Efficiency Evaluation of Acrylic Coatings for Corrosion Inhibition on Silver Cultural Heritage Objects

Natália R. P. Freitas[1*] (PG), João C. D. de Figueiredo Junior[2] (PQ) e Luciana Bonadio[2] (PQ)

[1] Department of Chemistry, Institute of Exact Sciences (ICEx), Federal University of Minas Gerais (UFMG)
[2] School of Fine Arts, Federal University of Minas Gerais (EBA/UFMG)
[*] natalia.rodrigues.p.freitas@gmail.com

ABSTRACT

RESUMO - Este trabalho avaliou a eficácia de revestimentos acrílicos na proteção de ligas de prata contra a corrosão. Foram testadas soluções de Paraloid® B72 (em acetona e em acetato de isoamila) e Paraloid® B44 (em acetato de isoamila), aplicadas por pincel e por aspersão em amostras de prata 900 e 500. A performance dos revestimentos foi analisada por meio de medidas de brilho (60°) e ensaios de corrosão artificial em atmosfera de H_2S, com a variação de cor (ΔE) determinada pelo sistema CIELAB. Os resultados indicaram que o Paraloid® B72 em acetato de isoamila, aplicado por aspersão, apresentou o melhor desempenho, combinando boa proteção e baixa interferência estética. Observou-se que o solvente e o método de aplicação influenciam significativamente a formação da camada protetora, sendo fatores determinantes para a eficiência do revestimento.

Keywords: metal corrosion, corrosion inhibitor coating, acrylic coatings, silver alloys, cultural heritage.

Introduction

Silver alloys are widely used in cultural heritage objects due to their malleability and the characteristic shine they impart to surfaces. However, their composition makes them susceptible to corrosion (1), especially in environments with high relative humidity and the presence of sulfides, such as hydrogen sulfide (H_2S). The interaction with these agents promotes the formation of corrosion products, such as silver oxide (Ag_2O) and, mainly, silver sulfide (Ag_2S) (Equation 1), which is responsible for surface darkening and the consequent loss of the object's aesthetic legibility (2-3). The severity of corrosion is directly related to the alloy composition, being more intense in materials with lower silver content.

$$Ag_2O + H_2S \rightarrow Ag_2S + H_2O \quad (1)$$

The application of protective coatings has proven to be an effective strategy to inhibit corrosion on metal surfaces by preventing contact with corrosive agents (4). In the context of conservation, acrylic coatings are widely used due to their stability, reversibility, and compatibility with metal alloys (5). Therefore, this work investigates the efficiency of different acrylic formulations applied on silver alloys, analyzing the influence of the solvent and the application method on corrosion protection and also on the final appearance of the object.

Experimental

Metallic samples of silver 900 (90% Ag, 10% Cu) and silver 500 (50% Ag, 50% Cu) were selected, previously cleaned with neutral detergent and sodium glycinate, and polished using a micro rotary tool. To evaluate acrylic coatings, 5% (w/w) solutions of Paraloid® B72 in acetone and in isoamyl acetate, as well as Paraloid® B44 in isoamyl acetate, were tested. The coatings were applied using two methods: brushing (in both horizontal and vertical positions) and spraying (at pressures of 6 and 10 psi, and distances of 6 and 10 cm from the surface). In the brushing method, a visually uniform layer was applied to each sample, reproducing the procedure commonly adopted in restoration processes. In the spraying method, each sample was placed in a 7.5 cm Petri dish, onto which 1 mL of the corresponding solution was applied.

After application, gloss measurements (at a 60° angle) were performed to evaluate the visual impact of the coatings on the metal surface. The difference between the values obtained was expressed as the percentage change in gloss (AB%) (Equation 2).

$$AB\% = \frac{B_f - B_i}{B_i} x100 \quad (2)$$

Subsequently, the samples were subjected to artificial corrosion tests in an H_2S atmosphere for 24 hours in order to assess their respective degrees of protection. The effectiveness of the coatings was quantified by the color variation (ΔE) (Equation 3), which was determined through CIELAB colorimetry measurements taken before and after the tests.

From these values, the difference was also expressed as a percentage index of the ΔE values (ΔE%) (Equation 4).

$$\Delta E = \sqrt{(L_1 - L_2)^2 + (a_1 - a_2)^2 + (b_1 - b_2)^2} \quad (3)$$

$$\Delta E\% = \frac{\Delta E_r}{\Delta E_c} x100 \quad (4)$$

Results and Discussion

Gloss measurements indicated that brush application, especially with samples positioned horizontally, resulted in coatings with higher residual gloss, which may compromise the aesthetic readability of the metal surface by giving it a plastic-like appearance. Spray application, on the other hand, produced more uniform films with less aesthetic alteration, particularly when combined with solvents of lower volatility.

Regarding anticorrosive protection, the acrylic coatings showed satisfactory performance in most tests. Among the results obtained, Paraloid® B72 in isoamyl acetate stood out as the most efficient coating (Figure 1), presenting the lowest ΔE values for both 900 and 500 silver samples (Figure 2). This superior performance can be attributed to the lower evaporation rate of the solvent, which favors the formation of a more homogeneous and stable film during application.

Figure 1. Paraloid® B72 at 5% in Isoamyl Acetate (spray application)

Spray application at 10 psi and a 10 cm distance was especially effective for this coating, providing excellent protective performance with minimal visual interference.

On the other hand, Paraloid® B72 in acetone, despite its widespread use, showed lower efficiency when applied by spraying, due to the solvent's high volatility, which favors the formation of thin and poorly cohesive films. Paraloid® B44 also demonstrated good performance, although slightly lower compared to B72.

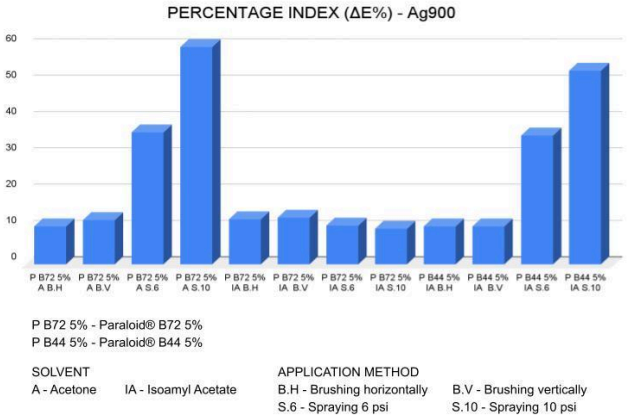

Figure 2. Percentage index of ΔE values - Ag900

Conclusions

The analysis of the tested acrylic coatings indicates that their effectiveness is associated with the type of solvent used and the application method employed. Paraloid® B72 diluted in isoamyl acetate and applied by spraying showed the best performance, combining effective corrosion protection with minimal aesthetic alteration. These results contribute to the informed selection of materials and application techniques in the conservation of metal artifacts, with particular relevance to silver cultural heritage objects.

Acknowledgements

The author gratefully acknowledges the institutional support provided by the CECOR/EBA/UFMG.

References

1. G. D. de Souza; M. A. Rodrigues; P. P. Silva; W. Guerra, *Educ. Quím.*, 2013, 24(1), 14–16
2. V. Costa, in Anais do 2º Congresso Latino-Americano de Restauração de Metais, Rio de Janeiro, 2005, 13–28.
3. P. Vassiliou; V. Gouda, Corrosion and Conservation of Cultural Heritage Metallic Artefacts, Elsevier Inc. Chapters, 2013.
4. D. Watkinson, Preservation of Metallic Cultural Heritage, Elsevier eBooks, 2010, 3307–3340.
5. M. T. Molina; E. Cano; B. Ramírez-Barat, *J. Cult. Herit.*, 2023, 62, 99–113.