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REVIEW ARTICLE

# Aspects of Nanomaterials in Wound Healing

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**Abstract:** Wound infections impose a remarkable clinical challenge that has a considerable influence on morbidity and mortality of patients, influencing the cost of treatment. The unprecedented advancements in molecular biology have come up with new molecular and cellular targets that can be successfully applied to develop smarter therapeutics against diversified categories of wounds such as acute and chronic wounds. However, nanotechnology-based diagnostics and treatments have achieved a new horizon in the arena of wound care due to its ability to deliver a plethora of therapeutics into the target site, and to target the complexity of the normal wound-healing process, cell type specificity, and plethora of regulating molecules as well as pathophysiology of chronic wounds. The emerging concepts of nano-biomaterials such as nanoparticles, nanoemulsion, nanofibrous scaffolds, graphene-based nanocomposites, etc., and nano-sized biomaterials like peptides/proteins, DNA/RNA, oligosaccharides have a vast application in the arena of wound care. Multi-functional, unique nano-wound care formulations have acquired major attention by facilitating the wound healing process. In this review, emphasis has been given to different types of nanomaterials used in external wound healing (chronic cutaneous wound healing); the concepts of basic mechanisms of wound healing process and the promising strategies that can help in the field of wound management.

**Keywords:** Angiogenesis, cell proliferation, controlled release, nanomaterials, reepithelialization, tissue regeneration, wound healing process, wound management.

## 1. INTRODUCTION

Undoubtedly, nano is an important key term for developments in science and technology [1]. The emergence of nanotechnology has a significant impact on drug delivery sector, and nanomaterials are at the leading edge with a diverse array of industrial and medical applications. Research in nanotechnology for medical and health-related issues show a range of applications such as drug delivery, vaccine development, antibacterial, diagnosis and imaging tools, wearable devices, implants, high-throughput screening platforms, etc. using biological, nonbiological, biomimetic, or hybrid materials [2-5].

Modern technologies for constructing micrometer- and nanometer-sized structures can be classified as two approaches, such as bottom up and top down [6]. The initial development of nanotechnology mainly depends on top-down methods including various micro- and nano-fabrication techniques. Subsequently, the counterpart concept of the bottom-up approach has become more popular for the construction of functional materials and systems by using supramolecular interactions and self-assembly processes [7]. The bottom-up approaches are further divided into those using low-molecular-weight compounds, synthetic polymers, bio-macromolecules like proteins, DNAs, etc. In this approach, construction of homogeneous or heterogeneous cell-assemblies, for instance, is accomplished through solution processing in which synthetic polymers or bio-macromolecules are linked with cells to form organized assemblies [6]. However, nanotechnology can help us to design nanomaterials by using simple tools only, but sometimes we need to design and synthesize more sophisticated materials and structures [7]. Thus, the concept of nanoarchitectonics evolved to arrange nanoscale structural units into a required configuration [1, 8].

It is well known that nanomedicines have the potential to enter the mainstream of cancer therapeutics to improve the therapeutic index of anti-cancer drugs by modifying their pharmacokinetics and tissue distribution to improve delivery to the site of action [9]. Recently, the roles of DNA and oligonucleotides in materials science are becoming interesting

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