

Pressurized H₂S Removal from Syngas Using High-Temperature Solid Sorbents

The removal of sulfur contaminants from syngas represents a key challenge for its downstream utilization in catalytic processes and hydrogen production. In this work, high-temperature H₂S removal using solid sorbents is investigated, with particular attention to the effect of operating pressure on sorbent performance. Previous experimental activities at atmospheric pressure were carried out using transition-metal-based sorbents containing Fe, Zn and Ni oxides promoted with Al₂O₃, together with low-cost industrial residues such as red mud and a commercial Ni–Mo/Al₂O₃ material. The sorbents were tested in the 400–650 °C temperature range using model gas mixtures containing 100 ppm H₂S, first in N₂ and subsequently under syngas-like conditions. Fe-based materials showed high H₂S removal efficiency at temperatures up to approximately 550 °C, while Zn- and Ni-based sorbents maintained good performances at higher temperatures. Among the investigated materials, Ni–Mo/Al₂O₃ showed particularly promising behaviour under simulated syngas conditions, reducing the H₂S concentration to approximately 20 ppm at 600 °C. Low-cost red-mud-derived sorbents also demonstrated significant sulfur capture capacity, highlighting their potential within circular process schemes. Building on these results, the current experimental activity focuses on H₂S removal under pressurized conditions, with initial tests being performed at 5 bar. The objective is to assess how pressure affects sulfur capture efficiency, sorbent capacity and stability under conditions closer to those encountered in practical syngas upgrading units. Particular attention is devoted to the interaction between pressure, temperature and syngas composition and to the possible enhancement of gas–solid contact and sulfur uptake. The comparison between atmospheric and pressurized operation will provide new information for the design and scale-up of compact high-temperature syngas purification systems based on regenerable solid sorbents.