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DECORATIVE LAYERS ON SILICON BRONZES

1. INTRODUCTION

Decorative coatings are used first of all for providing the metal or the non-metal items with aesthetic appearance, for which the decisive factors are: the colour, gloss, tarnish resistance, and the surface texture (hammered, crinkled, crystalline). The protective-decorative coatings also protect the items against corrosion and small mechanical scratches [1, 2, 3].

First traces of patination can be found already on artworks from the Bronze Age. Items excavated from ancient Chinese tombs prove that already at those times chemical compounds were applied to bronze castings on purpose. It is not known if the decorative coatings were to stress the social status of the owner or were applied only for aesthetic reasons to reveal the beauty of the item itself. It proves, however, that the intended bronze colourization dates almost as far back as its casting. Traces of artificial patination or colourizing of bronze has been found also in other ancient cultures. Traces of extrinsic pigments which permit to insist that surfaces have been painted with a mix of eggs, water, and pigments have been observed on bronze sculptures in India and Greece [3, 4].

A renewed interest in colourization of metals took place in High Middle Ages. This interest resulted from searching the way of transforming base metals into gold rather than from aesthetic or historical quests. During the Late Middle Ages and the early Renaissance period bronze patination flourished in Europe as a peculiar domain of art. Alchemists could not only reconstruct the effect of natural patinas, but also create new and long-lasting appearance by using then-innovative methods, namely by using wax and leak stoppers to prolong the persistence of patinas on the surfaces of bronze sculptures. Then in the late Renaissance and in Baroque gold plating or gilding came into fashion and the art of patination ceased until the beginning of the XIX century. Over the XIX and the XX century French and Italian artists competed in expanding the variety of patinas. In XIX century

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French artists introduced deep, intensive, translucent colours. A wide spectrum of colours was achieved by using pigmented lacquers, which in many cases were intended to imitate translucent patinas obtained by chemical measures [2, 3, 4].

At the beginning of the XX century, as the chemistry advanced, a circle of persons engaged in patination grew larger. Thanks to this the art of patination flourishes nowadays expanding not only the spectrum of colours, but also their richness and texture range. It gives still greater possibilities of surface finishing to the sculptors, allowing them to express their emotions more freely [2, 3, 4].

The proper preparation of the casting surfaces is extremely important for achieving the desired final patination effect. Surface preparation is significant for two reasons. First, it allows for revealing the metal ability to reflect light, which is important if shining finish is applied, exposing the depth of modern translucent patinas. Second, it cleans the surface, what in turn allows for reaction of copper with chemical compounds applied during the patination process. The copper alloy pieces should be mechanically and chemically prepared in a proper way before building the chemical coating. There are many ways of such preparation. They depend both on the type of the casting process itself and on the type of the sculpted surface: if it is smooth or not [2, 3, 4, 5].

2. METHODS OF INVESTIGATION

The work has been aimed to determine the influence of abrasive working of the BK331 bronze surface on the quality and durability of its decorative coating for given recipes for patinating solutions. The scope of work has included making specimens of BK331 silicon bronze for comparative examinations, mechanical preparation of their surfaces, applying the individual decorative layers by either hot or cold method and the assessment of their quality. Additionally the metallographic examinations have been held by means of the optical microscope at the 400× magnification. These examinations have been aimed to find the thickness of the patina layers and to check the degree of their binding with the BK331 bronze.

Specimens with the shell motif of dimensions 50×85×4 mm have been made of BK331 silicon bronze employed for examination. They have been cast in block moulds using the investment casting method. The ways of their surfaces preparing have been diversified – specimens have been either sandblasted or manually ground with 100, 150, or 320 grit sandpaper. Sandblasting have been carried out in a dust-proof chamber to avoid the dust arising during the operation. Fine dry silica sand has been used for this process. Artificial decorative coatings have been applied directly after sandblasting. Flat surfaces of specimens assigned for abrasive working has been ground by means of a pneumatic rotational 100, 150, or 320 grit grinder. Such intricate surfaces as the textured shell shapes could not be ground with high speed grinders which may spoil the surface texture. They have been hand ground with sandpaper of an assumed grit in order to achieve the suitable surface roughness. The appearance of specimens after the abrasive working is shown in Figure 1.

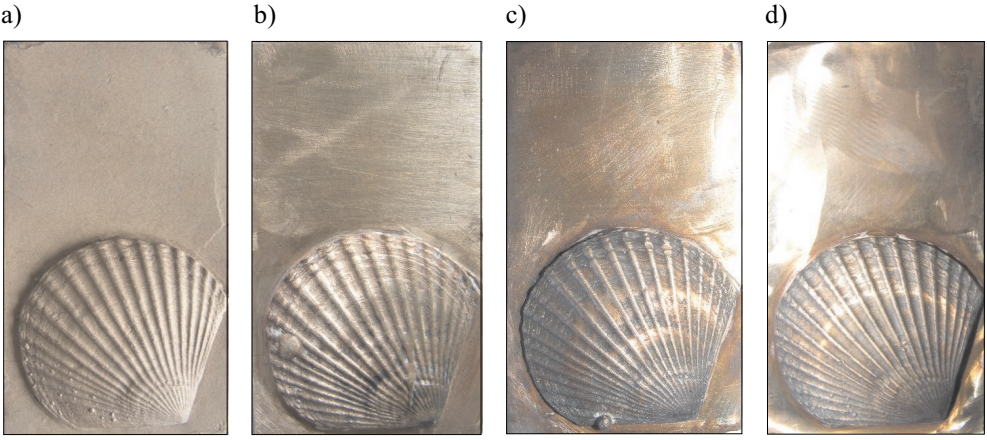

Fig. 1. *The surface appearance after mechanical working: a) sandblasting; b) 100 grit sandpaper; c) 150 grit sandpaper; d) 320 grit sandpaper*

The patinating solutions have been applied either by hot or cold processes (in room temperature) by dipping, brush painting, or spraying (Tab. 1). Specimens for hot treatment have been heated on the laboratory heater up to about 80 ^{o}C.

Table 1. Composition of patinating solutions

Solution	Component
Patina No. 1	150 ml H_2O + 30 g K_2S_x
Patina No. 2	2 cm^3 K_2S_x + 5 cm^3 H_2O
Patina No. 3	5 g $Cu(NO_3)_2 \cdot H_2O$ + 50 ml H_2O
Patina No. 4	1st layer: 2 g K_2S_x + 500 ml H_2O 2nd layer: 5.3 g $Cu(CH_3COO)_2$ + 50 ml H_2O
Patina No. 5	1st layer: 2 g K_2S_x + 500 ml H_2O 2nd layer: 5 g K_2S_x + 4 g FeO + 1 dm^3 H_2O
Patina No. 6	1st layer: 2 g K_2S_x + 500 ml H_2O 2nd layer: 20 g $CuSO_4 \cdot 5H_2O$ + 500 ml H_2O

One of the final stages of the experimental work has been the assessment of the obtained decorative coatings. The rating from 1 to 5 have been assumed, with 1 standing for weak adherence of a patina to the under-layer, irregular coating of the specimen, non-uniform colour and discolouration occurring, and with 5 representing good adherence to the casting, uniform coating of the sample, even colour without stains. The visual assessment is, however, a subjective one and depends on many factors, e.g. emotions or possible sight defects of the judging person, light intensity and so on.

3. RESULTS OF EXAMINATION

Applying of patinating solutions to the surfaces of specimens has resulted in their colour changes, however the resulting colour is diverse both for different patination solutions and for the altered ways of surface preparing. The results of experimental decorative patinating of BK331 bronze specimens are illustrated in Table 2.

Table 2. The appearance of specimens with respect to the type of applied patina and to the type of surface working

Surface / Patina designation	Sandblasting	100 grit sandpaper	150 grit sandpaper	320 grit sandpaper
Patina No. 1				
Patina No. 2				
Patina No. 3				

Table 2 cont.

Patina No. 4				
Patina No. 5				
Patina No. 6				

Thickness of obtained patinas is shown in Figures 2–4.

a) b)

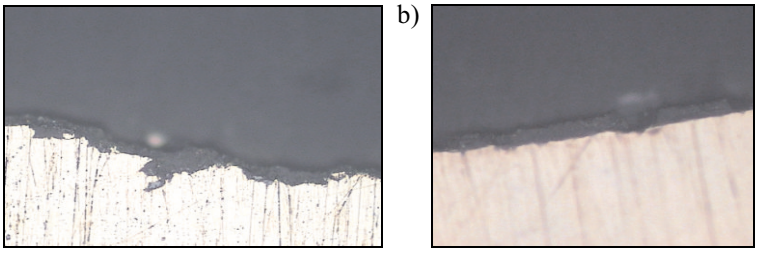

Fig. 2. *A cross-sectional view of silicon bronze specimen with the 'Patina No. 1' decorative layer, magn. 400×: a) for sandblasted specimen surface; b) for specimen surface ground with 320 grit sandpaper*

Table 3 presents the quality assessment of the obtained patinas; the factors taken into account are: the degree of adherence of patina to the specimen surface, the degree of coating, colour intensity and uniformity.

Table 3. Results of quality assessment

Patina	Type of working	Colour intensity	Colour uniformity	Degree of adherence to the surface	Degree of coating
Patina No. 1	Sandblasting	5	4	4	4
	100 grit sandpaper	3	3	2	2
	150 grit sandpaper	3	2	2	2
	320 grit sandpaper	2	2	1	1
Patina No. 2	Sandblasting	4	4	5	5
	100 grit sandpaper	3	2	2	2
	150 grit sandpaper	1	2	2	2
	320 grit sandpaper	1	2	2	1
Patina No. 3	Sandblasting	5	5	5	5
	100 grit sandpaper	4	3	3	3
	150 grit sandpaper	4	3	3	3
	320 grit sandpaper	3	3	2	2
Patina No. 4	Sandblasting	2	2	3	3
	100 grit sandpaper	1	1	2	2
	150 grit sandpaper	1	1	2	2
	320 grit sandpaper	1	1	1	1
Patina No. 5	Sandblasting	4	4	4	4
	100 grit sandpaper	4	4	2	4
	150 grit sandpaper	4	3	3	2
	320 grit sandpaper	3	4	2	4
Patina No. 6	Sandblasting	4	4	4	5
	100 grit sandpaper	3	5	3	4
	150 grit sandpaper	4	4	3	4
	320 grit sandpaper	4	4	2	4

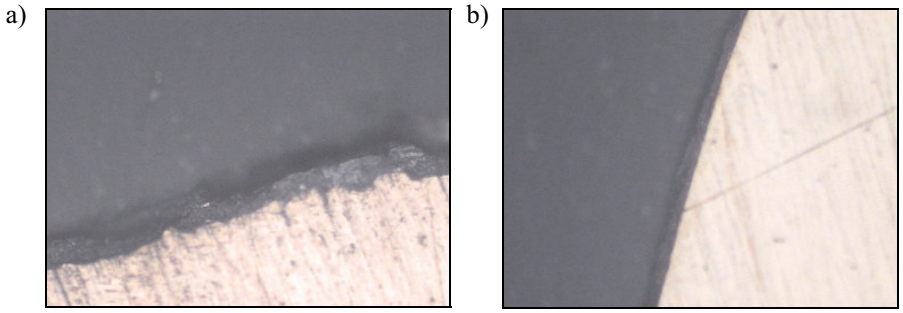

Fig. 3. *A cross-sectional view of silicon bronze specimen with the 'Patina No. 4' decorative layer, magn. 400×: a) for sandblasted specimen surface; b) for specimen surface ground with 320 grit sandpaper*

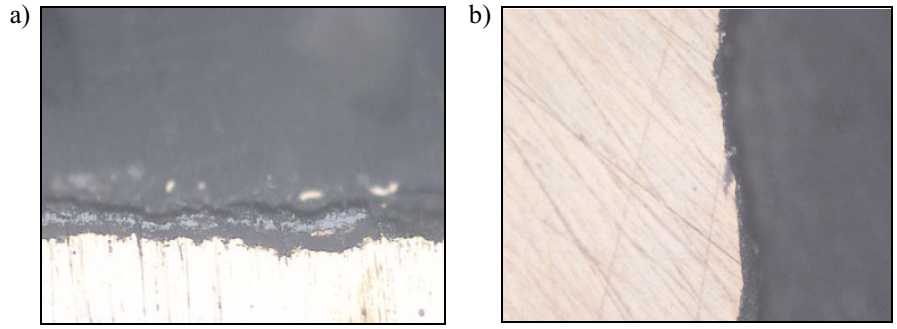

Fig. 4. *A cross-sectional view of silicon bronze specimen with the 'Patina No. 6' decorative layer, magn. 400×: a) for sandblasted specimen surface; b) for specimen surface ground with 320 grit sandpaper*

4. ANALYSIS OF RESULTS

It results from the carried out examinations that the surface preparation of material assigned for patination influences significantly the quality and durability of the obtained coating. A particular attention should be paid to the sandblasting process which has given more developed bronze surface than grinding with sandpaper, and patinas applied to the sandblasted surfaces manifest the uniformity of coating. Sandblasting is a method which do not desire for additional preparation of metal before applying the artificial decorative layers, so that it is quick and economic method of finishing castings. Grinding with sandpaper of the examined grits makes difficult obtaining durable decorative coatings of uniform colour. Grinding demands also for additional preparation of casting in order to remove the grinding remains (binder, abrasive material, polish compounds), thus complicating the process and increasing costs of patination. Patinas obtained on ground specimens exhibit the

non-uniform colour of low intensity and the weak binding with the underlying material, as compared with patinas on sandblasted specimens.

However, it should be taken into account that, as far as artistic casting are concerned, the final choice of the method of surface preparation depends on the sculptor's idea and decision.

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