PRELIMINARY RESULTS OF ACCELERATED AGEING TESTS ON ACRYLIC ART PAINTS

Ioana Maria CORTEA[1], Alexandru RĂDVAN[2], Cristina VASILIU[3], Niculae PUŞCAŞ[4]

Despite recent and significant advances regarding the conservation of materials used in modern and contemporary art, there's still a severe lack of information in terms of understanding their chemistry and condition, and how they might alter or deteriorate with age, with different treatments, in storage, exhibit or display. In the present paper, five widely used acrylic art paints were gradually stressed under UV exposure and extreme conditions in terms of temperature and humidity. Possible variations and deterioration processes, especially related to color, lightness and/or stability, were expected.

Keywords: acrylic paints, art conservation, accelerated ageing, UV exposure, CIELAB colorimetry, FT-IR spectroscopy

1. Introduction

Since the beginning of the second half of the 20th century, visual artists have used an extremely wide variety of new materials and techniques. With limited or even nonexistent data regarding the behavior in time of these modern materials and the ways in which they might respond and react to different stress conditions or potential restoration treatments, conservators are often challenged when confronting conservation issues of modern and contemporary artworks [1].

In order to pass this artistic legacy to future generations it is essential thus to understand as comprehensively as possible the factors that govern material behavior and stability, the long-term effects of conservation treatments and the mechanisms of specific deterioration processes.

This paper is an initial stage of an extended study focused on modern materials (paints, mediums, varnishes, resins, consolidants) and on the evaluation of the degradation risks due to natural factors and/or improper applied restoration techniques.

[1] National Institute of Research and Development for Optoelectronics INOE 2000 Bucharest, Romania, e-mail: ioana.cortea@inoe.ro
[2] National University of Arts Bucharest, Romania, e-mail: radvan@inoe.inoe.ro
[3] National Institute of Research and Development for Optoelectronics INOE 2000 Bucharest, Romania, e-mail: icvasiliu@inoe.ro
[4] Prof., Physics Department, University POLITEHNICA of Bucharest, Romania, e-mail: pnt@physics.pub.ro

The preliminary experience of the research team in the field of cultural heritage conservation indicates the large utility of portable analytical instruments for in situ monitoring of chemical, physical, and/or surface changes in objects as well as the vantage of using digital models for future accurate documentation [2-3].

As a first step in the development of a reliable database that will facilitate the above mentioned techniques in the next years, a complex characterization of modern materials used in contemporary art is in progress.

2. Acrylic paints

In the long history of art materials, acrylic paints are a relatively new addition as they were commercially available only since the 1950s. It was German chemist Otto Röhm who actually brought the practical potential of these materials into light when in 1901 published his dissertation on the polymerization products of acrylic acid.

Later, in 1953, Jose L. Gutierrez in Mexico (Politec Acrylic Artists Colors) and then in 1955, Permanent Pigments (Liquitex) in the United States, launched on the market the first acrylic emulsion artists paints. Compared to oil, tempera or watercolor, acrylics offered at that time extraordinary promises as a revolutionary new artists' medium, because of their distinct set of characteristics and attributes such as great clarity, UV stability, high flexibility, quick drying and water solubility.

As it opened the way for a new wave of creativity and innovation, acrylics became shortly the perfect vehicle for many contemporary artists. Achieving its place within the cannon of world collections, issues regarding conservation and acrylic behavior in time had to be addressed.

One of the first studies examining these new materials [4] focused on color-field paintings that were created by flooding areas of the canvas with extremely diluted mixtures of acrylic paint and water or solvent. It was observed that in some parts very low levels of binder were present to hold the pigments in place, leaving the surfaces susceptible to abrasion. Also, large areas of the raw canvas were prone to yellowing and embrittlement. Due to the sensitivity of acrylics to water and other organic solvents, restoration techniques proved to be difficult, making the painting vulnerable to chemical changes in time.

3. Accelerated ageing

Since the development of the first accelerated weathering test equipment at the beginning of the 20th century, which simulated the fading effect of the sun on fabric, to today's complex weathering testing instruments and services, the need

for rapid evaluations of the resistance of materials with respect to their chemical stability and physical durability, and on the other hand the desire to predict the long term behavior of material systems under expected conditions of use, still stands as major aims [5].

Although artificial ageing tests have been used as a general research tool in the past decades, several questions regarding the practical aspects remain, as these tests have proven to have a number of intrinsic problems which have to be considered both when designing the trial and its analysis, and when estimating the significance and accuracy of the results [6].

In the art conservation field, the effort to conduct sensible accelerated-ageing tests can be seen as an attempt in forecasting the effects of certain conservation and restoration treatments. Photochemical and thermal ageing aspects, as well as the effects of other environmental factors such as humidity or outdoor and indoor generated air pollutants, were studied on museum and archival materials. Regions of the visible and ultraviolet spectrum have been investigated for reactions involving yellowing and bleaching of paper and leather, and also chain-breaking and fading due to temperature and relative humidity [7 -8].

In the case of polymer materials, it was observed that long term exposure to sunlight will result in crack formation, chalking of the surface, and changes in color or gloss. The presence of catalyst residues and other impurities will often act as free radical receptors, parts per billion values of sodium in polycarbonate for example, being able to initiate color instability [9].

On another approach, experiments carried in the early 1980s on a large variety of modern artists' colorants and pigments exposed to ozone levels found in the urban areas or to atmospheric nitric acid [10-11], showed that several pigments fade dramatically or suffer significant color shifts.

Taking into consideration the variety of stress agents to whom a work of art could be submitted in time, and none the less the interaction of degradation agents, a comprehensive and reliable assessment of accelerated ageing tests is still a desired quest.

4. Experimental

For the present study five widely used acrylic art paints manufactured by Liquitex® under the BASIC series were chosen: Naphthol Crimson (PR170 Naphthol Carbamide), Primary Yellow (PY74 Arylide Yellow 5Gx), Ultramarine Blue (PB 29 Complex Silicate of Sodium and Aluminum with Sulfur), Dioxazine Purple (PV23 Carbazole Dioxazine) and Yellow Oxide (PY42 Synthetic Hydrated Iron Oxide). Samples of paint were brushed on small rectangular pieces of canvas and for a better understanding of material behavior in complex systems half of each canvas was varnished (extra-fine painting varnish, Lefranc & Bourgeois).

Taking into account the most important environmental stress factors that could induce rapid and significant degradation and aesthetic modifications to the artifacts, the accelerated ageing tests were organized under two sets of investigations: long term UV exposure and microclimate dynamics.

Samples were gradually irradiated with a UV fluorescent lamp at 50, 100 and 230 hours, while for the thermal and humidity ageing a BINDER GmbH climatic chamber was used at specified experimental conditions during 30 days. The climate dynamics was designed to cover temperatures from -5°C to +60°C and a relative humidity between 40% and 60%, at each 24 hours.

In order to evaluate the immediate effects of the weathering tests on regard to the paints properties, colorimetric measurements were carried on all of the samples with the use of a GretagMacbeth ColorEye XTH portable Spectrophotometer.

Due to the wide applicability in measuring and ordering object color, the CIELAB color system was used. Random readings were taken on the surface of each sample and the L* (lightness), a* (red/green) and b* (yellow/blue) coordinates values were systematically registered; ten readings were carried, and an average value was used.

For a better correlation of the results, and in order to identify the possible induced modifications at a chemical level, FTIR spectroscopy measurements were carried with the use of a PerkinElmer Spectrum 100 Series FT-IR spectrometer; for each spectrum 32 scans between 550-4000cm^{-1} were registered, with a resolution of 4 cm^{-1}.

5. Results and Discussion

In the case of all samples examined, data comparison between untreated reference material and artificial aged ones revealed variations of the colorimetric parameters. As expected, the varnish layer acted as a protective coat, for these situations very light modifications of the colorimetric parameters being observed.

In terms of stability with respect to the UV radiation, the red paint (PR170) and both yellows (PY74/PY42) were among the most stable, while the blue acrylic (PB29) and the purple one (PV23) showed the highest sensibility as they faded under long UV exposure hours (Fig.1).

Regarding the thermal treatment it could be seen a slightly decrease of the colorimetric parameters, or in certain situations comparable effects with those from the UV exposure.

Experimental, it was observed for the majority of the samples that the thickness and uniformity of the painting layer pays an important part when colorimetric studies are involved, as in some cases high L*a*b* variations were measured in different points corresponding to the same painted area.

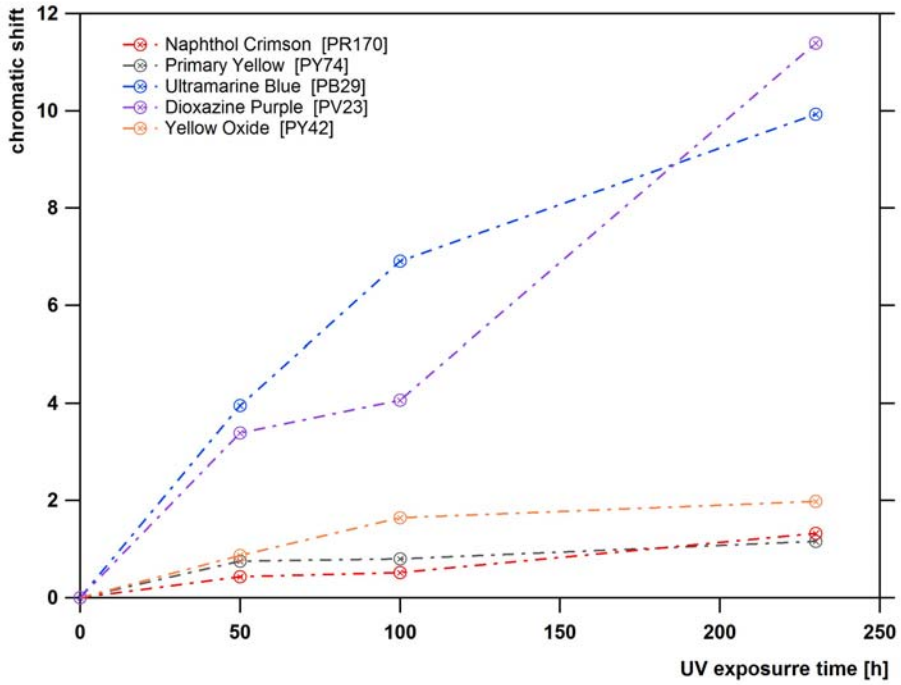

Fig. 1 – total color difference based on UV irradtiaon time for the unvarnished samples

Due to the colorimetric results, it was considered for the FTIR examination only the blue acrylic paint. Characteristic bands of the PB29 pigment were found between 1100-1200cm^{-1} and 700-1000cm^{-1}, as well as specific absorption bands of the acrylic polymer emulsion within the region 1760-1665 cm^{-1}. Besides some minor variations in the absorption bands intensity than can be assessed to the relative thickness of the painting layer, FTIR data didn't reveal any significant changes induced in the aged materials (Fig.2).

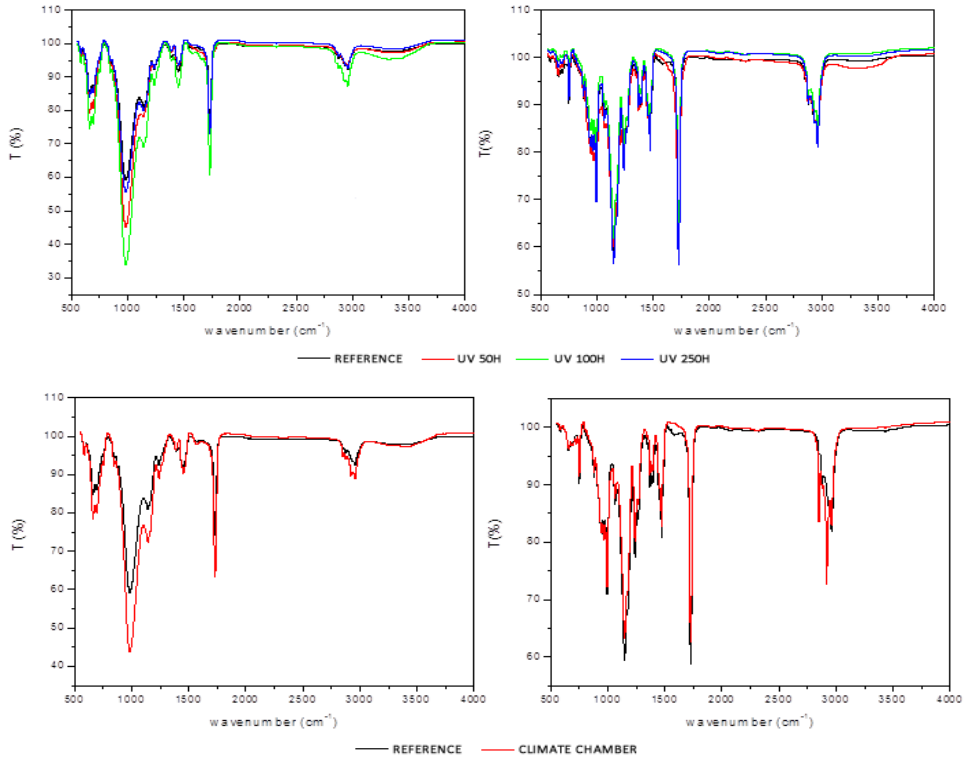

Fig. 2 - IR spectrum comparison between reference and accelerated aged blue acrylic samples; varnished samples on the right side

A shift of the absorption bands within the spectral region 700-1200 cm^{-1} was observed though when comparing the spectrum of the varnished and unvarnished regions of the reference sample (Fig. 3), fact that may indicate some type of interaction of the painting layer with the applied vernis, probably a transition of one compound into another.

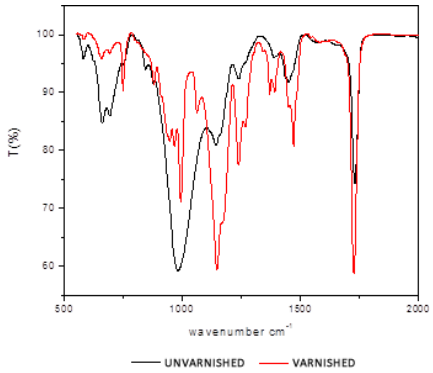

Fig. 3 - IR transmittance spectra for the reference blue acrylic samples

6. Conclusions

Overall, on a first examination, the majority of the acrylic paints tested appeared to be quite stable, but as the measurements were taken in narrow points, thin or patchy deterioration products formed on the paint surfaces might still be present. For a clear view thus and for an accurate evaluation of the stability range for these type of materials, and ultimately for better documented, accessible, and reliable collections of reference materials with which analytical methods can be developed and ageing studies conducted further studies are needed, along with the optimization and validation of the procedures according to the characteristics and particularities of each tested material.

Acknowledgements

The presented activities are part of the national project "Contemporary Visual Art Conservation Platform", funded by ANCS, CNDI – UEFISCDI, Partnerships in prioritary domains, project number: PN-II-PT PCCA-2011-3.2-0342

R E F E R E N C E S

[1] Conservation Issues of Modern and Contemporary Art (CIMCA), Museum of Modern Art, New York, 2008
[2] *L. Angheluta, A. Moldovan, R. Radvan*, The teleoperation of a LIF scanning device, University Politehnica of Bucharest Scientific Bulletin - A Series, Applied Mathematics and Physics, **vol. 73**, no. 4, pp.193-200, 2011
[3] *D. Ene, R. Radvan*, Interactive digital representation of Sasspol temples, Journal of Optoelectronics and Advanced Materials, **vol. 12**, no. 6, pp. 1394-1398, 2010
[4] *M. Watherston*, "The Cleaning of Color Field Paintings", in E. Carmean (ed), The Great Decade of American Abstraction: Modernist Art 1960-1970, Museum of Fine Arts, Houston 1974, pp.119-29
[5] *R. L. Feller*, Accelerated aging: photochemical and thermal aspects, Getty Conservation Institute, 1994
[6] *R. P. Brown*, A Review of Accelerated Durability Tests, Versailles Project on Advanced Materials and Standards (VAMAS Report no. 18), 1995
[7] *R. L. Feller, M. Curran, C. W. Bailie, V. Colaluca, J. Bogard*, Evaluation of Procedures Used in Accelerated Photochemical Aging Testing of Museum and Archival Materials, Getty Conservation Institute, 1989
[8] *N. Herascu, M. Simileanu, R. Radvan*, Color changes in the artwork materials aged by UV radiation, Romanian Reports in Physics, **vol. 60**, no. 1, pp. 95-103, 2008
[9] ZEUS Technical Whitepaper (2005), UV Properties of Plastics: Transmission & Resistance | http://www.zeusinc.com

[10] *G. R. Cass, W. W. Nazaroff, D. Grosjean, P. Whitmore, J. R. Druzik*, Protection of Works of Art from Damage Due to Photochemical Smog, Getty Conservation Institute, 1985
[11] *L. G. Salmon, G. R. Cass, D. Grosjean, M. C. Jones, M. P. Ligocki, W. W. Nazaroff*, Protection of Works of Art From Atmospheric Nitric Acid, Final Report to the Getty Conservation Institute, 1992