Color Tailoring Techniques for Electroactive Polymer-Based Electrochromic Devices

John P. Ferraris, D. S. K. Mudigonda, David L. Meeker, Jeffrey Boehme, David C. Loveday, Thuc H. Dam, and Ian D. Brotherston

Department of Chemistry
The University of Texas at Dallas, POB 830688
Richardson, TX, 75083-0688, USA
email: ferraris@utdallas.edu

Tailoring the color of electrochromic devices remains an area of active investigation. We have previously reported both physical and chemical methods to control the perceived color of electroactive polymer-based systems that included the use of copolymers, polymer blends, discrete electrochromes, patterns (*via* screen printing) and laminates.[1,2,3,4,5] Our most recent work involves the use of ink-jet printing to construct two novel device configurations: dual-ink patterned electrochromic devices, and hybrid active/passive electrochromic devices.

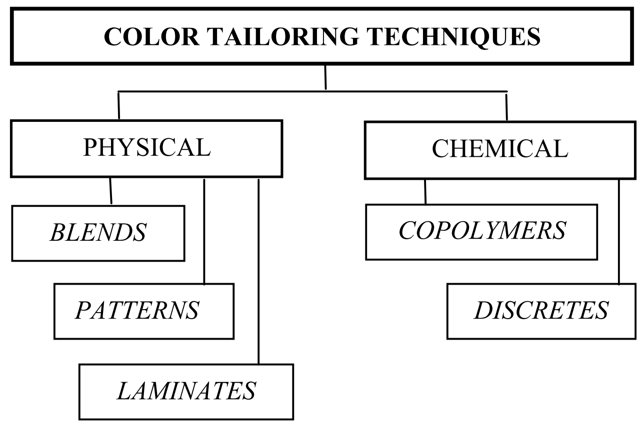
Both the techniques utilize ink-jet printing of processable polyaniline, poly (N-methylpyrrole), and polythiophene materials to prepare working electrodes that were assembled with a polymer gel electrolyte and vanadium oxide coated counter electrodes into functional devices. Devices fabricated using the first technique ("dual ink electrochromic devices") are based on the concept that two electrochromes *dither printed* in various ratios will afford perceived colors that are subtractive color combinations of the two individually deposited electrochromes. The second technique (hybrid electrochromic devices) overlays a semitransparent electrochromic device onto various non-active color backgrounds, so that the hybrid device's perceived color is a combination of the foreground and background colors. These techniques allow for a wider tailoring of electrochromic device colors from a limited number of processable electrochromic polymers. Color changes for these electrochromic devices were measured using spectrocolorimetry and analyzed using Commission Internationale de l'Eclairage (CIE) 1931 (x,y)-chromaticity coordinates. The dual ink electrochromic device's colors in their fully doped and dedoped states were linearly dependent on the composition of the two individual deposited polymers. Similarly, the hybrid device's colors in their fully doped and dedoped states varied linearly between color coordinates of the foreground and background colors.

Ink-jet printing of electrochromic devices provides several advantages. First, both categories of devices described allow a wider color range than that is available by a single electrochrome. Mathematically, the number of N unique colors that can be made from mixing n colors r different ways with allowable repetition of the individual colors is given by equation 1.[6]

$$N = \frac{(n + r - 1)!}{r!(n - 1)!}$$

For instance, a 4 x 4 matrix (r = 16) of dots created with three different color inks can theoretically produce 153 unique colors. Furthermore, IJP allows for the dither printing of multiple electrochromic colorants and also nonelectrochromic colorant in the case of hybrid devices, which creates the illusion of color mixing without having to physically blend the different colorants. Finally, this process allows for ease of fabrication and color altering. By simply printing from 2-3 primary electrochromic ink reservoirs, a user could predictably adjust a device's color by varying the deposition.

Fabrication and characterization of these new devices will be described and compared to other color-tailoring techniques.



[1] David L. Meeker, Dhurjati S. K. Mudigonda, Jessica Osborn, David C. Loveday and John P. Ferraris, Macromolecules, **1998**, *31*, 2943-2946.
[2] D. L. Meeker, M. S. K. Dhurjati, J. Osborn, D. C. Loveday and J. P. Ferraris, Polymer, **1999**, *40 (12),* 3407-3412.
[3] Ian D. Brotherston, Dhurjati S.K. Mudigonda, Jessica M. Osborn, Julie Belk, Judy Chen, David C. Loveday, Jeffrey L. Boehme, John P. Ferraris and David L. Meeker, Electrochim Acta, **1999**, *44*, 2993-3004.
[4] J. L. Boehme, D. S. K. Mudigonda and J. P. Ferraris, Chem. Mater. 2001, 13(12), 4469-4472.
[5] Ian D. Brotherston, Dhurjati S. K Mudigonda, Jessica M. Osborn, Julie Belk, Judy Chen, David C Loveday, Jeffrey L Boehme, John P. Ferraris, David L Meeker, Chem. Mater. 2000, 12, 1508-1509.
[6] J. L. Johnson, *The Handbook of Nonimpact Printing Technology*; Palatino Press: Irvine, CA, 1998.