

Multicolor and High Stable Electrochromism of Novel Hyperbranched Polyamides

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Introduction

Electron-rich triaryl amines are known to be easily oxidized to form stable polarons, and the oxidation process is always associated with a noticeable change of the coloration. For commercial applications of electrochromics, long-term stability, rapid response times, percent transmittance or luminance change, low-power requirements, high efficiency color changes, and ease of structural modification for color tuning are very important. However, the most electrochromic materials exhibited poor long-term stability. The objectives of this work is to obtain electrochromic polyamides with high stability, multicolor, high contrast ratio, high coloration efficiency, and low-switching voltage. We focused on specifically designed new hyperbranched polyamides containing four triarylamine units.

Results and Discussion

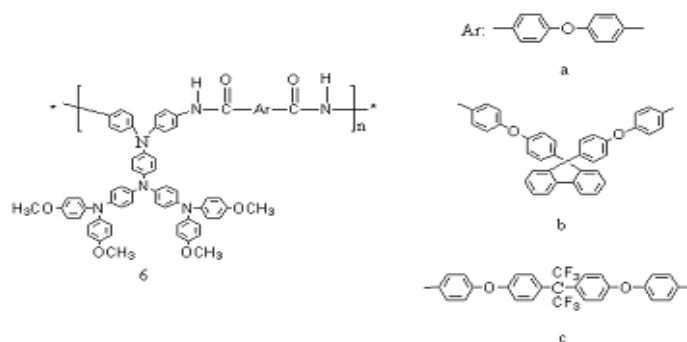
Polyamides **6** exhibited four reversible oxidation redox couples (Figure 1). Polyamide **6a** showed reversible CV behavior by continuous 10000 cyclic scans in the first oxidation stages (Figure 2). During the electrochromical oxidation of the polyamide thin films, the color of polymer film changed from colorless neutral form to yellow, yellow-green, purple, and then to blue at applied potentials ranging from 0.00 to 1.20V (Figure 3). When the applied potential was switched between 0.0 and 0.5V, polyamides **6a** revealed switching time of 2.8 s for coloring process and 1.6 s for bleaching. The electrochromic stability of the polyamides **6a** was determined by measuring the transmittance and optical change as a function of the number of switching cycles. The polymer **6a** was found to exhibit high coloration efficiency (CE) and contrast of optical transmittance change ($\Delta T\%$) in visible (CE=572cm²/C and $\Delta T\%=55\%$) and NIR(CE=367 cm²/C and $\Delta T\%=66\%$) region with excellent electroactive stability (more than 20000 cyclic switches within 2.47% decay) at the first oxidation stage (Figure 4(A)). As the dipolaron form of second oxidation stage, the polymer **6a** exhibited high $\Delta T\%$ (76%) and good electroactive stability (more than 4000 cyclic switches) (Figure 4(B)). In addition, **6a** also exhibited good long-term stability (Figure 5).

Conclusions

A series of novel electrochromic polyamides with hyperbranched triarylamine units showed reversible electrochromism with high contrast ratio both in the visible and NIR region, which also exhibited high coloration efficiency, short switching time, and excellent electroactive stability. The polyamide showed excellent electroactive stability (more than 20000 cyclic switches within 2.47% decay) at the first oxidation stage. The excellent stability was attributed that the delocalization forms of polaron are highly stable to form on the hyperbranched triarylamine units. Additionally, the polyamides also revealed multicolor of electrochromic characteristic, with a color change from colorless to yellow, yellow-green, purple, and then to blue.

Reference

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Scheme 1. Chemical structures of polyimides **6**.

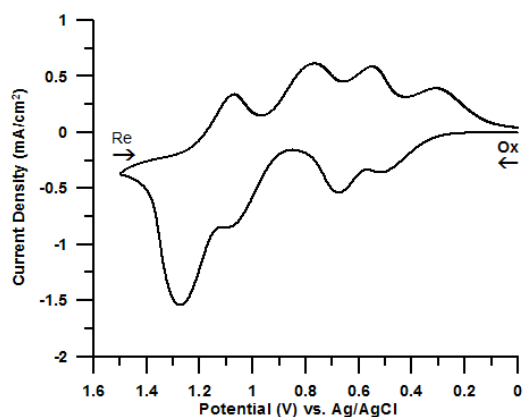


Figure 1. Cyclic voltammograms of the polyamide **6a** on an ITO-coated glass substrate in CH₃CN solution containing 0.1 M TBAP at scan rate of 50 mV/s.

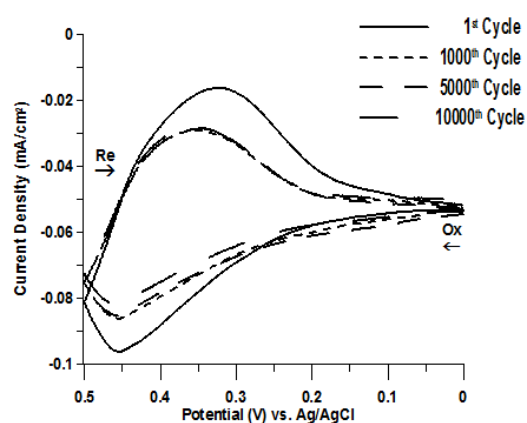


Figure 2. Cyclic voltammograms of the polyamide **6a** on an ITO-coated glass substrate over cyclic scans in CH₃CN solution containing 0.1 M TBAP at scan rate of 50 mV/s.

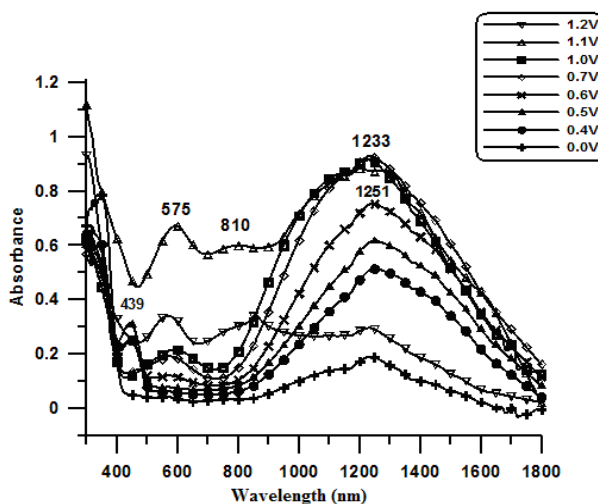


Figure 3. Electrochromic behavior of polyamide film **6a** (in CH₃CN with 0.1 M TBAP as the supporting electrolyte) 0.0→1.2V.

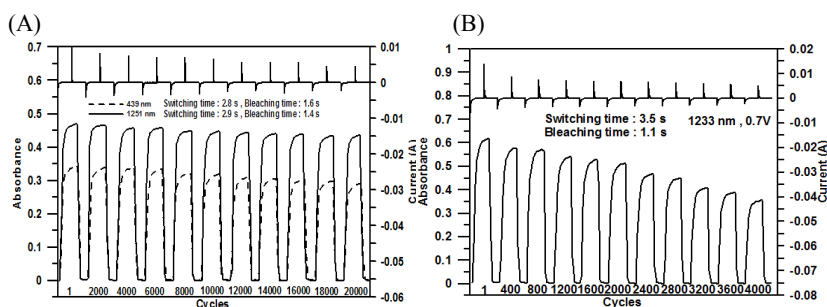


Figure 4. Electrochromic switching between (A) 0 and 0.5 V and (B) 0 and 0.7 V of polyamide **6a** thin film on the ITO-coated glass substrate (coated area: 2 cm × 0.8 cm) in 0.1 M TBAP/CH₃CN with a cycle time of 20 s.

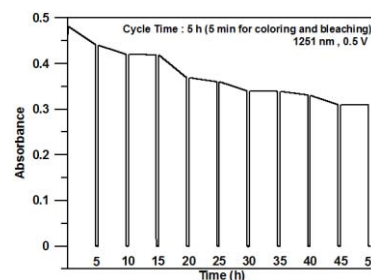


Figure 5. Potential step absorptometry during the continuous cycling test of polyamide **6a** by applying a potential step 0.0V→0.5V with cycle time 5 h and 5 min for coloring and bleaching processes, respectively.