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An energy-efficient single-pane "green window" via the photothermal effect of chlorophyll thin film coatings

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To prevent heat loss through windows in cold climates, the conventional methods mainly rely on low-e coatings and thermal insulating materials on double-pane windows. In this study, naturally occurring chlorophyll is utilized as a thin film coating on glass (also known as "Green Window" for its natural and green appearance) and demonstrates applicability to significantly reduce thermal loss, thus improving energy savings. Chlorophyll exhibits a unique optical characteristic with strong absorptions in the blue-violet and NIR regions while remaining highly transmissive in much of the visible region. This unique property allows, on one hand, simulated solar energy, in the non-visible region, to be converted to heat by chlorophyll through the so-called photothermal effect. Only slight heating due to the photothermal effect on the window surface is required to significantly reduce the U-factor (related to thermal loss). On the other hand, the chlorophyll coating density required to generate this temperature rise by thin film deposition on glass retains high light transmittance attributable to minimum absorption in the visible range. This concept lifts the dependence on insulating materials making single-pane windows highly possible. Chlorophyll synthesis, thin film deposition, optical characterization, photothermal effect, and energy performance quantification are carried out in this study with engineering considerations in window designs.

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