ACCELERATED AND OUTDOOR DURABILITY TESTING OF organic materials

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Foreword

This publication, *Accelerated and Outdoor Durability Testing of Organic Materials,* contains papers presented at the symposium of the same name, held in Fort Lauderdale, FL on 19–20 Jan. 1993. The symposium was sponsored by ASTM Committee G-3 on Durability of Nonmetallic Materials and ASTM Subcommittee D01.27 on Accelerated Tests. Warren D. Ketola of the 3M Company in St. Paul, MN and Douglas Grossman of The Q-Panel Company in Cleveland, OH presided as symposium chairmen and are editors of the resulting publication.

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Overview

Recent advances in polymer chemistry and stabilization and increasing consumer demands for longer lasting products require use of faster, more reliable methods to evaluate durability of materials. However, there is no lack of controversy about how to properly test materials for resistance to sunlight, rain, and atmospheric acid and salt. Even when agreement is reached on a method of exposure, there is still controversy about how far one can go in drawing conclusions from the exposure data. Proper use of results from accelerated tests depends on understanding: (1) how the exposure stresses in the accelerated test match those found in field use and (2) impact of variability in results from accelerated tests and outdoor exposures.

In January of 1993, ASTM Committee G-3 on Durability of Nonmetallic Materials, in conjunction with ASTM Subcommittee D1.27 on Accelerated Tests for Paints, sponsored a symposium on Accelerated and Outdoor Testing of Organic Materials. This publication is a result of this January 1993 symposium. It covers research in characterization of exposure tests and new developments in exposure equipment and exposure test design. The following paragraphs provide a brief overview of how the results presented in the papers address important issues.

Characterization of Exposure Tests

A good understanding of the primary exposure stresses to which materials are exposed during "natural weathering" is essential for explaining the mechanism and rate at which materials degrade and for providing a "target" environment for the development of appropriate laboratory accelerated tests. In order to make better use of exterior and laboratory exposure tests, it is important to fully characterize the level and consistency of the critical stresses (UV radiation, temperature, and moisture). Variation in stress level or intensity is the primary cause of variability in all exposure tests. As pointed out by Fischer, it is important to understand and characterize the variability in order to appropriately use the results from exposure tests for evaluation of new or modified products and for specifying the performance of existing products. The papers included in this section cover solar ultraviolet radiation, the effect of spectral distribution of the light source on degradation mechanism, use of radiant energy dose as a way to "time" exposures, the surface temperatures of materials subjected to exterior and laboratory accelerated weathering tests, and how glass transmission and seasonal variation in solar energy effect results for materials exposed to glass filtered sunlight.

Zerlaut provides an excellent review of current knowledge of the solar UV spectrum, how it is measured, and how and why it varies, particularly with atmospheric ozone levels. He also points out the need for monitoring solar UVB radiation and how laboratory accelerated tests that expose materials to high irradiance in the short wavelength UV-B region can significantly alter degradation mechanisms. Martin, et al. compare the methods used within the medical and agricultural communities for characterizing the effects of solar ultraviolet radiation with the measurement of broad band total UV typically used to characterize the effects of UV radiation in the coatings industry. They conclude that measuring spectral UV irradiance, material absorption spectra, and spectral quantum yield for photodegradation to determine an integrated "total effective UV dosage" can provide a better approach to predicting service life of materials exposed outdoors.

Searle discusses the interaction of UV radiation on polymers and shows how degradation mechanism depends on the spectral absorption of the material and the spectral emission properties of the light source. This is described by the activation spectrum, which also depends on specimen thickness and the presence of stabilizing additives in the polymer. She also shows examples where different spectral emission bands from the same light source can produce antagonistic effects (e.g., yellowing and bleaching) in polymers. Grossman shows that variations of over 200% in degradation are possible when identical materials exposed to identical dosage of UV radiation. The use of UV radiant exposure as a method for comparing exposures is only feasible when the temperature, moisture conditions, and the spectral power distribution of the light source used for the exposure test are identical, or where it can be shown that moisture and temperature have no effect on rate of degradation.

Fischer and Ketola compare the surface temperatures of a series of colored specimens measured in typical exterior and laboratory accelerated tests, and show that the temperature separation of colored specimens in outdoor exposures depends primarily on total solar irradiance. A linear regression procedure to predict temperature of different colors from black panel measurements provided excellent agreement with actual measurements. In laboratory accelerated tests, radiant heating from the light source determines the temperature separation between dark and light colors. This becomes especially important in the "high irradiance" devices now being used, where exposures at very high irradiance can actually produce slower degradation when surface temperature of light colored specimens is very low relative to that of a black panel used to control device operation.

Fischer provides a summary of an extensive series of round-robin tests conducted by ASTM subcommittee G3.03 to develop precision statements for ASTM standards G 23, G 26, and G 53, which describe carbon arc, xenon arc, and fluorescent UV exposures, respectively. The results show that identical tests performed in different labs show poor absolute reproducibility in terms of gloss loss, but excellent reproducibility in terms of relative rankings of durability. Fischer recommends that ASTM standards for these tests warn that conclusions can only be drawn relating to relative durability, not absolute durability.

There are two papers that deal with sources of variability in exposures to glass-filtered daylight. Ketola and Robbins quantify the variability in UV transmission of single strength window glass and show how it is related to iron content. They also show how UV transmission differences can affect the rate of photodegradation for materials exposed behind glass. Crewdson and Bahadur-Singh show how degradation of materials exposed behind glass is affected by seasonal variation in solar radiation and by differences in the window glass transmission. Their paper also provides an excellent illustration of how the use of multiple replicate specimens of each material can detect subtle differences between materials. This work forms the foundation for revising and improving ASTM G 24 and other standards describing exposures to glass-filtered daylight.

New Test Developments

Equipment manufacturers continue to develop and modify exposure devices in an effort to provide faster, more reliable tests. The papers in this section describe some of the new equipment available and how it is being used. Robbins provides an excellent review of the development of solar concentrating exposure devices and gives a summary of recent advances in ASTM G 90 Fresnel concentrator type solar exposures. Suits describes work done within the ASTM D 35 committee to develop accelerated tests based on xenon arc and fluorescent UV exposure for assessing the durability of geosynthetic fabrics. This paper also discusses problems with variability and meaningful interpretation of results. Fedor and Brennan describe irradiance control and high irradiance testing in fluorescent UV devices, and illustrate how this can improve reproducibility and shorten test times with UVA fluorescent lamps. A paper by Suga and Suga and a paper by Scott describe high irradiance xenon exposures and illustrate how they have been used to rapidly evaluate color stability of fabrics.

The next paper, also by Suga and Suga, describes a method for simulating acid rain corrosion using a modified salt-spray chamber and compares results from this test to those for tests at several sites located in Japan. Finally, the paper by Murray illustrates how results from laboratory accelerated tests in exposure procedures designed according to reliability theory can be used to estimate the service life of products expected to perform for many, many years. Murray's example is for testing compact discs, but illustrates the power of this approach, which is a significant departure from the traditional methods used to evaluate "weatherability" of organic materials.

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