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Polymer surface modification for the attachment of bioactive compounds

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Abstract

This paper reviews recent advances in the covalent attachment of bioactive compounds to functionalized polymer surfaces including relevant techniques in polymer surface modification such as wet chemical, organosilanization, ionized gas treatments, and UV irradiation. Methods of analysis of biofunctionalized polymer surfaces, including spectral methods (X-ray photoelectron spectroscopy, Fourier transform infrared spectroscopy, atomic force microscopy, and others) as well as non-spectral methods (contact angle, dye assays, biological assays, and zeta potential) are also considered. State-of-the-art techniques in covalent conjugation of bioactive compounds to the modified surfaces, such as usage of hydrophilic, bifunctional, and/or branched spacer molecules, are presented. Relevant bioconjugation reagents and chemistries are described and tabulated. Recently reported applications in areas such as biomedicine, biosensors, enzyme reactors, and textiles, all of which utilize a common set of surface bioconjugation techniques to address these diverse needs, are discussed. Finally, challenges to this emerging field of research are critically evaluated.
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Keywords: Polymer surface modification; Surface analysis; Covalent attachment; Bioactive compounds; Biosensors; Biomaterials

Abbreviations: AFM, atomic force microscopy; Ar, argon; ATR-FTIR, attenuated total reflectance Fourier transform infrared spectroscopy; BCA, bicinchoninic acid; CAH, contact angle hysteresis; CO_2, carbon dioxide; DNA, deoxyribonucleic acid; ECM, extracellular matrix; EDC, 1-ethyl-3-(3-dimethylaminopropyl)carbodiimide; ELISA, enzyme-linked immunosorbent assay; EVOH, ethylene vinyl alcohol; ESCA, electron spectroscopy for chemical analysis; h, height; HIT, heparin induced thrombocytopenia; H_2O, water; IgG, immunoglobulin G; HUVEC, human umbilical vein endothelial cell; MEMS, microelectromechanical systems; N_2, nitrogen; NH_3, ammonia; NHS, *N*-hydroxysuccinimide; O_2, oxygen; PCL, poly(caprolactone); PDMS, poly(dimethyl siloxane); PE, poly(ethylene); PEG, poly(ethylene glycol); PET, poly(ethylene terephthalate); PGA, poly(glycolic acid); PLA, poly(lactic acid); PLGA, poly(lactic-co-glycolic acid); PMMA, poly(methyl methacrylate); pN, picoNewton; PP, poly(propylene); PPY, poly(pyrrole); PS, poly(styrene); PTFE, poly(tetrafluoroethylene); PU, poly(urethane); RFGD, radio frequency glow discharge; RGD, arginine-glycine-aspartic acid peptide; RNA, ribonucleic acid; SAM, self assembled monolayer; SEM, scanning electron microscopy; ToF-SIMS, time-of-flight secondary ion mass spectrometry; UV, ultraviolet; VEGF, vascular endothelium growth factor; x, half width; XPS, X-ray photoelectron spectroscopy; Θ_a, advancing contact angle; Θ_r, receding contact angle; Θ_s, static contact angle

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Contents

1. Introduction

1.1. Definition

The covalent immobilization of bioactive compounds onto functionalized polymer surfaces has seen rapid growth in the past decade in such industries as biomedical, textiles, microelectronics, bioprocessing, and food packaging. While the end use of the biofunctionalized polymer varies with each application, the overall concept is the same, as illustrated in Fig. 1. The first step is to design or

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