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Functionalized gold nanostructures: promising gene delivery vehicles in cancer treatment

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Surface-modified gold nanoparticles are recognized as promising gene delivery vehicles in the treatment of cancer owing to their excellent biocompatibility with biomolecules (like DNA or RNA) and their unique optical and structural properties. In this context, this review article focuses on the diverse transfection abilities of the gene to the targeted cell on the basis of different shapes and sizes of gold nanoparticles in order to promote its effective expression for cancer treatment. In addition, recent trends in gold nanoparticle mediated gene silencing, gene delivery, detection and combinatory therapies are highlighted considering their cytotoxic effects on healthy human cells.

1. Introduction

Cancer, with high incidence and deregulated cell growth, has caused death all over the world. Conventionally, cancer treatment relied mainly upon tumour resection along with chemotherapy, where there is non-specific accumulation of drugs and/or radiotherapy resulting in various side effects. A large number of cancer cells have become drug resistant towards these therapies mostly due to the molecular mechanism. These drawbacks of the traditional approach towards treatment of cancer can be overcome by combining gene therapy with other related therapies such as chemotherapy, photothermal therapy, photodynamic therapy, *etc.*[1–4] Gene delivery vectors reported in recent years, include polymer-based, lipid-based, and inorganic nanoparticle-based systems.[5–9] Ideal non-viral gene vectors offer numerous advantages, such as chemical stability, biocompatibility, effective targeting, stimulus responsiveness and feasibility for combined treatments.[2–4] Due to irregular signalling pathways and genetic alterations, the concept of novel molecularly targeted therapeutic strategies such as gene-silencing or knockdown therapies have been introduced.[10–14] RNA interference (RNAi), one of the significant gene therapy approaches followed by tumour resection has fascinated researchers in cancer treatment,[15] where microRNA (miRNA) and plasmid DNA (pDNAs) are frequently utilized because of their higher stability and specificity than those of small interfering RNA (siRNA).[16,17] Surface-modified gold nanomaterials are acknowledged as favourable gene delivery vehicles,[18–21] in consequence of their small size, general non-toxicity, ease of functionalization and high surface to volume ratio, localized surface plasmon resonance (LSPR) of gold nanoparticles resulting in improved consideration from non-viral siRNA gene delivery.[11,22,23] Additionally, these nanoparticles can also be used for imaging of tumours by computed tomography, a leading radiologic technology in the field of biomedical imaging.[24]

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