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Photothermal Properties of Carbon Aerogels

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Abstract

Carbon aerogels are lightweight, highly porous materials with remarkable thermal, electrical, and optical properties, making them promising candidates for energy and environmental applications. Carbon aerogels exhibit high absorption across the visible spectrum, and their temperature can be elevated via the photothermal effect when they are subjected to solar or artificial light. The ability to directly heat carbon aerogels with incident light enables new capabilities for the design of energy efficient processes such as solar-driven interfacial water evaporation, photothermal catalysis on aerogel supports, and temperature swing adsorption.

Herein we evaluate the photothermal effect in carbon aerogels by employing Fourier-transform infrared (FTIR) spectroscopy, ultraviolet-visible (UV-Vis) spectroscopy, scanning electron microscopy (SEM), and infrared imaging. FTIR is utilized to measure the reflectance and transmittance in the infrared spectrum, which in turn is used to calculate the emittance of the carbon aerogels. UV-Vis spectroscopy is used to measure the reflectance and transmittance of the carbon aerogels, which is used to calculate their solar absorbance. The solar absorbance and emittance of the carbon aerogels are used as input parameters to model and predict their photothermal behavior. That is, numerical analysis is conducted to determine the temperature of the carbon aerogels under solar-simulated radiation incident at various intensities.

Furthermore, experiments are carried out to measure the photothermal behavior of carbon aerogels subjected to solar-simulated radiation incident at different intensities. A comparison of the theoretical and experimental results yields insights into the photothermal behavior of carbon aerogels. By advancing the understanding of the photothermal behavior of carbon aerogels, this research contributes to the broader development of next-generation energy efficient technologies for energy and environmental applications. For example, the ability of these materials to efficiently absorb and convert light into heat offers a promising pathway for designing low-energy, solar-assisted CO_2 capture technologies. The integration of photothermal materials, such as carbon aerogels, into CO_2 capture systems offers an innovative pathway to reduce energy consumption by utilizing solar or artificial light as a direct heat source for adsorption and desorption cycles. Thus, the results from this research are discussed in the context of solar-driven CO_2 capture.