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Opinion Article

Effects of Nanoparticles in Polymerase Chain Reaction

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DESCRIPTION

Using the powerful nucleic acid amplification technology known as Polymerase Chain Reaction (PCR), a single strand of DNA can be swiftly amplified into thousands of pieces. Since Mullis's invention of PCR in 1984, the area of biological science has undergone significant change, and PCR is now one of the most extensively used procedures in molecular diagnosis. Gel electrophoresis, a time-consuming technique requiring the employment of expert personnel, has traditionally been employed to detect PCR findings. Traditional PCR can also only be utilized for qualitative analyses.

The introduction of fluorescent PCR technology, particularly real-time PCR, which allows for the quantification of analyses, has substantially expanded the reach of PCR techniques in various fields. This PCR technology provides additional advantages due to its sensitivity, repeatability, and ease of use. However, it necessitates costly reagents and equipment reading, and with a cycle number greater than 35, its background develops substantially, potentially leading to false-positive results and limiting its uses. Furthermore, fluorescent dyes are commonly damaged due to their photo stability and the auto-fluorescence of biological components.

Polymerase Chain Reaction (PCR) is a popular molecular biology technique utilized in a variety of domains, including biomedical research, clinical diagnostics, and forensic science. Denaturation of double-stranded DNA, annealing of primers, and extension of new DNA strands by a thermostable DNA polymerase are all crucial processes in the PCR amplification of nucleic acids. However, several factors, including the presence of nanoparticles, can alter the sensitivity and efficiency of PCR. In this study, they will look at the impacts of nanoparticles on PCR and how to reduce their influence.

Nanoparticles are particles that range in size from 1 to 100 nanometers and can be made of a variety of materials such as metals, metal oxides, polymers, and ceramics. Because of their unique physical and chemical features, such as large surface area, reactivity, and biocompatibility, nanoparticles are frequently used in biomedical research and therapeutic applications. However, the presence of nanoparticles can interfere with PCR amplification through a variety of processes, including DNA polymerase inhibition, adsorption of primers and templates, and the creation of aggregates that can interfere with PCR reagents.

Gold Nanoparticles (AuNPs) are one of the most commonly employed nanoparticles in biomedical research because of their unique optical properties, which make them valuable in imaging and sensing applications. AuNPs, on the other hand, can impede PCR amplification by adsorbing to DNA templates and primers and preventing them from being annealed and extended by DNA polymerase. The inhibitory effect of AuNPs on PCR can be decreased by utilizing biocompatible modified gold nanoparticles, such as Polyethylene Glycol (PEG), or by optimizing PCR settings, such as raising $MgCl_2$ concentration or decreasing annealing temperature.

Similarly, it has been demonstrated that Silver Nanoparticles (AgNPs) hinder PCR amplification by adsorbing to DNA templates and primers and interfering with the annealing and extension stages. Using modified AgNPs with a biocompatible coating or raising the dose of DNA polymerase or primers can lessen the inhibitory effect of AgNPs on PCR.

Carbon-based nanoparticles, such as Carbon Nanotubes (CNTs) and Graphene Oxide (GO), have also been found to disrupt PCR amplification by adsorbing to DNA templates and primers and impeding annealing and extension. The inhibitory effect of CNTs and GO on PCR can be decreased by optimizing the PCR settings, such as raising the annealing temperature or decreasing nanoparticle concentration. Magnetic Nanoparticles (MNPs) can also interfere with PCR amplification by adsorbing to DNA templates and primers or aggregating and producing clusters that can interfere with PCR reagents. The inhibitory effect of MNPs on PCR can be minimized by utilizing modified MNPs with a biocompatible coating, such as PEG, or by optimizing PCR settings, such as decreasing MNP concentration or boosting DNA polymerase or primer concentration.

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