Chapter 15

Nanocomposites in Drug Delivery and Imaging Applications

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ABSTRACT

Nanocomposites are a class of materials in which one or more phases with nanoscale dimensions are embedded in a metal, ceramic, or polymer matrix. The properties of nanocomposites depend on matrix, loading, degree of dispersion, size, shape, and orientation of the nanoscale phase and interaction between the matrix and the nanoscale phase. Nanocomposites are generally prepared using direct melt intercalation. The formation of nanocomposite is ascertained by XRD pattern, FTIR spectra, electron microscopy, and thermal analysis like DSC and TGA. Nanocomposites have properties of nanoparticles, multifunctional capabilities, chemical functionalization, huge interphase zone. Novel nanomaterials offer a new chemotherapeutic route for cancer treatment by combining cell imaging and hyperthermia in a synergistic way. In spite of toxicity and safety concerns, multifunctional nanocomposite still interest the researchers because of emergence of versatile properties, better understanding of disease biomarkers, and quest for ways to improve biocompatibility.

1. INTRODUCTION

Targeted nano drug delivery envisage not only improved bioavailability but also safety of therapeutic agents. This may provide solution to problems associated with cancer treatment viz. dose-dependent cytotoxicity, drug resistance. Passive targeting is obtained by enhanced permeation and retention (EPR) effect while active targeting depends upon specific interaction between drug carrier and cellular target. Nanocarriers can be functionalized with ligands which bind specifically to receptors on cancer cells which enable them to undergo receptor mediated endocytosis. Tumor cells have been found to overexpress one of these receptors: lectin receptors, Fc receptors, complement receptors, interleukin receptors, lipoprotein receptors, transferrin receptors and dopamine receptors. It has been found that

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dopamine (DA) receptors are overexpressed in human colon adenocarcinoma cells and breast cancer cells. DA functionalized nanocarriers have been used to selectively deliver anticancer drugs curcumin, camptothecin and doxorubicin to human colon adenocarcinoma cells (Das, & Jana, 2015). Considerable efforts have been made towards translation of nanotechnology into medical practice specially for cancer management. The two main applications are diagnosis and therapy. The targets being same, the development of separate approaches can miss opportunity to improve efficacy. The physical properties of nanomaterials enable them to serve as the basis for superior imaging probes to simultaneously locate and deliver therapeutics to cancerous lesions. These technologies have resulted in development of nanotheranostics with both imaging and therapeutic functionalities. These multimodal platforms are valuable components for emerging trend towards personalized medicine (Xie, Liu, Eden, Ai, & Chen, 2011; Chen, Ai, Liu, & Lu, 2014).

Nanocomposites are a class of materials in which one or more phases with nanoscale dimensions are embedded in a metal, ceramic or polymer matrix. There are principally three types of nanocomposites metallic, ceramic, polymer matrix nanocomposites as shown in Figure 1. Polymer nanocomposites have been extensively used for biomedical applications. The possibility to form self-assembled and supramolecular morphologies makes organic polymers and inorganic nanoparticles desirable building blocks for the design of nanocomposite hydrogels. The properties of nanocomposite depend on matrix, loading, degree of dispersion, size, shape and orientation of the nanoscale phase and interaction between the matrix and the nanoscale phase (Kumar, & Krishnamoorti, 2010). Nanocomposites are generally prepared using direct melt intercalation. Layered double hydroxides are used as nucleating agent which induces crystallization of biopolymers like poly (L-lactide), polycaprolactone. The formation of nanocomposite is ascertained by XRD pattern, FTIR spectra, electron microscopy and thermal analysis like DSC and TGA. Nanocomposites have properties of nanoparticles, multifunctional capabilities, chemical functionalization, huge interphase zone (Taneja, Pareeka, Vermaa, Jaina, Ratana, & Ashawatb, 2012). Many polymer nanocomposites have been used for improved drug delivery. Nanocomposite films of layered double hydroxide tethered with ibuprofen (IBU) blended into poly (l-lactide) polymer exhibited six times higher release rate than non-composite films. Mechanism of drug release changed to diffusion/ion exchange from diffusion controlled process. The prepared nanocomposite film had improved elastic

Figure 1. Schematic representation of a nanocomposite and its types. It is the matrix which determines the type of nanocomposite.