Selective transmission and absorption in oxide-based nanofluid optical filters for PVT collectors

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Abstract

The division of the solar spectrum in a photovoltaic thermal (PVT) collector serves a dual purpose for separate heat and electricity applications. One part of the spectrum is used for generating electricity, which prevents the excessive temperature increase of the photovoltaic cells, while the other part facilitates a thermal gain. This concept is termed as spectral beam splitting (SBS). In this work, the implementation of SBS in a PVT collector using a nanofluid-based optical filter is investigated. An optical model, based on Rayleigh scattering, is developed to analyze various oxide-based nanofluids for SBS. The purpose of the model is to determine the transmittance and absorbance of ZnO, Fe3O4, and SiO2-based nanofluids across the solar spectrum range of 300 nm to 2500nm. The model takes into account the complex refractive indices of the particles and base fluids to determine the scattering, extinction, and absorption efficiencies of the nanofluids being studied. The oxide-based nanofluids outperformed the polypyrrole and Cu9S5-based nanofluids in terms of spectral transmission and absorption of sunlight. Water, de-ionized water, and ethylene glycol are used as base fluids. The nanoparticle-base fluid duos determine the agglomeration and size of the particles in the nanofluid and hence affect their optical properties. Therefore, ZnO-based nanofluids are synthesized in-house to correlate the effects of agglomeration and particle size on the optical properties of the nanofluids derived from the developed theoretical model. Using ethylene glycol as a base fluid has a significant impact on reducing agglomeration, resulting in smaller and more stable nanoparticles, in comparison to using de-ionized water. Furthermore, the influence of particle size, dispersion in the base fluid, and optical length on the optical properties of the nanofluid are examined. It is concluded that adjusting the size (dispersion), concentration, and optical length of the particles can allow for the efficient use of the solar spectrum to generate both electrical and thermal energy.

Keywords: Photovoltaic thermal, Spectral beam splitting, Optical filter, Nanofluid, Rayleigh scattering

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