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**Synthesis, Characterization, and Applications of Polymer
Nanocomposites for Targeted Drug Delivery**

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Abstract

Polymer nanocomposites have emerged as promising advanced materials for targeted drug delivery due to their unique physicochemical properties, biocompatibility, tunable surface characteristics, and ability to improve the therapeutic efficiency of pharmaceutical agents. These nanocomposites are generally synthesized by incorporating nanoscale materials such as metal nanoparticles, silica, carbon-based nanomaterials, or other functional nanostructures into biodegradable polymeric matrices. Various synthesis approaches, including nanoprecipitation, emulsion techniques, solvent evaporation, and in situ polymerization, can be employed to obtain nanoparticles with controlled size, morphology, and drug-loading capacity. Characterization techniques such as scanning electron microscopy, transmission electron microscopy, dynamic light scattering, Fourier-transform infrared spectroscopy, X-ray diffraction, and thermal analysis are used to evaluate their structural, morphological, chemical, and thermal properties. In targeted drug delivery, polymer nanocomposites can enhance drug solubility, stability, controlled release, and bioavailability while minimizing systemic toxicity and undesirable side effects. Surface functionalization with specific ligands, antibodies, peptides, or biomolecules can further improve selective accumulation at diseased tissues or specific cellular targets. These materials have significant potential applications in cancer therapy, antimicrobial treatment, gene delivery, and treatment of chronic diseases. Overall, polymer nanocomposites represent a versatile platform for developing safer, more effective, and controlled therapeutic delivery systems, although challenges related to toxicity, biodegradability, large-scale production, and regulatory approval remain important areas for future research.

Keywords: Polymer nanocomposites, targeted drug delivery, nanoparticles, controlled release, drug loading, biocompatibility, surface functionalization, nanomedicine, cancer therapy, biodegradable polymers.