Use of Microemulgels Based on Isoamyl Acetate, Water, and Xanthan Gum for the Removal of Acrylic Paints from Cultural Heritage Objects

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RESUMO

RESUMO – A Conservação – Restauração de Obras de Arte utiliza solventes orgânicos, como os aromáticos, para a remoção de tintas acrílicas. Devido à toxicidade e ecotoxicidade destes solventes, novos sistemas são estudados como substitutos, entre esses os microemulgéis. Neste trabalho, microemulgéis à base de acetato de isoamila, água e goma xantana foram estudados para a remoção de tinta acrílica. Um pseudodiagrama ternário dos solventes com o sistema surfactante 1:2 Tween 80 / Etanol foi obtido e três formulações de microemulsões foram testadas. A dimensão nanométrica das microemulsões foi medida por Espalhamento Dinâmico da Luz. Testes de eficiência de remoção foram realizados com microemulgéis obtidos da mistura de goma xantana com as microemulsões. A remoção foi realizada em fac-símiles de tinta recém-aplicada e envelhecidas por processo fotoquímico e térmico. A eficiência da remoção da tinta pelos microemulgéis foi maior nos sistemas de menor diâmetro de micela e na tinta recém aplicada.

Palavras-chave: Microemulsão, Microemulgel, Remoção de tintas, Conservação-Restauração

Introduction

The conservation-restoration of artworks has traditionally used systems containing organic solvents, such as aromatic compounds, for the removal of paints from cultural heritage objects. These solvents present occupational hazards and ecotoxicity. One way to reduce the occupational risks associated with these substances is to use them in an emulsified form within an aqueous dispersing phase, which aligns with Green Chemistry principles. If the emulsion is at the nanometric scale (a microemulsion), the solvent's removal effectiveness is maintained due to the high surface area, and when applied in a gel, it forms a microemulgel that offers greater control for conservators working on cultural heritage objects (1). This research aimed to study microemulgel formulations that could replace aromatic solvents in the removal of acrylic paints. Isoamyl acetate is used as the substitute solvent, microemulsified in water. The paint removal efficiency was also observed on artificially aged facsimiles, given the changes in paint solubility resulting from deterioration due to aging.

Experimental

A pseudo-ternary phase diagram was initially obtained by titrating water into the system composed of isoamyl acetate and a 1:2 mixture of Tween 80/ethanol (surfactant/co-surfactant) in different proportions. This pseudodiagram allows the determination of the monophasic and biphasic regions in the diagram, with microemulsions located in the monophasic region. Once the pseudodiagram was obtained, three microemulsion formulations were selected, each with a fixed content of 5% isoamyl acetate and varying amounts of water and surfactant system, to evaluate their effectiveness in removing acrylic paint. The diameters of the microemulsions were measured using Dynamic Light Scattering (DLS) analysis. For the removal tests, prototypes were produced using Prussian Blue acrylic paint (Acrilex brand) applied to glass slides. The paints were divided into three categories: freshly applied paint, paint aged artificially through photochemical processes (using a fluorescent lamp emitting both visible and ultraviolet light), and paint aged thermally (heated in an oven at 50 °C). The aging duration for both photochemical and thermal processes was 30 days.

To obtain the microemulgels, the microemulsions were incorporated into a 5% xanthan gum hydrogel at a ratio of 3:1. A quantity of 0.100 g of microemulgel was applied to the prototypes, which were left to rest for 16 minutes. The paint was then removed using a cotton swab, and the time required for complete removal was recorded.

Results and Discussion

The pseudo-ternary diagram for the system composed of water, isoamyl acetate, and 1:2 Tween 80 / ethanol is shown in Figure 1.

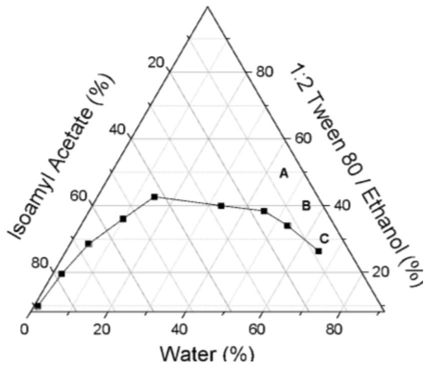

Figure 1. Pseudo-ternary diagram of the system water, isoamyl acetate, and 1:2 Tween 80 / ethanol

Based on this diagram, three microemulsions were formulated with a fixed content of 5% isoamyl acetate and varying water contents of 45%, 55%, and 65% (formulations A, B, and C, respectively). Their droplet sizes were characterized using Dynamic Light Scattering (DLS), with all formulations showing polydispersity index (PDI) values between 0.05 and 0.70. These results indicate low polydispersity. In all formulations, more than 50% of the droplets had diameters below 100 nm, thus classifying them as microemulsions (2)

MICROEMULSION	DIAMETERS / CONTENT (nm / %)	PDI
A (45% water)	20.73 (53.5) 245.3 (36.6) 5.363 (5.6)	0.357
B (55% water)	23.99 (78.0) 152.7 (18.4) 4,878 (3.6)	0.368
C (65% water)	14.21 (90.4) 610.5 (8.0) 3,563 (1.6)	0.280

Table 1. Microemulsions A, B, and C with respective diameters, proportions, and polydispersity index (PDI).

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The paint removal times for the three types of paints are shown in Figure 2

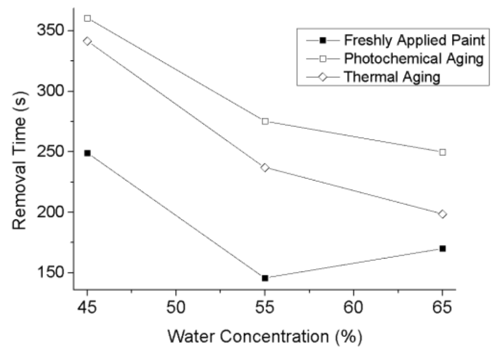

Figura 2. Diagram showing paint removal times as a function of water content.

The diagram reveals a relationship between removal time and water content. The removal time serves as an indirect measure of the solvent system's efficiency in removing paint — the longer the time, the lower the efficiency.

Initially, removal times varied depending on the paint type. The freshly applied paint was the easiest to remove, showing the shortest times. Artificially aged paints exhibited greater resistance, which is attributed to deterioration of the acrylic fraction in the paint due to crosslinking reactions between polymer chains.

Microemulsion C (65% water) demonstrated the highest cleaning efficiency in all three scenarios, despite having the highest water content. This effectiveness was attributed to the droplet size of the microemulsion — 14.21 nm — with 90.4% of the system comprising droplets of this size.

Conclusions

The obtained microemulgels proved to be promising solvent systems for the removal of acrylic paints. They contained isoamyl acetate as a substitute for aromatic solvents typically used in this type of paint removal. The high water content in the formulations also makes them more sustainable alternatives for acrylic paint removal.

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Laboratório de Encapsulamento Molecular e Biomateriais – LEMB - UFMG

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