https://doi.org/10.1080/00914037.2026.2661646

Check for updates

# Polymeric biomaterials in translational nanomedicine: a review on drug delivery, gene therapy, and tissue engineering

Km Anjali[a], Arvind Raghav[b] and Urvashi Saxena[b]

[a]Department of Pharmaceutical Chemistry, Sahu Onkar Saran School of Pharmacy (Faculty of Pharmacy), IFTM University, Moradabad, Uttar Pradesh, India; [b]Department of Pharmaceutics, Teerthanker Mahaveer College of Pharmacy, Teerthanker Mahaveer University, Moradabad, Uttar Pradesh, India

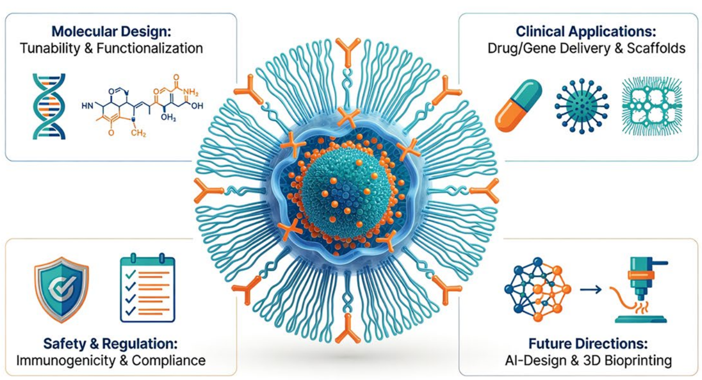
**ABSTRACT**

Polymeric biomaterials have become central to translational nanomedicine, bridging molecular design with clinical applications in drug delivery, gene therapy, and tissue engineering. Their tunable structure, biocompatibility, and functionalization enable precise control over pharmacokinetics, biodistribution, and targeted drug release. Natural polymers like chitosan, alginate, and collagen provide inherent bioactivity, while synthetic polymers such as PLGA, PEG, and PCL offer enhanced chemical precision and controlled degradation. Advances in hybrid and stimuli-responsive systems allow site-specific, on-demand release triggered by pH, temperature, redox conditions, or enzymes. Progress in polymer chemistry and nanotechnology has led to multifunctional theranostic platforms that integrate diagnosis and therapy, supporting personalized medicine. Polymeric systems also act as promising non-viral gene delivery vectors and as scaffolds in regenerative medicine, mimicking extracellular matrices to promote tissue repair. However, clinical translation requires addressing challenges related to biocompatibility, immunogenicity, scalability, and regulatory standards. Emerging tools like AI-assisted design and 3D bioprinting are accelerating the development of efficient, customizable polymeric nanomedicines.

**ARTICLE HISTORY**
Received 24 November 2025
Accepted 14 April 2026

**KEYWORDS**
Polymeric biomaterials; nanomedicine; drug delivery; gene therapy; tissue engineering; personalized nanomedicine

**GRAPHICAL ABSTRACT**




## 1. Introduction

Nanomedicine is an interdisciplinary field that combines nanotechnology and medical sciences, revolutionizing drug delivery, diagnostics, and therapeutic interventions through its ability to manipulate materials at the molecular and nanoscale. Their programmable physicochemical properties, biocompatibility and deformability have found their place as important tools in this field in polymeric biomaterials.[1,2] The utilization of polymers provides an outstanding platform for constructing nano-carriers that can encapsulate, protect, and deliver therapeutic molecules in a regulated environment, thereby surmounting the constraints posed by conventional drug formulations. Their ability to be functionalized and form nanostructures, as well as their properties to detect biological use, make them the indispensable element of the notion of translational nanomedicine.[1,3]

Polymeric biomaterials are significant in nanomedicine because they can be employed as a means of replicating and mimicking the interactions in biological systems. Polymers such as poly (lactic-co-glycolic acid) (PLGA), polyethylene glycol (PEG), chitosan, polycaprolactone (PCL), and dendrimers are widely used owing to their customizable architectures and degradability into nontoxic byproducts.[4,5] These

**CONTACT** Km Anjali anjali.ved.2303@gmail.com Department of Pharmaceutical Chemistry, Sahu Onkar Saran School of Pharmacy (Faculty of Pharmacy), IFTM University, Moradabad, Uttar Pradesh, India.