Current investigations into the genotoxicity of zinc oxide and silica nanoparticles in mammalian models in vitro and in vivo: carcinogenic/genotoxic potential, relevant mechanisms and biomarkers, artifacts, and limitations

By: Kwon, JY (Kwon, Jee Young)¹; Koedrith, P (Koedrith, Preeyaporn)²; Seo, YR (Seo, Young Rok)¹

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Abstract
Engineered nanoparticles (NPs) are widely used in many sectors, such as food, medicine, military, and sport, but their unique characteristics may cause deleterious health effects. Close attention is being paid to metal NP genotoxicity; however, NP genotoxic/carcinogenic effects and the underlying mechanisms remain to be elucidated. In this review, we address some metal and metal oxide NPs of interest and current genotoxicity tests in vitro and in vivo. Metal NPs can cause DNA damage such as chromosomal aberrations, DNA strand breaks, oxidative DNA damage, and mutations. We also discuss several parameters that may affect genotoxic response, including physicochemical properties, widely used assays/end point tests, and experimental conditions. Although potential biomarkers of nanogenotoxicity or carcinogenicity are suggested, inconsistent findings in the literature render results inconclusive due to a variety of factors. Advantages and limitations related to different methods for investigating genotoxicity are described, and future directions and recommendations for better understanding genotoxic potential are addressed.

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Author Information
Reprint Address: Seo, YR (reprint author)

Dongguk Univ, Room 408-1 Hyehwa Bldg,30 Pildong Ro 1-Gil, Seoul 100715, South Korea.

Addresses:
[ ¹ ] Dongguk Univ, Inst Environm Med, Dept Life Sci, Seoul 100715, South Korea
[ ² ] Mahidol Univ, Fac Environm & Resource Studies, Phuttamonthon Dist, Nakhon Pathom, Thailand

E-mail Addresses: seoyr@dongguk.edu

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