Chapter 1

Catalytic Nanocomposites in Oxidative on Adsorptive Delsulfurization Process: A Comprehensive Review

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ABSTRACT

Humanity's need for energy is an undeniable fact, and this reality is increasing day by day. To meet its growing energy needs, humanity has turned to fossil fuels. Fossil fuels are fuels derived from animal and plant fossils formed over millions of years. However, the excessive use of fossil fuels for energy needs has created a dangerous

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situation that threatens to deplete fossil fuel reserves. Furthermore, the burning of fossil fuels releases toxic emissions. These emissions cause serious health problems for living organisms and also harm the ecosystem. These gases include sulfate (SO_2) and sulfur derivatives, carbon dioxide (CO_2), carbon monoxide, and nitrogen oxide derivatives (NOx). This chapter focuses on catalytic techniques using nanocomposite materials for the removal of SO_2 and sulfur derivatives, with detailed references to relevant sources. SO_2 and sulfur gases are harmful gases released by the combustion of fossil fuels. Nanocomposite production methods include sol-gel formation, gel shaping, chemical vapor deposition (CVD), and physical vapor deposition (PVD), layered production, electrospinning, mechanical and ultrasonic techniques, additive manufacturing, and melting mixture. Desulfurization processes using these methods are as follows: (i) oxidative desulfurization, photocatalytic desulfurization, and absorptive-catalytic desulfurization. All techniques are explained with references to the relevant sources. This chapter provides theoretically important information for researchers working on nanotechnological catalytic studies in desulfurization.

1. INTRODUCTION

Humanity's need for energy is increasing day by day (Darabi et al., 2023). Energy types are needed in a wide variety of areas, including heating (Guelpa & Verda, 2019; Jamar et al., 2016; Ürge-Vorsatz et al., 2015), electricity (H. Chen et al., 2009; Dillon, 2010), and systems to increase clean water resources (Süme et al., 2024). Especially for essential needs like heating, humanity has turned to fossil fuels. Energy derived from fossil fuel sources such as coal (Longwell et al., 1995; Strielkowski et al., 2021), oil (Abas et al., 2015; Chew, 2014; Shafiee & Topal, 2009), and natural gas(Shafiee & Topal, 2010) largely meets this need. However, because humanity is so heavily reliant on fossil fuels to meet its energy needs, energy reserves are nearing depletion, and finding a new energy source is crucial (Ritchie & Rosado, 2017). Furthermore, sulfur-derived gases and toxic emissions from fossil fuels are extremely harmful to living organisms, polluting the environment and damaging ecosystems (Glass, 1979; J. Liu et al., 2024). Therefore, researchers have focused on eliminating toxic emissions from fossil fuels.

Fossil fuels are formed millions of years ago when animal and plant remains undergo chemical changes under high temperatures and pressures (Armaroli & Balzani, 2011a; Ritchie & Rosado, 2017; Soeder, 2021). Their high density and easy accessibility are key advantages (Wuebbles & Jain, 2001). Fossil fuels take various forms depending on the chemical reactions they undergo, their pressure and temperature, and their evolution (Burnham, 2017). These forms include coal (Lockwood, 2017), natural gas (Stejskal et al., 2021), and petroleum (Peixoto et