Self-Powered Flexible Multicolor Electrochromic Devices for Information Displays

This paper aims to solve the following problems: Electrochromic displays are limited to a few material choices which limits their applications. Furthermore, most displays use aqueous electrolytes which require complex installation procedures and therefore lack flexibility in application. Also an electrochromic displays suffer from cycling limitations between states and high cycling times limiting their usability. And finally multicolor electrochromic displays have rarely been achieved.

Electrochromic displays are of interest because they provide color switching without an external power supply and therefore has a lot of potential in future display technology.

The paper tested multiple hypotheses: it aims to use Prussian Blue analogs to increase the number of materials and thus colors. Furthermore, it aims to use a gel material as electrolyte as opposed to aqueous ones as it is easier to work with. To increase cycling efficiency additional chemicals are to be added to the device. To achieve multicolor two devices were superimposed on each other.

The people which participated in this research are Wenzhao Xue, Yun Zhang, Feng Liu, Yao Dou, Mei Yan and Wenshou Wang.  
The device is made using a Tri layer structure by using a gel electrolyte consisting of polyacrylamide/lithium chloride (PAM/LiCl) and two cathodes consisting of Prussian Blue (PB) and Nickel Hexacyanoferrate (NiHCF). The cathodes are made using nanoparticles to which a small amount of poly(3,4-ethylenedioxythiophene):poly(styrene sulfonate) (PEDOT:PSS) is added these are deposited using a spray coating technique a scanning electron microscope was used to confirm the uniformity of the material. An aluminium anode was used to change the color of the material. Transmittance was measured in function of wavelength time and cycles to confirm the functional effects of the device. This was also done with the full multicolor device to get its data. The voltage was tracked during changes to monitor the electrical properties during changes. X-ray photoelectron spectroscopy (XPS) was used to track the ionic composition of the materials during phases. Lithium in the electrolyte and (NH4)2S208 were added to improve switching times. The device was deposited on a flexible substrate to prove this functionality as well as spray painted and a demonstration writing board was made using the cathode and a pen with PAM/LiCl “ink” and aluminium cathode.

The results were in accordance with the hypothesis. The cathodic materials could be made using the Prussian blue and analog and were uniformly deposited using the spray coat technique. The electrolytic gel also working, making applications easier to make. The device functioned as expected, the colors given had peaks of 400nm (NiHCF) and 700nm (PB) the devices bleached to 90% within 8.5s and 18s respectively and recovered to 90% within 21.5 min and 29s respectively. The cycles they could go through were 25 and 55 cycles respectively. The voltage when recovering could be measured and increased to 1.41V and 11.35V respectively. The peaks of metal ions during phases could be measured which showed that the color bleached by reducing Fe3+ to Fe2+. It was also demonstrated that adding Li ions and (NH4)2S208 sped up the changing speed. Combining two colors showed that they combine their colors. The device works on flexible surfaces and works when spray-painted. The Ion board works as intended.

This research shows that Electrochromic displays can be optimized and increase the range of appliance where this technology can be used.