



Permeability measurement of polymeric coatings used in art conservation practice

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Introduction and motivation

Acrylic resins are used in the conservation practice. The water vapour transmission rate (WVTR) of the coating determines the protection efficiency and corrosion resistance. The aim of our study was to introduce a standardized, reproducible method, which was missing so far, to characterize the resins, furthermore, the developed method can be useful in other applications, too. Its strength is that it can also be used for substrate/coating composites, when the coating is non-self-supporting, accordingly cannot be tested directly.

Knowledge of a more fundamental parameter, the diffusion coefficient, is desired. To obtain it, we first calculated the permeability coefficient from the WVTR, then measured the solubility coefficient by a gravimetric method, and at the end using these data, determined the diffusion coefficient.

This work is summarized in our paper, which is under review [1].



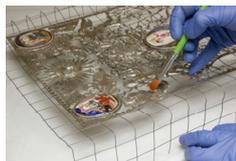
Monument to János Arany
The three-figured statue, whose main figure is János Arany with his poetic characters, Miklós Toldi on the right and Piroska Rozgonyi on the left side, can be found in front of the entrance of the Hungarian National Museum. The figure shows the Piroska statue before and after art conservation.

Materials and methods

Acrylic resins → Paraloid B-44 / Paraloid B-72 solved in acetone.



Immersion



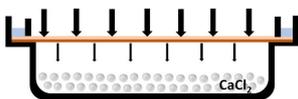
Brushing



Spin-coating

1. Permeability measurement - Cup method

- EN ISO 7783-1: „Cup method” [2]
- Anodized aluminium cup
- Standard surface area: 25 cm²
- Hygroscopic material: CaCl₂
- Hermetically sealed: molten paraffin
- Climate chamber: constant T = 20°C, RH = 60%
- Weight increment (analytical balance: 0.1 mg accuracy)
- WVTR and solubility calculations

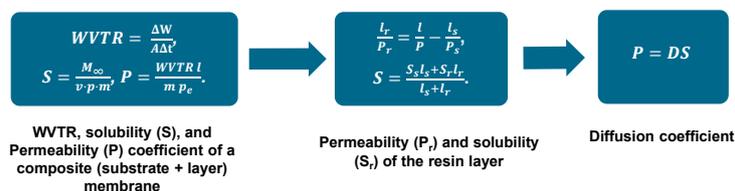


2. Solubility measurement - Gravimetric method

The gravimetric method was chosen for the solubility measurement in this work [3].

Theory

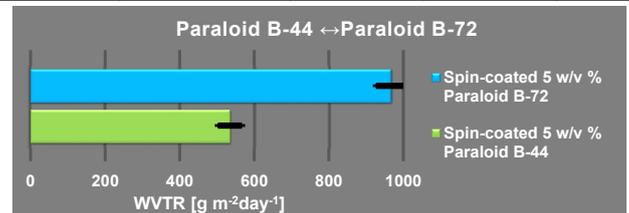
Calculation of WVTRs, solubilities, permeabilities and diffusivities.



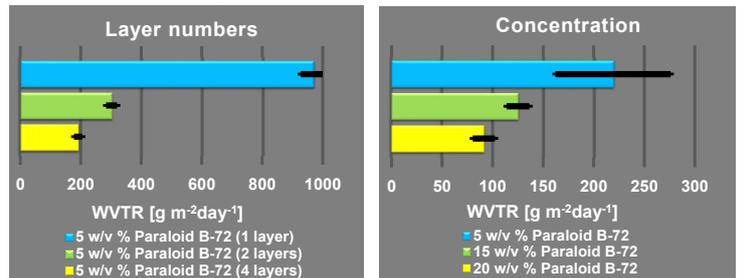
Results

The calculated WVTRs, permeabilities (P), solubilities (S) and diffusion coefficients (D).

Sample	WVTR [g m ⁻² day ⁻¹]	P [m ⁻¹ s ⁻¹ Pa ⁻¹]	S [m ³ Pa ⁻¹]	D [m ² s ⁻¹]
Impregnated paper (substrate)	612 ± 5%	6.081×10 ¹²	1.04×10 ²⁴	5.83×10 ⁻¹²
5 w/v % Paraloid B-44	535 ± 6%	1.522×10 ¹¹	1.87×10 ²⁴	8.14×10 ⁻¹⁴
5 w/v % Paraloid B-72	966 ± 4%	2.512×10 ¹¹	1.65×10 ²⁴	9.25×10 ⁻¹⁴



The WVTR of the coating made by 5 w/v % Paraloid B-44 is lower than Paraloid B-72.



With the number of applied layers the WVTR decreases significantly: the double layers by about a factor of 3, whereas the quadruple layers by about a factor of 5-6.

The higher the amount (concentration) of the resin, the lower the transmission rate of the coating layer.

Practical test

Salt spray (fog) test (ASTM B117-11) + SEM-EDS



The average zinc content of the surface covered by Paraloid B-44 is 26.98 wt%, whereas 24.57 wt% in the case of B-72 (SEM-EDS).



Conclusions

In this work, a method was introduced to evaluate the WVTR – and also the permeability, solubility and diffusion coefficients – of different coatings highly used in different areas of applications, for instance in conservation practice.

The technique based on the ISO cup-method. To demonstrate the procedure and its strength, we studied the Paraloid B-44 and B-72 resins. We showed that the transmission rate of B-44 is by 55% less than the B-72. Salt spray (fog) test – SEM/EDX experiments showed that the zinc loss in the sample coated by the Paraloid B-44 is also by 55% less than in the sample coated by the Paraloid B-72 resin.

Although the method in this work is used to study resins as coating material, the routine can be used in a variety of applications, for example substrate/coating composites, when the coating is non-self-supporting, accordingly cannot be tested directly.

References

- [1] R. L. Kovács et al., Water vapour permeability measurement of organic coatings for conservation of metallic artifacts. Prog. Org. Coat. (2019), under review
- [2] K. Lahtinen et al., Characterization for Water Vapour Barrier and Heat Sealability Properties of Heat-treated Paperboard/Poly lactide Structure. Pack. Tech. And Sci. (2009)
- [3] C. D. Barr et al., Determination of Solubility Coefficient Values Determined by Gravimetric and Isostatic Permeability Techniques. Pack. Tech. And Sci. (2000)