# Novel Synthesis of Thermochromic VO2 Nanocomposite Films for Energy-Efficient Windows

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An estimated $35 billion of energy is lost annually through windows with 45% of the average American household energy bill spent on heating and cooling. Recent developments in materials science have enabled thermochromic window films with optical properties that vary with an applied stimulus, thus minimizing energy loss far more efficiently than conventional window films. Vanadium (IV) oxide is one of the most promising materials for thermochromic films due to its unique, reversible crystal phase transition from monoclinic (M1) to rutile (R) at its critical temperature (Tc) which corresponds to a change in optical properties. Above Tc, VO2 films exhibit a decreased transmittance for infrared wavelengths of light, which are the primary components of solar heat. However, a high transmittance modulation often sacrifices luminous transmittance which is necessary for commercial and residential applications of this technology. This study explores the potential for synthesis of VO2 films in a matrix of metal oxide nanocrystals, using In2O3, TiO2, and ZnO as diluents. Since the diluted V2O3 must be oxidized via thermal annealing to yield VO2, the experiment seeks to optimize the annealing conditions to yield desirable optical properties. Although the films diluted with TiO2 and ZnO failed to show transmittance modulation, those diluted with In2O3 exhibited strong thermochromism. This investigation introduces a novel, inexpensive window film consisting of a VO2-In2O3 nanocrystalline matrix, demonstrating a significant increase in luminous transmittance without any measurable impact on thermochromic character. This study represents a crucial development in film chemistry and paves the way for further application of VO2 nanocomposite films towards chromogenic fenestration.