Chapter 2
Nanomaterials and Nanocomposites for Adsorptive Desulfurization:
From Synthesis to Application

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ABSTRACT

Desulfurization (removal of S compounds) of fuels is an important research topic in recent years. Several techniques have been reported to remove the sulfur-containing compounds in fuels. One of these techniques is adsorptive desulfurization (removal based on chemisorption and physisorption), which has received much attention because of low energy consumption and facile operation condition. This chapter discusses the methods employed under this technique and the types of nanocomposites and hybrid materials (adsorbents) that have been investigated as potential adsorbents. The strategies to enhance sulfur adsorption capacity and main challenges will be discussed.

INTRODUCTION

Adsorptive Desulfurization

Various desulfurization technologies have been explored either to complement the current hydrodesulphurization (HDS) technology. The main alternative techniques include oxidative desulfurization, extractive desulfurization, biodesulfurization

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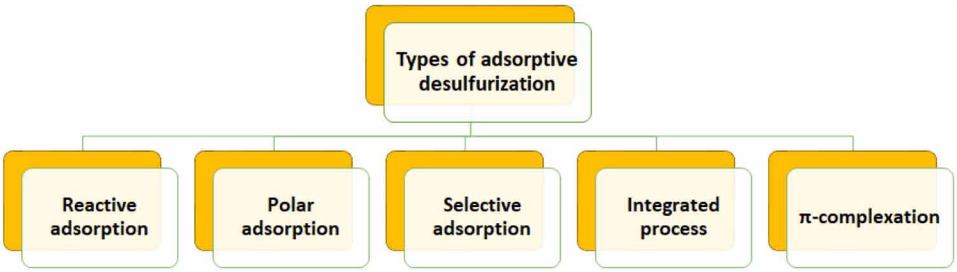
Figure 1. Types of adsorptive desulfurization



and adsorptive desulfurization (ADS). There are various forms of adsorptive desulfurization which will be discussed in this section and these include reactive adsorption, polar adsorption, selective adsorption, integrated adsorption, π-complexation. The schematic showing different forms of desulfurization is given in Figure 1. ADS is one of the most studied alternative technologies to replace or supplement conventional HDS. In ADS, sulfur compounds are removed via adsorption using a selective adsorbent. This means that the adsorbent plays an important role in the selectivity, capacity, and sustainability such as renewability of adsorbents, of the process.

Sulfur can be removed via two mechanisms, depending on the interaction between the adsorbent and the sulfur compounds:

1. Physical adsorption in which sulfur compounds and adsorbents are mainly bound by van der Waals forces, which is a relatively weak interaction. This enables the adsorbent to be regenerated relatively easily.
2. Chemical adsorption (such as reactive adsorption), which employs chemical bonding between the sulfur compounds and the adsorbents, which may alter the physical and chemical nature of the sulfur compounds.

ADS is a promising technique since it has the potential to be regenerative, cost-effective and environment-friendly while operating under ambient conditions. However, there are some challenges including selectivity and diffusion limitations which are the most important challenges in this type of desulfurization.

A reactive adsorption is a form of ADS whereby the sulfur compounds in fuel are removed by chemical interaction between the fuel and the sorbent material. The reaction involves removal or transfer of the sulfur compounds from the fuel followed by attachment of the compounds to the sorbent material which will allow the sulfur-free fuel to be collected in the mainstream. The process uses metal-based sorbent for sulfur removal to form metal sulfide, Figure 2.