Abstract

Multifunctional smart scaffold for simultaneous drug delivery and sensing application has a long history in the medicinal field. However, their extensive applications are challenged by a few shortcomings, such as the usage of toxic crosslinkers during scaffold fabrication, leaching out of nanomaterials from the matrix, lack of target specificity and stability in different physiological environments, poor cellular uptake and excretion from the body, and premature release of the drug before reaching the target site. Moreover, post-drug loading techniques based on the physisorption or diffusion mechanism to encapsulate drug molecules into the scaffolds are often related to the insufficient % of drug loading (DL) and drug encapsulation (DE) efficiency. Last but not least, after endocytosis, the tracing of drug molecules is a very challenging task.

Henceforth, this thesis work has tried to resolve some of these above-mentioned issues by designing different stimuli-responsive multifunctional scaffolds. For this purpose, gelatin-carbon dots-based hydrogel, microsphere, and nanoparticles are fabricated and loaded with different model drugs (cefadroxil, vitamin B12, 5 Fluorouracil). These scaffolds had successfully addressed several issues (replacement of toxic crosslinker, improvement of % DL, DE, and improvement of quantum yield percentages) and produced pH-responsive sustainable drug-release behavior with excellent bio-sensing ability. In addition, their excellent cytocompatibility while delivering loaded drug molecules to the targeted sites (intestinal region, a wound bed, or a cancerous site) is worth mentioning. However, solving one aspect creates another, which was eventually addressed in successive work. Ultimately, a triazole-linked drug-receptor-nanohybrid was formulated by facile click chemistry to conjugate drugs, receptors, and chromophore nanoparticles in a single platform for target-specific anticancer activity and simultaneous drug-tracing application. Extensive characterizations were conducted to establish the structure-property relationship of all the scaffolds, and successively *in vitro* drug-dissolution studies were performed by mimicking different physiological pH conditions. Moreover, various biological assessments (cell viability, apoptosis study, cell cycle analysis, flow-cytometry-based cellular uptake, and cellular imaging) were carried out to prove these scaffolds' cytocompatibility and biological efficacy as a multifunctional smart scaffold.

Keywords: pH-responsive drug delivery; Hydrogel; Microsphere; Carbon dots; Gelatin; Anticancer activity; Antibacterial activity; Wound-dressing; Bio-sensing; Bio-imaging; Click chemistry.