Tailoring the properties of calcium modified fibrous mesoporous silica KCC-1 for optimized sulfur dioxide removal

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Abstract
Dry regenerative flue gas desulfurization (FGD) is a promising method to tackle industrial issues regarding SO_2 emission into the atmosphere due to its sorbent being highly accessible, the lack of water dependency and reduction in waste management. This study examined the feasibility of using fibrous mesoporous silica KCC-1 which has been reported to possess better properties than several other predecessor mesoporous silica as alternative sorbents for dry FGD. Calcium metal was introduced to overcome the lack of active sites available on KCC-1 while simultaneously providing sufficient basicity to counter the increase in acidity brought by SO_2 adsorption. Three sorbent modification parameters were analyzed: metal loading (5–15 wt %), calcination temperature (823–973 K) and calcination time (5.5–7 h), and the prepared samples were characterized using BET surface area and pore analyzer, FESEM-EDX, XRD and H_2-TPR. The breakthrough experiment was conducted using a lab scale fixed bed reactor system with 1500 ppm SO_2/N_2 at 200 mL/min. SO_2 removal was optimized by sorbent prepared with calcium loading of 5 wt %, calcination temperature of 923 K and calcination time of 6.5 h with adsorption capacity of 3241.94 mg SO_2/g KCC-1. The optimized sorbent demonstrated highest surface area, good pore development, high dispersion of calcium metal, appropriate impregnation of calcium oxide which caused only minor distortion to the silica framework of KCC-1. Subjecting the optimized sample to five consecutive regeneration cycles by heating at 773 K while simultaneously flowing N_2 gas for an hour shows good regeneration performance with a total final reduction of only 25% from the initial adsorption capacity obtained from a fresh sample.

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