Waters Lab Highlights

An Internal Communication of Applications and Techniques

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Using GPC to Monitor the Weathering of Polymers Used in the Conservation of Cultural Objects

The goal of conservation science is to study methods of preservation of cultural, artistic and historical heritage and understand mechanisms of deterioration. Ideally, materials used for treatment of outdoor objects should be able to withstand high levels of solar radiation, temperature changes including freeze-thaw cycles, rain, and pollutants typical for an urban setting. A recent paper[1] has reported an approach using GPC to determine the failure of an adhesive used in art conservation by following the molecular weight degredation of the restorative polymer. The application is a clear example of how modern HPLC is delivering benefits to society.

Two panels were prepared to conform to standard conservation practice; one panel was kept in a controlled laboratory environment in the dark, and the other panel was exposed to the outdoor environment on the roof of the museum laboratories. One half of the exposed panel was sheltered with a sheet of glass; the other half was left uncovered. Visual observations and photographic documentation were recorded throughout the one year exposure. Samples of exposed and unexposed material were scraped from the panels, and analyzed on Ultrastyragel™ columns.

Weld-On #40. Figure 1, is the chromatogram of an adhesive (acrylic resin) used in art conservation. In spite of the visual observation of adhesion loss to the glass substrate, Weld-On #40 showed the best chemical resistance to the outdoor weathering in comparison to the other materials under study. There was less than a 15% decrease in the number-average molecular weight (M_N) and weight-average molecular weight (M_W). The reason for the adhesion failure on glass is unknown at this time.

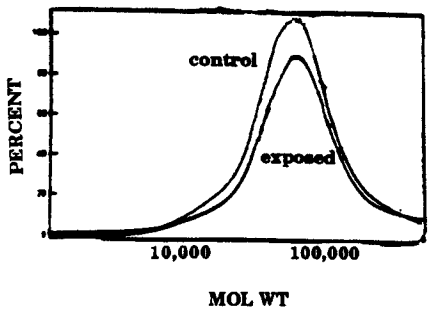

Figure 1. Molecular weight distributions (MWD's) of unexposed and exposed Weld-On #40

Acryloid B72. Figure 2 shows the chromatogram of an acrylate-ethylmethacrylate copolymer used as an adhesive, coating and consolidant. After one year of

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outdoor exposure, Acryloid B72 did not show any visible changes of color, surface topography or adherence to the glass panel, and only slight increase in brittleness was noted. Despite this fact, GPC results indicate a weathering effect on the polymer such that the polydispersity (d) of the copolymer increased almost 50%. There was a 23% decrease in M_N which can be correlated with observed changes in brittleness. The 15% increase in M_W, however, provides for greater tensile strength. Perhaps, both modes of polymer degradation counter each other and cause apparent stability of the polymer even though there were changes in the distribution.

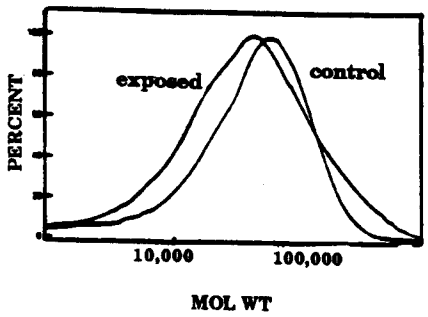

Figure 2. MWD's of Acryloid B72 unexposed and exposed.

Duco Cement. Figure 3 is a chromatogram of a cellulose nitrate adhesive which is not recommended for use in art conservation due to its short service life. The control sample stored in the dark was clear, but it did not adhere well to the glass plate. In addition to poor adhesion, the outdoor exposed sample also developed yellow-brown discoloration and became very brittle. There was a 90% decrease in M_N and M_W which corresponds to the observed decrease in film strength and increase in film brittleness.

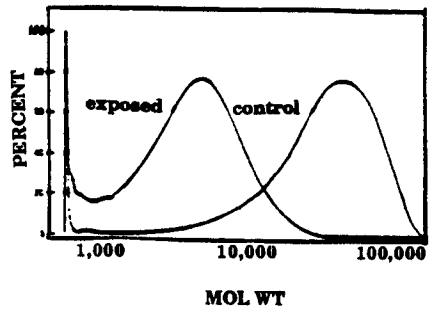

Figure 3. MWD's of Duco Cement unexposed and exposed.

Conclusion. GPC, in combination with physical testing methods, can provide valuable information about stability under long term exposure to outdoor environment. Furthermore, molecular weight distributions helps to predict the changes in exposed polymers which parallel the visual observations. In addition, the quantitative results from GPC provide an opportunity to study degradation kinetics. Cellulose nitrate materials degraded rapidly, illustrating their unsuitability for use where long term stability is desired. The analysis of Weld-On #40 demonstrated good stability of the polymer. (However, there may be other aesthetic or material science criteria for deciding to use this product.) In the case of Acryloid B72, GPC was able to show a state of polymer changes not apparent by visual observation.

References

1. Cecily M. Druzik and Herant P. Khanjian (The Getty Conservation Inst., 4503 Glencoe Ave., Marina del Rey, CA 90292) and Susan E. Lansing (The J. Paul Getty Museum, 17985 Pacific Coast Hwy., Malibu, CA 90265), GPC Symposium, 1989, Waters Chromatography Division (1989) in press.

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