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Enhanced visible-light photocatalytic activity of multi-elements-doped ZrO_2 for the degradation of indigo carmine

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In this study, C,N,S-doped ZrO_2 and a series of Eu doped C,N,S-ZrO_2 photocatalysts were synthesized by a modified sol-gel method using thiourea as the source of C,N and S and Eu(NO3).6H_2O as source of Eu. The materials were characterized by X-ray diffraction (XRD), Raman spectroscopy, Fourier transform infrared spectroscopy (FTIR), UV-Visible diffuse reflectance spectroscopy, scanning electron microscopy (SEM)/ energy dispersive X-ray spectroscopy (EDX), and transmission electron microscopy (TEM). Indigo Carmine (IC) was chosen as a model for organic pollutants and used to evaluate the photocatalytic performance of the photocatalysts under simulated solar light. Commercial ZrO_2 was used as a reference material. XRD and Raman results indicated the formation of both tetragonal and monoclinic phase ZrO_2 with particle size ranging from 8-30 nm. Multi-element doping had a great influence on the optical responses manifested as red shift in the absorption edge. The highest photocatalytic activity towards IC was observed for the Eu,C,N,S-doped ZrO_2 (0.6% Eu) sample (k=1.09 x 10-2 min-1). The commercial ZrO_2 showed the lowest photodegradation activity (k=5.83 x 10-4 min-1). The results showed that the control of Eu doping in the C,N,S-ZrO_2 is very important in reducing electron-hole recombination. The synergistic effect of Eu, C, N, and S in the ZrO_2 matrix led to enhanced utilization of simulated solar energy for the degradation of IC through narrowing of bandgaps.

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