Assessing and Improving the Durability of Electrochromic Devices

Thomas F. Guarr, Jeffrey R. Lomprey, and Kelvin L. Baumann
Gentex Corporation
600 N. Centennial
Zeeland, MI 49464 (USA)

The durability of electrochromic (EC) devices is often evaluated by measuring the change in transmittance (or reflectance) as a function of test duration. However, this approach is inadequate for evaluating the performance of such devices, since many degradation processes result in unacceptable changes in device appearance, yet have little effect on white light transmittance. The use of color coordinate analysis offers a more critical assessment of the durability of EC devices, and suitable methods for such testing will be described.

During the course of these studies, we have also found that undesirable changes in device coloration can be ascribed to a variety of factors. In conventional organic-based EC devices, at least two chromogenic materials are generally employed, so that color is generated at both anode and cathode and coloration efficiency is optimized. One of the problems inherent in this approach is that the presence of even small amounts of oxidizing or reducing impurities can lead to residual coloration in the high transmittance or reflectance state. Similarly, residual coloration in the high transmittance or reflectance state may be evident if either of the chromogenic materials is susceptible to even a small degree of thermal or photochemical decomposition in its colored state. For these reasons, achieving acceptable performance of an EC device over long periods or under extreme conditions is exceptionally difficult, and requires the utmost care during the manufacturing process.

We have recently shown that the addition of certain color-stabilizing additives can dramatically improve the long term durability of EC devices.[1-3] These materials, for which we coined the term "redox buffers", are largely uncolored in two adjacent oxidation states, and function to resist color change by a mechanism analogous to the way in which pH buffers resist pH changes.

Figure 1 compares the performance of an EC mirror containing redox buffers with that of an analogous unbuffered mirror during the course of thermal durability testing. The data clearly show that the inclusion of buffers results in a significant enhancement of thermal stability. In Figure 2, the performance of a buffered EC window is monitored during the course of durability testing in which the window is (a) cycled between their high and low transmission states at 70 °C; and (b) exposed to high intensity simulated solar radiation while cycling between their high and low transmission states (at about 65 °C). Again, the data indicate that the inclusion of buffers leads to excellent durability.

1. J.R. Lomprey and T.F. Guarr, U.S. Patent 6,188,505.
2. J.R. Lomprey and T.F. Guarr, U.S. Patent 6,310,714.
3. J.R. Lomprey , T.F. Guarr, and K.L. Baumann, U.S. Patent 6,433,914.

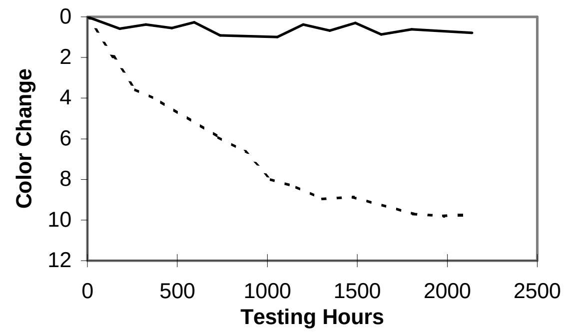

Figure 1. Color change during the course of a thermal exposure test (85 °C) for a standard outside electrochromic mirror incorporating redox buffers (solid line) and for an analogous mirror without redox buffers (dashed line).

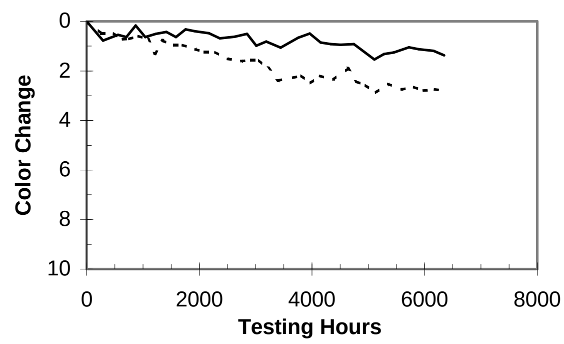

Figure 2. Color change of an electrochromic window during the course of a thermal cycling test (70 °C, solid line) and a UV cycling test (0.55 W/m^2 @340 nm, 65 °C, dashed line).