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Nanostructures for DNA transfection

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Recombinant proteins are produced by the genetic engineering of the gene of interest into a host cell whose machinery is used to produce the desired protein, which is then employed in the production of pharmaceutical products in drug delivery as a scaffold in tissue engineering, and various other applications. Enhancing the DNA transfection efficiency is essential to improve gene function and protein expression. Conventionally, DNA can be delivered into the cells directly through chemical methods (calcium chloride-heat shock method), physical methods (electroporation) or biological methods (viral or bacterial vectors). However, the major disadvantage of these methods is that the efficiency of DNA transfection into the cells is considerably low due to certain enzymes, immunogenicity, pH variation, cell contamination and other factors; therefore, leading to cytotoxicity and lower cell viability. To overcome this, a new method using nanotechnology has been implemented for DNA transfection. The nanopolymers or the dendrimers are highly branched nanostructures that form polyplexes with the negatively-charged DNA and protect the DNA from nuclease or deoxyribonuclease (DNase) enzyme activity, thereby helping in the release of DNA into the cell. In order to protect the DNA from being inactivated during transfection, the DNA-dendrimer complexes are surrounded by water-soluble polymers and are then allowed to deposit on the biodegradable polymer films to allow efficient gene transfection. One such example of a widely used polyplex is the polyamidoamine (PAMAM) dendrimer-DNA polymer complex. Although direct transfection of DNA with the help of nanoparticles has been effective, these nanopolymer complexes show improved results. Nanotubes, especially carbon nanotubes (CNTs) are vertically arranged nanostructures that have the ability to penetrate the cell through the plasma membrane and release the DNA and proteins to the target cell. These nanotubes are widely used for transfecting mammalian cells specifically. CNTs are either closed-ended, often called nanowires or hollow tubes (open-ended) called nanotubes. The biomolecules are adsorbed on the walls of the nanowires and in the case of hollow nanotubes, the biomolecules are transfected into the cell through fluid transport of the nanotube lumen. Nanotechnology has provided many new and innovative approaches to the delivery of genetic materials, hence additional research is required to optimise these methods and obtain approval for clinical use.

Keywords: Nanoparticles, DNA transfection, Carbon nanotubes, Nanopolymers, Dendrimers

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