Low-cost manganese mineral sorbents for mercury removal from coal-fired flue gas

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Sorbent injection is widely accepted as a promising method for controlling mercury emissions from coal combustion. The traditional activated carbon sorbent is restricted by the high operating cost, sorbent recovery and reuse. Therefore, it is necessary to develop the high-efficiency, low-cost and regenerable sorbents for Hg0 removal from flue gas. Compared with activated carbon, natural mineral sorbents are promising candidates as cost-effective sorbents for mercury removal due to its cheap price and abundant reserves. However, the systematic study on Hg0 removal by natural manganese mineral has not yet been reported. In this work, mercury removal performance of natural manganese mineral sorbent was systematically investigated in a fixed-bed reactor. The physical and chemical properties of manganese mineral were analyzed by Brunauer–Emmett–Teller (BET) surface area, X-ray diffraction (XRD) and X-ray photoelectron spectroscopy (XPS). Experimental results indicate that Hg0 removal efficiency is much higher than 90% in the temperature window of 100-250 °C. Moreover, the effects of flue gas components on mercury removal were investigated. O2, NO and HCl exhibit a promotional effect on mercury removal by natural manganese mineral. H2O and SO2 show a slight influence on Hg0 adsorption. Further, XPS and temperature programmed decomposition desorption (TPDD) results suggest that the adsorbed mercury compounds on the used sorbent surface are mainly ascribed to HgO, HgCl2, Hg(NO3)2 and HgSO4. Manganese mineral shows excellent regeneration performance for Hg0 capture from flue gas. The regeneration process shows little effect on the physical and chemical properties of sorbents. Theoretical results obtained from density functional theory calculations show that chemisorption mechanism is responsible for Hg0 adsorption on manganese mineral surface.