

Nanoengineered Nanofibers: A Potential Approach to Design New Drug Delivery Systems

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doi: 10.71168/NMP.02.03.131

Received Date: January 14- 2026**Publication Date:** May 10- 2026

In the emerging landscape of health sector, nanotechnology has been employed in each field of pharmacy. Amid most impactful platforms, nanofibers that are ultrafine fibres with dimension typically < 100 nm, have arose as highly adaptable arena within different relevance i.e. drug delivery, regenerative medicine tissue engineering and theronostics. Their exclusive architecture and properties such as vast surface-area-to-volume ratios, porosity, and simulation with extracellular matrix (ECM), have placed nanofibers attractive platform for designing of novel dosage formulations and drug delivery.

Electrospinning technique, the highly demanded approach for fabrication of nanofiber, facilitates precise control on nanofiber composition and architecture. This flexibility grants researchers to integrate or addon different therapeutic agents like small molecules, proteins, genes, cell organelle, and even living cells onto nanofiber scaffolds. Resultant, nanofiber-embedded drug delivery systems can be designed to target controlled/ stimuli responsive and site-specific releases. For instances, fast-dissolving oral nanofiber patches/films provide instant onset of action, whereas theronostics loaded nanofiber scaffolds enable prolong and site-specific drug delivery, specifically in cancer therapy and chronic wound treatment.

Next transformative role lies in regenerative medicine and tissue engineering, where nanofibers are employed as biomimetic scaffolds. Its ECM-like architecture encourages cell adhesion, cell proliferation, and cell differentiation that are ideal for regeneration of skin, bone, cartilage, and neural tissues. Moreover, functionalized nanofibers with growth factors, proteins/ peptides, and any conductive materials further improves regenerative efficiency. Further, biodegradable and biocompatible polymeric nanofibers provide an impressive remedy for tissue repairing.

Another interesting application of nanofiber is revealed in active packaging systems of pharmaceuticals. Incorporation of oxygen-scavenging materials or antimicrobials on the surface of nanofibers substantially enhance the shelf-life and stability of sensitive components in the formulations.

Similarly, membrane filters based on nanofiber technology are revolutionizing filtration units that efficiently separate out particulate matter, pyrogens and microorganisms with nominal resistance to flow.

Despite these innovations, translation of nanofiber-based formulations into pharmaceutical market endures limited. Confronts like reproducibility, large-scale production, regulatory acceptance, and biocompatibility are still to be addressed. Cooperative efforts among academia, industry, and regulatory bodies will be necessary to conquer these shortcomings.