineteenth century.

Soda ash from halophyte plants such as *barilla* (imported from Spain already in use by the second half of the sixteenth century), and the less prized *soda di Catania* (imported from the Sicily, from the mid-eighteenth century), was still being used as a flux and stabiliser. Natron was also still used, a mineral soda that had been imported to Murano from Egypt since the seventeenth century, which had been the flux used in Roman glass until the eighth century. In 1790 its use was motivated by the lack of soda ash, mainly for the production of common glass. It continued to be used throughout the nineteenth century and until the early twentieth century.

Industrial soda, gradually replaced the other fluxes; it is indicated for the first time in 1856 and was initially made with the Leblanc process, which gradually gave way to the Solvay process (recipes from the end of the nineteenth century).

The use of potassium nitrate continued (less frequently also potassium carbonate) associated with lead compounds. Potash-lead-silica glass also remained in use in the first half of the nineteenth century, to be then gradually replaced with the traditional soda-lime-silica glass.

Calcium carbonate is indicated in Murano recipes only from the second half of the nineteenth century, for the first time in one for the production of blown crystal by Giovanni Ongaro.

Glass cullet was also imported. Bohemian cullet had already been imported to Murano from the beginning of the eighteenth century, as documented in 1711 by the privilege granted to Giovanni Sola to introduce *Pasta di Cristallo Forastiero* without tariffs. The exact composition of this cullet is not known but in the Murano recipes the glass 'as in Bohemia' was of a lead-potash-silica type. Various kinds of cullet are mentioned in nineteenth-century documents: *comune* (transparent glass) *cristallo* (more valued), *al piombo* (probably lead-potash-silica glass) and *latimo* (opaque white), confirming the

customary attention paid by the Murano glassmakers to the use of carefully selected cullet.

The traditional preparation of the frit (an intermediate product obtained by calcination of the glass batch at about 800°C in a reverberatory furnace) is found increasingly rarely in the Murano recipes of the nineteenth century, while the use of *cottizzo* (from the first years of the fifteenth century), a grit of colourless, transparent glass (molten glass cast in water and dried) used as a base for the glass batch[4], becomes frequent.

The glass of the nineteenth century confirms the constant search in Murano for new colours, often used in the production of multi-coloured products (Fig. 1). In addition to the traditional colourants, new elements appear in the nineteenth-century Murano recipe books borrowed from the European glass industry. Cobalt was in use as a blue colourant in the Murano glassworks right from their origin, even though the first document that mentions it dates from 1446. This was actually *zaffre*, the ore in which cobalt is found associated with other elements in inconstant ratios. This uncontrollable variability must have caused the glassmakers quite a few problems[5]. The purification of cobalt oxide perfected in the nineteenth century must therefore have been a significant development also for Murano glassmakers. The term *cobalt* is found for the first time in Murano recipe books at the end of the nineteenth century, but it is possible that the purified oxide was also used earlier, though retaining the traditional name *zaffre* of the unprocessed mineral.

Chrome, already used in England in the eighteenth century, appears in Murano from about 1870, both as oxide and as potassium bichromate. Green glass (Cr_2O_3) and yellow-green glass (CrO_3) were made with these compounds.

Recipes for topaz yellow that use uranium are found starting from about 1850 and the use of nickel for colouring grey glass dates from 1890. Selenium and cadmium are two elements that were discovered in 1817, fundamental for the modern production of yellow and red glass. They allow stable, reproducible colours to be easily obtained in the

[4] Zecchin 1989.

[5] Verità and Zecchin 2015.

transparent glass, unlike the previously used colourants. Both appear in the Murano recipes of the first years of the twentieth century, but their use in Murano may go back to the end of the nineteenth century.

Important innovations are also found in the use of opacifiers. The traditional lead-tin calx, already in use in Murano from the fourteenth century, is rarely found in the nineteenth-century recipe books. Its replacement had already begun at the end of the sixteenth century with the use of cheaper and/or more effective opacifiers. Numerous references to antimony added to glass in the form of oxide, which formed crystals of calcium (or sodium) antimonate during cooling, are found in the nineteenth-century recipes. Alternatively, antimony was added in large quantities to a glass to prepare an intensely opaque intermediate product (*corpo*), which was then added to the transparent glass. Lead arsenate (in use from the second half of the seventeenth century) was frequently used because of its particular properties as a very intense white glass (*smalto*) or as a semi-transparent colourant for a dichroic glass known as *girasol* (sunflower, now *opalino*) which looks blue in transmitted light and yellow in reflected light. Finally, the use of fluorine was borrowed from the glass industry (from 1874) in the form of cryolite (Na_3AlF_6) and later of fluorspar (calcium fluoride). The micro-crystals of sodium (or calcium) fluoride that form during cooling give the glass a particularly delicate and intense opaque white appearance.

Glass batch

Some recipes for the production of artistic blown glass from the second half of the nineteenth century are shown in Table 1. Mixtures borrowed from northern European glassworks were used alongside the traditional soda-lime-silica Murano glass, in line with a renewal that had begun at the end of the seventeenth century, such as lead-potash-silica glass (Si-K-Pb in Table 1) or mixed alkali glass stabilised with lime (Si-Na-K-Ca glass). It is interesting to note that at the end of the nineteenth century the use of traditional soda-lime-silica glass once again predominated for artistic production; it remained the main glass used in Murano for luxury and artistic blown items for the

entire twentieth century (and still does).

In the nineteenth century *conterie* is a term that refers to both large and small beads (Fig. 2). The beads were the economically most important Venetian glass export in the eighteenth century, and continued to be in the nineteenth. Beads were exported mainly to the East and to Western Europe, to be resold in Africa and North America. Very different kinds of base glass are indicated for this production in the recipe books; some examples are shown in Table 2. The use of different kinds of glass to shape the same product is also seen several times within the same glassworks. These range from lead-potash-silica glass similar to that used for the production of blown items, but with a greater and very variable lead content, to lead-potash-soda-silica glass made with different batches.

After a period when it fell into oblivion, the production of glass mosaic tesserae (coloured vitreous pastes and gold or leaf tesserae) came back into vogue with important innovations made in the mid-nineteenth century by Antonio Salviati's glassworks, employing the Murano technician Lorenzo Radi. The *Angelo Orsoni Smalti e ori per Mosaico* company (still active in Venice as Angelo Orsoni Srl), was founded in 1888 and successfully took part in the International Exposition in Paris in 1889, presenting a remarkable panel made up of 1000 opaque, multi-coloured and metal leaf tesserae (Fig. 3). The glass was made by remelting scrap artistic glass (probably lead-potash-silica glass) with additions of sodium-nitrate (e.g. 100 kg of scrap glass and 36 kg of sodium-nitrate for the *cartellina*) in order to make the final glass more fluid. Small quantities of elements were also added to improve its optical qualities, such as antimony (refining compound), manganese (decolourant) and iron oxides (colourant)[6].

Furnaces

In Murano in the nineteenth century, the quantity of colourless, transparent glass melt in each crucible varied between 300 and 700 kg in large furnaces with several crucibles. The first furnaces without

[6] Verità 1996.

crucibles, were rectangular tank furnaces fuelled by gas with a capacity of up to five tons, which were introduced in the second half of the nineteenth century. The use of wood, the traditional Murano fuel, continued mainly for artistic glass. Towards the end of the century big coal-fired furnaces also came into operation (for a total of about seven tons of worked glass) as did smaller furnaces fuelled by lighting gas (introduced to Venice in 1843).

Chemical analyses

Quantitative chemical analyses of glass allow the raw materials used, and the ratios in which they were mixed in the preparation of the glass batch, to be traced. There are still only a few analyses of nineteenth-century Murano glass and these are not on all types of product.

Analyses of artistic blown glass (and in agreement with what is shown by the recipe books) show the use of different kinds of glass: lead-potash-silica, soda-lime-silica and lead-lime-potash-silica glass. In some cases these show the use of very pure silica (Al_2O_3 0.1-0.2%, and Fe_2O_3 0.03-0.1%: very low concentrations, never before achieved in Venetian glass production) and in others of lower quality silica.

The glass used in multi-coloured items such as millefiori (made in Murano in the nineteenth century also in imitation of ancient Roman glass), is of a soda-lime-silica type with a variable quantity of potassium and lead (PbO 0-10%). Alumina is generally less than 0.5% but in some cases rises even to 2%[7].

Few analyses of nineteenth-century beads and mosaic tesserae have been published; the result is a very complex picture because of the extremely varying PbO content (PbO 0-30%) and the use of various pigments, a picture that may be clarified only by extending the analyses to a significant number of items.

Finally, the analyses confirm the use of soda-lime-silica glass, but no longer made with vegetable ash, as shown by the low concentrations of chlorine (Cl less than 0.3%) and phosphorous (P_2O_5

[7] Page *et al.* 2001.

less than 0.15%). The addition of potassium also emerges in various cases (probably in the form of nitrate) along with lead. Regarding the minor elements, arsenic (or antimony) is often present, added as a decolourant and refining agent in quantities of less than 0.5%. Manganese is also found at times as a decolourant in transparent glass.

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Tab. 1 - Base glass batch composition to be used for luxury blown glass production (recipes dated 1868-1893).

Type of glass	**Si-K-Pb**	**Si-Na-K-Ca**	**Si-Na-Ca**
Silica	100	100	100
Ca-carbonate		28	20
Na-carbonate (industrial soda)		30	60
K-carbonate		10	
K-nitrate	60		
Lead oxide	15		

Tab. 2 - Base glass batch composition to be used for rods, enamels and bead production (recipes dated about 1830).

Type of glass	**Si-K-Pb**	**Si-Na-K-Pb**	**Si-Na-K-Pb**
Silica	100	100	100
Na-carbonate (natron or purified soda plant ash))		100	35
Soda plant ash		48	
Mixed alkali plant ash		25	
K-nitrate	64	2	20
Lead oxide	40-130	7	50

Fig. 1 - Salviati & Co., *Goblet*, 1895-1900. Murano, Museo del Vetro.

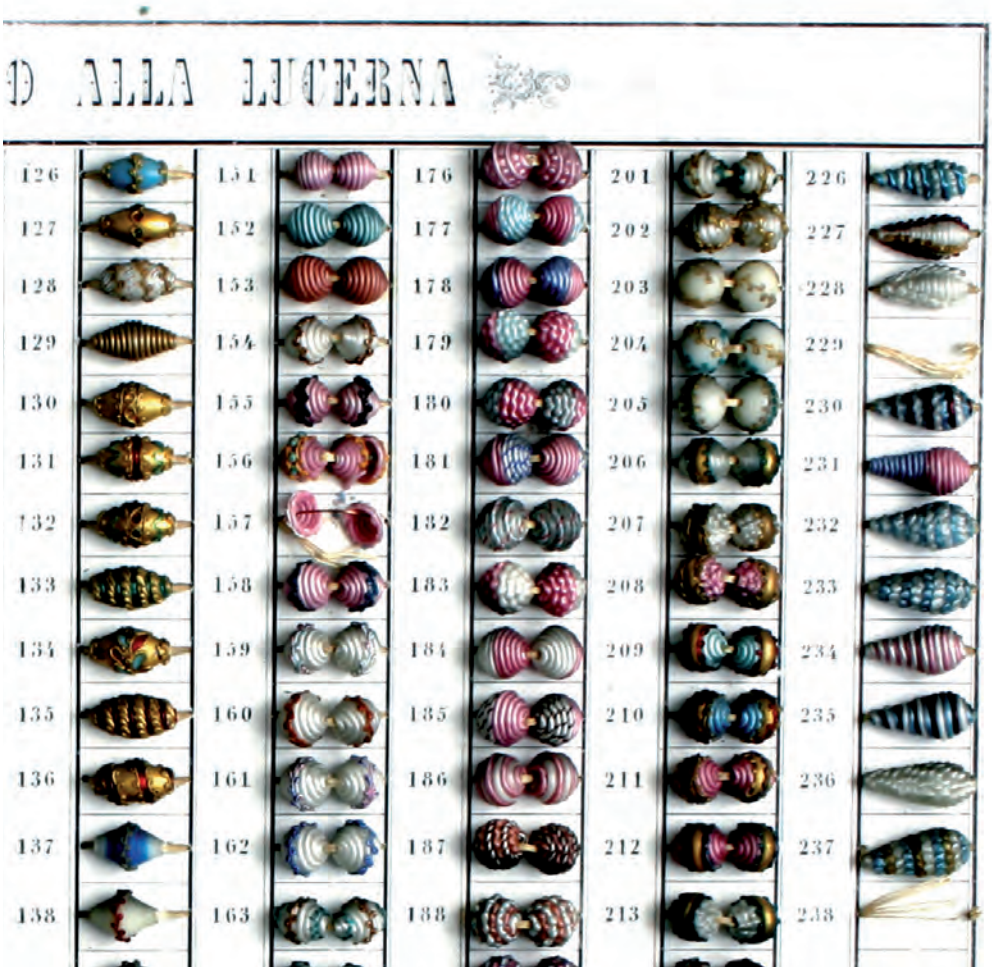

Fig. 2 - G.B. Franchini, *Bead samples*, detail, 1820-1838. Murano, Museo del Vetro.

Fig. 3 - Angelo Orsoni company, *Mosaic panel*. Venice, awarded at the *International Exposition of Paris* in 1889.