Development of Dual-Band VIS-NIR Electrochromic Materials Based on Plasmonic Metal Oxides and their Formulations

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Abstract: This study focuses on developing dual-band visible (VIS)-near-infrared (NIR) active materials for innovative technology of smart electrochromic application. Firstly, the VIS active material, tungsten oxide (WO_3), was synthesized by several synthesis methods including hydrothermal (acidic and non-acidic conditions), wet-chemical, and calcination of raw W powder. The structural and morphological properties of all synthesized WO_3 were examined using X-ray diffraction (XRD) and field-emission scanning electron microscopy (FESEM), resulting in varied structural and morphologies features. On the other hand, NIR-active materials, aluminium-doped zinc oxide (AZO) and indium tin oxide (ITO), were synthesized by the hydrothermal method. XRD and SEM were used to characterize their structural and morphological properties. Their electrochromic behaviour was also evaluated. For the electrochromic testing, thin films of the synthesized materials were prepared on FTO glass substrates using the spin-coating technique, ensuring uniform deposition. Electrochromic experiments showed that VIS-active WO_3 synthesized under non-acidic hydrothermal conditions exhibits higher optical density and variation in coloration and bleaching states. NIR active materials also show electrochromic activity. Furthermore, we developed dual-band VIS-NIR electrochromic two component formulations by combining them with WO_3/AZO and WO /ITO composites. This technique seeks to improve optical modulation in both the visible and near-infrared ranges, thereby contributing to the development of electrochromic technologies. Future research will concentrate on improving composite materials for greater performance and stability.

Keywords: Dual-band electrochromic materials; Thin film; Smart electrochromic technology.