Chapter 4
Analysis of Neurotoxic Effects on the Nervous System Induced by Nanoparticles

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ABSTRACT

Nanomaterials, with their unique physical and chemical properties, have attracted much interest across various industries. However, their potential to traverse biological barriers and interact with the delicate nervous system raises concerns about neurotoxicity. This chapter explores the mechanisms of nanomaterial-induced neurotoxicity, highlighting the vulnerability of the nervous system and the potential

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routes of exposure. It provides an overview of established methodologies for assessing neurotoxicity, presents case studies, and experimental findings that underline the importance of rigorous evaluation. Strategies for safer nanomaterial development, including surface modification and biogenic fabrication are discussed. Additionally, the chapter emphasizes the need for robust regulatory frameworks and international collaboration to ensure the responsible development and application of nanomaterials, particularly in the discipline of nanomedicine.

INTRODUCTION TO NANOMATERIAL TOXICOLOGY

The rapid advancement and extensive utilization of nanomaterials (NMs) across various industries have raised significant concerns about their potential impact on human health and the environment (Teleanu et al., 2019; Boyes & van Thriel, 2020). NMs, characterized by at least one dimension falling within the nanoscale range of 1-100 nm, exhibit unique physicochemical properties that differentiate them from their bulk elements, such as enhanced surface area, reactivity, and the ability to traverse biological barriers (Boyes & van Thriel, 2020). These properties have spurred interest in exploring their applications across diverse fields like energy, electronics, environmental science, food, agriculture, cosmetics, and medicine (Teleanu et al., 2019). However, the very characteristics that make NMs appealing also raise apprehensions about their potential toxicity, particularly their neurotoxic effects.

Studies have highlighted the neurotoxic potential of various NMs, such as graphene-based NMs (Li et al., 2017), nitrogen-doped graphene quantum dots (Xu et al., 2021), and graphene oxide quantum dots (Ren et al., 2018). These materials have been associated with behavioral deficits, neural damage, and oxidative stress, emphasizing the importance of understanding the implications of NM exposure, especially in biomedical applications (Li et al., 2017; Guo et al., 2021). The potential for NMs to cross biological barriers, such as the blood-brain barrier (BBB) and blood-nerve barrier, is a critical aspect that necessitates exploration to comprehend their neurological impacts (Win-Shwe & Fujimaki, 2011a; Masserini, 2013; Maiuolo et al., 2019).

While advancements in nanotechnology offer significant benefits, it is crucial to consider potential exposure sources and pathways that could lead to neurotoxicity (Boyes & van Thriel, 2020). Nanoparticles (NPs) can enter the human body through various routes, with inhalation and dermal exposure being significant pathways (Buzea et al., 2007; Musial et al., 2020). Inhaled NPs can translocate from the lungs to other organs, including the brain, through the blood or neuronal pathways (Buzea et al., 2007; Win-Shwe & Fujimaki, 2011a, 2011b). Additionally, studies have highlighted the impact of NPs on human health through different exposure routes, such as the

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