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Water Fastness of Screen Printed Pearl Luster Pigments based on Synthetic and Natural Mica on Polyvinyl Chloride Foil and Rich Mineral Paper

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Abstract:

The present study attempts to examine water fastness of screen printed pearl luster pigments based on synthetic and natural mica on polyvinyl chloride foil and Rich Mineral Paper. Three types of pearl luster pigments were used, each different from the other in composition, interference colour and particle size: one pigment based on synthetic mica (Pigment 1) and two pigments based on natural mica (Pigment 2 and Pigment 3). Pearl luster pigments were applied to the printing base (PVC transparent base) in 15wt.% concentration and printed by means of screen printing technique. The test of water fastness was made on prints, where the samples were soaked in distilled water for 6 and 12 days. It was established that this water treatment did not have any significant impact on the durability of screen printed pearl luster pigments. The pigments could demonstrate slightly better water fastness after being printed on Rich Mineral Paper.

Keywords:

Water Fastness, Pearl Luster Pigments, PVC foil, Rich Mineral Paper, Surface Roughness.

1. Introduction

Pigments are substances consisting of particles which are practically insoluble in the application medium. They are differentiated and classified with respect to the way they interact with light *(Pfaff et al, 2008)*. They are also substances that give a medium such as print or coating its actual colour. As opposed to dyes, pigments are minute, insoluble particles. They are divided into organic pigments, which originate from flora or fauna, and inorganic pigments, whose origin can be natural or synthetic. Natural sources of inorganic pigments are earth and minerals. Mica is one of the constituents of inorganic pigments from natural sources and it is a general name for a group of complex hydrous potassium-aluminium silicate minerals that differ in chemical composition. One of the most important applications of mica are pearl luster pigments, which belong to special effect pigments, and consist of transparent mica flakes coated on all sides with a thin layer of metal oxide, mostly titanium dioxide *(Štengl et al, 2003)*. The mica substrate acts as a template for the synthesis and as a mechanical support for the deposited thin optical layers of the pearl luster pigments *(Buxbaum and Pfaff, 2005)*. Mica can also be produced synthetically. Synthetic material is clear and the resulting effect is pure *(Pearl Effect, 2012)*.

Special effect pigments suitable for outdoor applications mus t meet the highest standards for colour fastness and weather resistance *(Pfaff et al, 2008)*. Many pigmented systems show a characteristic colour or structural changes when subjected to intense radiation or weathering. The best known are yellowing, chalking, loss of gloss and change of roughness. These processes involve photochemical reactions in which the pigment can act as a catalyst or in which the pigment itself undergoes chemical changes. Inorganic pigments, which include also special effect pigments, are chemically very stable and are rated as one of the most stable colouring matters. This is especially true for oxide pigments, which often have a highly protective effect on the substrate *(Buxbaum and Pfaff, 2005)*. During natural or artificial aging of colorants or colour formulations, the corresponding colour values change constantly. Colorations with effect pigments lose their initial colour physical properties due to physical or chemical influences. Due to the composition, morphology, and a greater size of such particles compared to the absorption pigments, the effect flakes present a bigger target. The consequences of natural or artificial degradation of effect colorations can be partially pursued with specially geared colorimetric evaluation methods *(Klein, 2010)*.

Two most critical elements with regard to water fastness are ink formulation and printing substrate. Pigmented inks, due to their crystalline structure, have better water fastness than dye-based inks *(Vikman, 2003)*.

This study deals with the impact of distilled water on water fastness of screen printed pearl luster pigments based on synthetic and natural mica on polyvinyl chloride (PVC) foil and Rich Mineral Paper (RMP).

2. Experimental

2.1 Screen printing of pearl luster pigments

In this study, three types of pearl luster pigments were used, which differed in composition, interference colour and particle size: one pigment based on synthetic mica *Iriodin®6103 Icy White* (further as a Pigment 1) and two pigments based on natural mica: *Iriodin® 524 Red Satin*(Pigment 2) and *Iriodin® GP Rutile Blue-Green WNT* (Pigment 3). Basic properties of pearl luster pigments are presented in Table 1.

Pearl luster pigments were applied to the printing base (PVC transparent base) in 15wt.% concentration and were printed by means of screen printing technique (Screen Printer TSH Print Swiss S550) on black polyvinyl chloride (PVC) foil and double coated Rich Mineral Paper (RMP). The mesh density was 120 threads/cm.

2.2 Testing methods

The test of water fastness was made in accordance with the standard SIST ISO 11798:2003. Samples of screen printed pearl luster pigments were soaked in distilled water for 6 and 12 days. The colorimetric properties (L*a*b* and L*C*h*) of the prints were measured before and after soaking, using Tehkon SpectroDens spectrophotometer (D50 standard illumination, 2° standard observer, 0°/45°). Based on these measurements, it was possible to calculate the colour

Table 1: Properties of pearl luster pigments.

Pigment type	Composition	Form	Color	Particle size
Iriodin®6103 Icy White (Pigment 1)	Mica: 68-76% TiO_2: 24-31% SnO_2: 0-1%	Dry, free-flowing powder	Silver-white	5-40 μm
Iriodin®524 Red Satin (Pigment 2)	Mica: 39-45% Fe_2O_3: 55-61%	Dry, free-flowing powder	Red	5-25 μm
Iriodin®GP Rutile Blue-Green (Pigment 3)	Mica: 41% TiO_2 (Rutile)+$CoTiO_3$: 57.5% ZrO_2: 1% SnO_2: 0.5%	Dry, free-flowing powder	Turquoise	5-40 μm

difference according to Eq. (1), the chroma difference to Eq. (2) and the hue difference according to Eq. (3), which appeared after soaking.

$$\Delta E^* = \sqrt{(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2} \quad (1)$$

$$\Delta C^* = \Delta C_{6/12days} - \Delta C^*_{0day} \quad (2)$$

$$\Delta H^* = \sqrt{(\Delta E^*)^2 - (\Delta L^*)^2 - (\Delta C^*)^2} \quad (3)$$

where $\Delta L^* = L^*(t) - L^*(0)$; $\Delta a^* = a^*(t) - a^*(0)$; $\Delta b^* = b^*(t) - b^*(0)$ are differences calculated for soaked (6/12 days) print and the original print (0 day) *(Golob et al, 2001)*.

The average surface roughness (R_a) of unsoaked and soaked prints was measured with a Surface Roughness Tester TR200, which uses contact profilometry.

3. Results and Discussion

3.1 Colorimetric change of screen printed pearl luster pigments

To examine the influence of distilled water on screen printed pearl luster pigments, the colour, chroma and hue difference of pigments after soaking were determined. Figures 1-2 summarize colour differences of pearl luster pigment printed on PVC foil and Rich Mineral Paper.

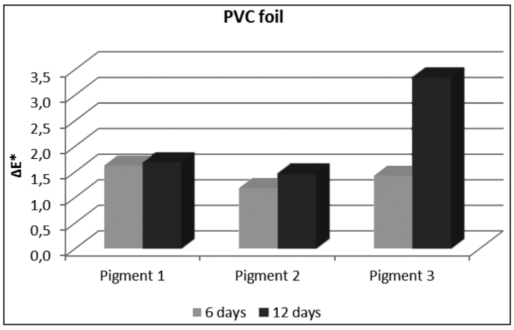

Figure 1: Color differences of pearl luster pigments printed on PVC foil.

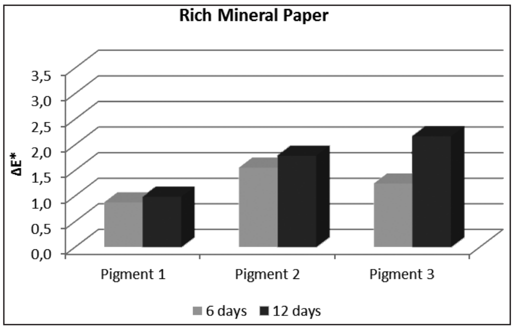

Figure 2: Color differences of pearl luster pigments printed on Rich Mineral Paper.

The results obtained show that there are differences in water fastness of the pigments printed on PVC foil (Figure 1) and the pigments printed on Rich Mineral Paper (Figure 2). It was established that with both printing substrates the pigments were very durable. The change of water damage increases as prints are stored for extended periods of time. Dye-based inks can be very susceptible to water damage, while pigment-based prints are relatively water-resistant *(Image Permanence Institute, 2007)*. Colour differences have not exceeded the value of 3, which corresponds to negligible changes in colour. The only exception was Pigment 3 printed on PVC foil, which gave the least satisfactory results after 12 days of soaking (ΔE*=3.3). Pigment 2 with the lowest colour difference after 12 days of soaking showed the best results on PVC foil (ΔE*=1.5). Pigment 2 is based on natural mica which is coated with a layer of Fe_2O_3 (see Table 1). Effect pigments which contain iron oxide are very stable and are practically insoluble in water *(Barle, 2003)*. Pigments printed on Rich Mineral Paper were noticed to demonstrate better water fastness after 12 days of soaking in distilled water. The best water fastness obtained Pigment 1 printed on Rich Mineral Paper, produced with a synthetic mica substrate that contains virtually no natural impurities, such as iron oxides and is therefore completely colour neutral. This is the reason why it offers better luster and brightness than traditional pigments, as well as outstanding sparkle effects in all shade areas *(Merck Chemical International, 2012)*.

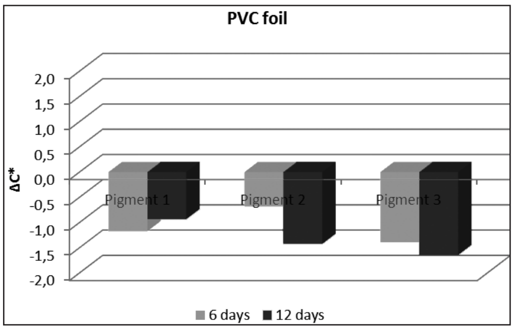

Figure 3: Chroma differences of pearl luster pigments printed on PVC foil.

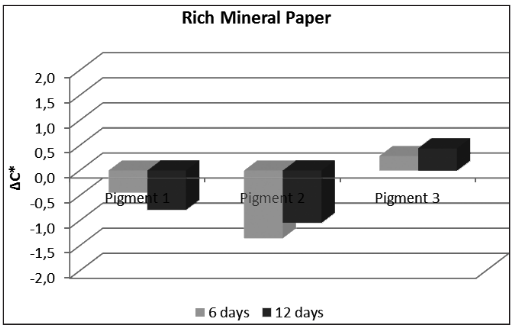

Figure 4: Chroma differences of pearl luster pigments printed on Rich Mineral Paper.

Figures 3-4 show significant discrepancies in chroma difference between pigments printed on PVC foil and Rich Mineral Paper. All three pigments printed on PVC foil became less pure after 12 days of soaking in distilled water, especially Pigment 3 (ΔC*=-1.6). An outstanding feature of Pigment 3 is its unique flop behaviour into green, its intensive colour and its colour clarity when used in coating applications. Pigment 3 is semi-transparent and has a green mass tone. It lends itself particularly for outdoor applications *(Merck Chemical International, 2012)*. It is evident from Figure 4 that Pigment 3 printed on Rich Mineral Paper became more pure after soaking. The biggest change was noticed for Pigment 2, where the chroma difference reached value of ΔC*=-1.4.

Figures 5-6 present hue differences of pearl luster pigments printed on PVC foil and Rich Mineral Paper.

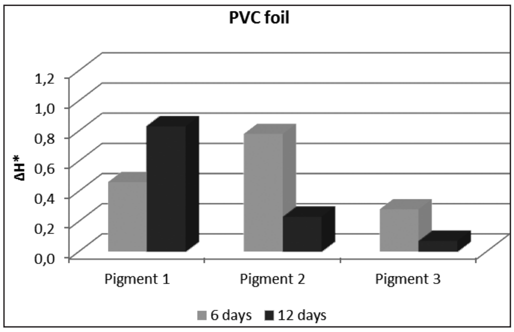

Figure 5: Hue differences of pearl luster pigments printed on PVC foil.

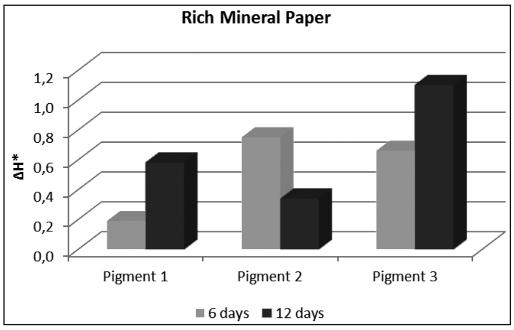

Figure 6: Hue differences of pearl luster pigments printed on Rich Mineral Paper.

The influence of distilled water on the hue difference of pearl luster pigments has resulted in considerable changes. For Pigment 3 printed on PVC foil surprisingly good results were obtained. On the other hand, Pigment 1 and Pigment 2 were noticed to have a slightly bigger hue difference. Among all three pigments printed on Rich Mineral Paper (Figure 6), Pigment 3 obtained the largest hue difference after 12 days of soaking, where the values reached ΔH*=-1.1.

3.2 Change in surface roughness of screen printed pearl luster pigments

Roughness of the printing substrate is a very important property for print quality. Surface roughness is usually divided into microscale and macroscale components (Xu et al, 2005). Printing substrates used in this study differ in surface roughness, where PVC foil has R_a= 2.223 and Rich Mineral Paper has R_a=1.418. Figures 7-8 summarizes the surface roughness (R_a) of pearl luster pigments printed on PVC foil and Rich Mineral Paper.

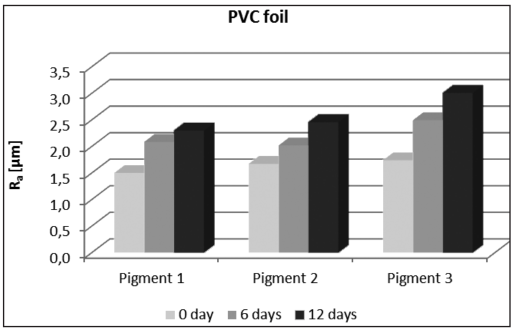

Figure 7: Surface roughness (R_a) of pearl luster pigments printed on PVC foil.

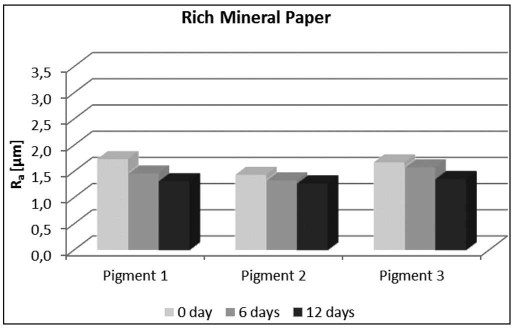

Figure 8: Surface roughness (R_a) of pearl luster pigments printed on Rich Mineral Paper.

A comparison of the results of unsoaked printed pigments on PVC foil shows similarly surface roughness (R_a=1.5 for Pigment 1, R_a=1.7 for Pigment 2 and Pigment 3). As can be seen from Figure 7, surface roughness experienced extreme increase after 12 days of soaking, especially at Pigment 3. On the other hand, distilled water on pigments printed on Rich Mineral Paper (Figure 8) didn't have any impact whatsoever on surface roughness. The surface of Rich Mineral Paper is more hydrophilic than that of a PVC foil, this corresponds to lower obtained surface roughness of printed pigments. The research showed that surface roughness decreased for all three pigments printed on Rich Mineral Paper after soaking.

4. Conclusions

The technique of water fastness was applied in the durability investigation of screen printed pearl luster pigments based on synthetic and natural mica on PVC foil and Rich Mineral Paper. The results obtained during processes of distilled water treatment indicated that pigment based on synthetic mica (Pigment 1) and also both pigments based on natural mica (Pigment 2 and Pigment 3) have good water fastness. The only exception was Pigment 3 printed on PVC foil, where a slight increase in colour difference, chroma difference, and surface roughness was noticed after 12 days of soaking in distilled water. The printing substrates have also affected water fastness of the printed pigments examined in this study, slightly better results obtained Rich Mineral paper.

Acknowledgements

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