Moisture Isotherms of Acrylic Emulsion Paints

Introduction

The physical and chemical behavior of modern artists' materials needs to be determined to insure a proper understanding of how paintings made from these materials will behave under different environmental conditions and conservation treatments. Reviews of the subject show changes in dimension and physical and mechanical behavior with moisture content by either changes in relative humidity (RH) or immersion in water (1,2). A previous article described the weight losses encountered in artists' acrylic emulsion paints as they initially dried (3). The data developed in that article indicated that the weight loss process was not complete even after 4 years, but the majority of weight loss had at least occurred within the first year. Since the majority of weight change had occurred in this time, the samples were then considered to be mature with weight changes due only to the loss of less volatile components than water. These four year old acrylic paints were then used to determine the moisture isotherm of 25 different paints with five different pigments.

There is data that demonstrate changes in acrylic emulsion paints with the addition of atmospheric moisture alone. These include increased turbidity, swelling, changes in glass transition temperature, and changes in mechanical properties (1,4,5). The magnitude of these changes can be assessed by the amount of water bound with changes in RH. These changes due to atmospheric moisture should be understood before evaluating the effects of solvent or aqueous conservation treatments.

Materials and Methods

Acrylic emulsion paints were purchased from Golden Acrylics, Winsor & Newton Finity Artists' acrylic color, Grumbacher Academy acrylics, Liquitex Basics acrylic color, and Dick Blick Artists' acrylic. The paints tested were those described as titanium white, ultramarine blue, burnt sienna, burnt umber, and yellow ochre.

The acrylic emulsion paints were first cast on to mylar strips, and some specimens were also spread on smaller strips with a spatula. These paints were weighed over 4 years until weight losses were minimal. These specimens were then desiccated to an RH of 26% from ambient RH (~45%). The moisture isotherm was then determined. A plexiglas environmental chamber was used to hold the specimens, and equilibrated silica gel was used to control the RH for the ascending and descending values. The ambient temperature was at 21° C. Specimens were weighed after equilibration for 10 days at each R H value. The final moisture isotherm plots were between 16% and 92% RH. Weight measurements were made to 0.1 mg using a Mettler AT 01 balance.

Results

The moisture content of an acrylic paint depends upon the ability of both the pigment and the binding medium to hold water. Earth colors such as yellow ochre, burnt sienna, and burnt umber may contain clays that have the capacity to bind a considerable amount of water while pigments such as titanium white and ultramarine blue bond less water. To ensure that the paints are at equilibrium, 10 days were allowed for moisture diffusion to occur. Figure 1 shows a plot of weight loss versus time for two different burnt umber acrylic paints on changing the RH from 70% to 52%. The plots show that the weight changes are complete within 10 days.

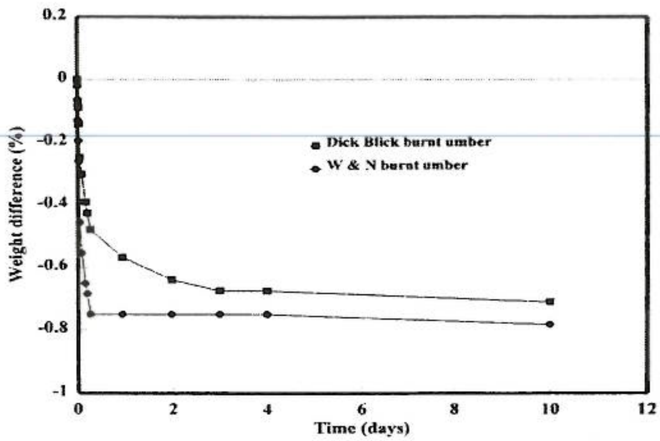

Figure 1 shows a plot of weight loss versus time for two burnt umber acrylic emulsion paints during a change in RH from 70% RH to 52% RH. The plots level off by 10 days.

Figure 2 shows the moisture isotherm plots for 5 different titanium dioxide acrylic emulsion paints. The plots cluster into two groups indicating similar responses to changes in RH. From an environmental point of view there is less than a 1% change in weight between 35% and 60% RH for all paints. The greatest change from 16% to 92% RH was a 4% increase in weight.

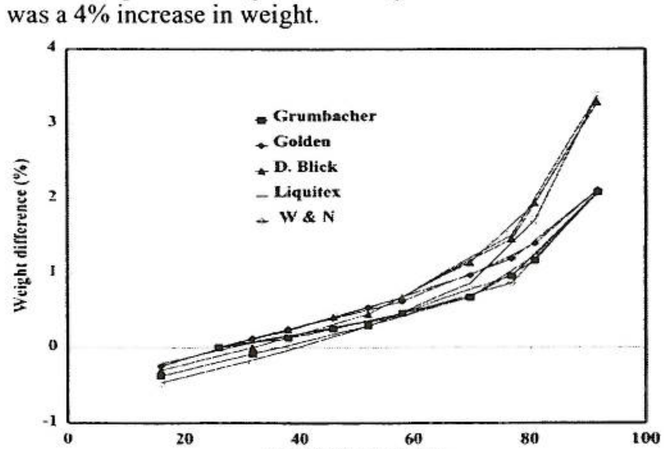

Figure 2 shows moisture isotherm plots for five titanium dioxide acrylic emulsion paints between 16% and 92% RH.

Figure 3 shows similar plots for 5 different ultramarine blue paints with a less clustered grouping of behavior. Again the change in weight between 35% and 60% RH is less than 1%. The greatest change from 16% to 92% RH was also a 4% increase in weight.

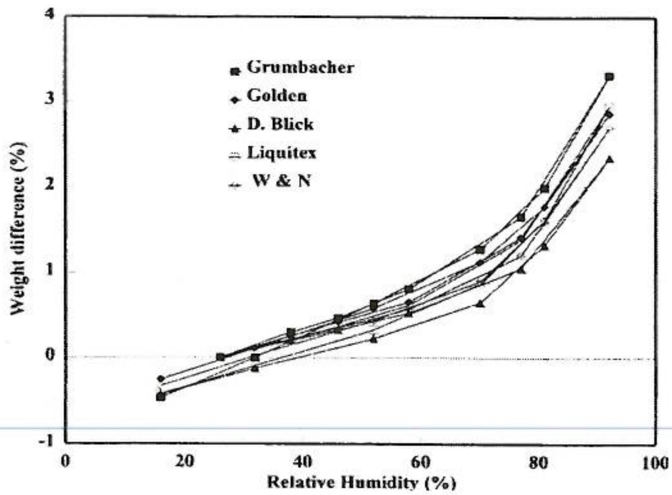

Figure 3 shows moisture isotherm plots for five ultramarine blue acrylic emulsion paints between 16% and 92% RH.

Three earth colors were tested as well. Figure 4 shows the moisture isotherm plots for 5 different burnt umber paints. The plot for the Grumbacher paint only shows the ascending curve because of damage to the specimen when the desorption curve was run. The maximum change in weight between 35% and 60% RH was approximately 1.5%. The maximum weight gain was, however, over 6% for the 16% to 92% isotherm.

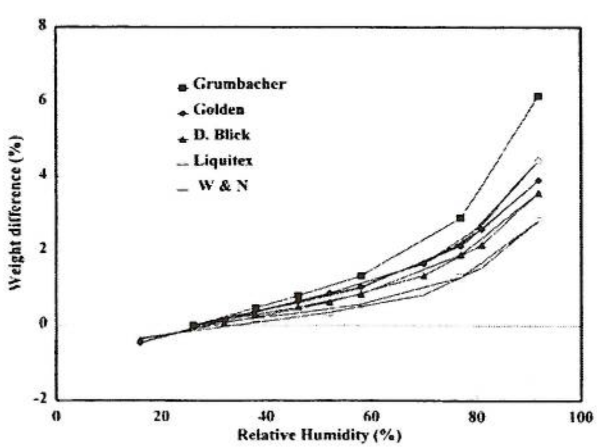

Figure 4 shows moisture isotherm plots for five burnt umber acrylic emulsion paints between 16% and 92% RH.

Figure 5 shows a similar plot for 5 burnt sienna paints. Four of the five plots are very similar but one shows a considerable difference in having a much greater response to moisture. The maximum change in weight between 35% and 60% is about 1%. The maximum weight gain was, however, over 6% for the 16% to 92% isotherm.

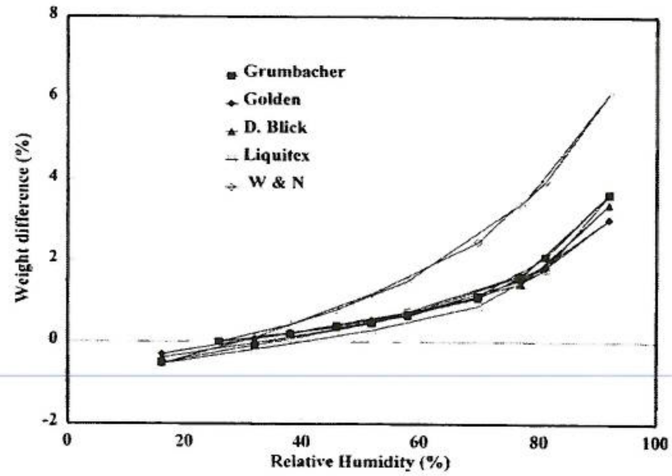

Figure 5 shows moisture isotherm plots for five burnt sienna acrylic emulsion paints between 16% and 92% RH.

Figure 6 shows the final set of isotherm plots for yellow ochre paints. There is less than a 1% change in weight between 35% and 60% RH for each of the paints. The maximum change in weight over the whole isotherm is about 4.5%.

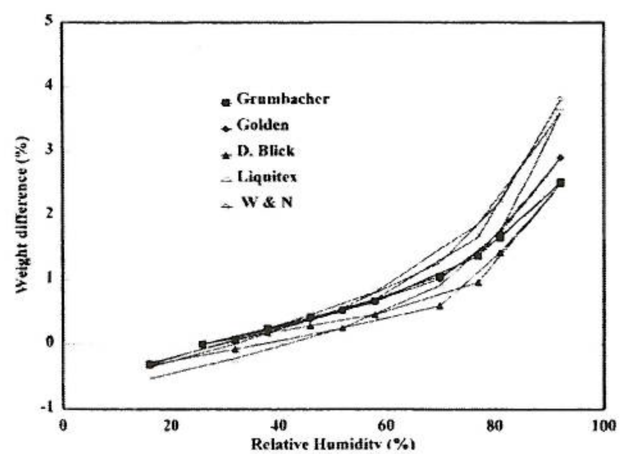

Figure 6 shows moisture isotherm plots for five yellow ochre acrylic emulsion paints between 16% and 92% RH.

Moisture Isotherms of Acrylic Emulsion Paints, continued

Conclusions

Different pigments show different responses to changes in RH with the earth pigments absorbing more moisture. Pigment concentration and/or different sources of pigments may also change this response to moisture.

The moisture isotherms for the acrylic emulsion paints show varying responses to water particularly at high RH, but this response is not as dramatic within the general environmental region of 35% to 60% RH where storage and exhibition take place. Equilibration at high RH can lead to considerable moisture uptake, up to several percent, and this will certainly alter the physical properties of the paint film by swelling or plasticization.

Hysteresis, i.e. different plots for increasing and decreasing moisture content with RH, within the 16% to 92% region seems to be minimal, indicating that the process is reversible within this region. This also indicates that the 10 day equilibrium time was adequate since a non-equilibrated system should show unequal plots.

Experiments at RH above 92% generally showed the formation of mold although this seemed to vary from pigment to pigment and manufacturer to manufacturer.

While our data was collected for a mature acrylic film, the moisture uptake of immature films may interfere with the process of coalescence to form the final continuous film.

References

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Review:
Research & Technical Studies

One of the main messages from the recent AIC annual meeting in Portland, Oregon is that conservation science is alive and strong, with new tools and procedures promising innovative solutions for old problems and questions. For those of us working to support science applications and research, this is every year's message, but it is often diluted by being sprinkled over many specialty group sessions.

This year was no exception. However, the Research and Technical Studies (RATS) session was certainly a place to revel in conservation science's robust health. No doubt the credit belongs to the RATS officers/organizers, Alison Murray, Ellen Chase, and Joseph Swider who provided a focused theme on lighting and drew an impressive international contingent of participants. They also assembled an excellent CD-ROM containing seven of the presentations. Still, a clear vision needs clear content, and the impressive line-up of speakers clearly delivered it.

First there are the new tools. The central theme of the session revolved around lighting practices and light damage and management. There were two papers presenting overviews of current tools - indoor light stability testing by Jeffrey Quill of Q-Panel Lab Products and Mark Gottsegen's paper on using ASTM standards. There are several important organizations that produce only standards such as ANSI, ISO, and ASTM as well as professional organizations that recognize their own unique standard needs such as ASHRAE (American Society of Heating, Refrigerating, and Air Conditioning Engineers). ANSI standards are better known to those who follow photography conservation, and ISO is familiar from its omnipresent attachment to the ISO Blue Wool standards.

But an ASTM resource of considerable value is the subcommittee ASTM D01.57, Artists' Paints and Related Materials. This group, like all ASTM committees, represents a collaboration between users, manufacturers, and scientists, and is the principle voice for quality and safety in traditional media products and accurate labeling of their contents. Conservators often participate in its twice annual meetings but in this reviewer's opinion the attention from the conservation community is not always proportionate to the value we derive from their work.

For fading evaluations ASTM D01.57 provides several standardized test methods. Mark Gottsegen's paper addressed particularly ASTM D 4303 and the strengths and limitations of using the ISO blue wools. Over the last 25 years that the ISO Blue Wools have been used in museum light exposure testing there have been some difficulties with their correlations from exposure condition to exposure condition. Also, two different types of standards have been made and sold that use different dye sets, and wool yellows as it is exposed to light. This makes some visual comparisons more difficult. Nevertheless, the author concludes that the standards are a valid and valuable methods for light