A Green Nanotechnological Approach for Energy Efficiency and Conservation: Tungsten-Doped Vanadium Dioxide Thermochromic Smart Windows

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Vanadium dioxide is a "functional material" that has gained notoriety in fundamental research and smart-window applications. It responds to environmental temperatures, making reversible structural changes from an infrared-transparent semiconducting state to an infrared-translucent metallic state when heated beyond its transition temperature (Tc). Application of VO2-thermochromic smart windows has been limited, however, due to Tc values higher than desired ambient temperature. In this research, tungsten-doped VO2-windows were synthesized, to lower the transition temperature to <30oC, and improve the transmission properties. The temperature-dependent optical properties of windows were studied from 400-4000nm via visible, near-infrared, and mid-infrared spectroscopies. Their ability to control infrared light transmission as a function of outside temperature was determined via thermal imaging. Results for the 1.7%W-VO2 window highlight %Transmission decreases of 25.3% and 42.8% through the near-infrared and mid-infrared regions, respectively, with heating from 29-60oC. Decreased transmission of W-VO2 windows is evident via a decreased thermal footprint; as the sample temperature was raised from 20-60oC, the VO2 window reached 58.1oC, determined by radiation, while the 1.7%W-VO2 windows reached only 37.9oC. Finally, modeling of overall increase in room energy efficiency was performed using 8in3 model-wooden homes, with W-VO2 (and control) windows, and constant infrared illumination. With an increase in the external window-temperature from 29-60oC, the home temperature of the VO2-window house rose from ambient to 29.5oC; the house with the 1.7%W-VO2 window rose to 28.8oC, for a 16% improvement in energy efficiency vs VO2, and 37% vs normal windows.

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