Engineered Nanocomposite Materials for Energy Efficient Smart Dynamic Windows

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Electrochromic materials are able to change their optical properties as a response to an externally applied electric potential. Along with the other members of smart chromogenic materials such as thermochromics and photochromics, they have been long considered as a subset of the "solar energy materials", thanks to their impact in terms of energy savings and sustainability in the building and transportation sector. An ideal smart window, based on these electrochromic materials, must independently and selectively control the transmittance of visible sunlight and solar heat into a building and should be globally applicable across different building types and climate zones. The novel concept of "dual-band electrochromism" offers this capability of dynamic control over the entire solar spectrum, which has led to an exciting development of a new generation of advanced glazing systems. In this respect, full understanding and optimisation of this unique electrochromic device is crucial for energy efficient building envelopes, which can massively contribute to reducing energy use in buildings and ensure occupant comfort. Herein we combine two spectrally complementary electrochromic materials to realize a dual band electrochromic system that synergistically embodying the electrochromic properties of individual components within a single engineered component. The composite film has been obtained through the potentiodynamic electrochemical disposition of a polyaniline film onto a nanocrystalline large surface area ITO electrode. The resulting bi-phasic organic/inorganic nanocomposite electrode embodies both the plasmonic features of ITO nanocrystals and the peculiar electrochemical redox prerogatives of PANI. Its fundamental optical and electrochemical properties have been exhaustively investigated and finally exploited to realize a four-state electrochromic device. It provides a high selective modulation both in the VIS range (ΔT= 80% in between -1.4V and +0.8V) and in the NIR range (ΔT= 90% in between +0.2V and +0.8V) accompanied with a long electrochemical stability.