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Polymer–inorganic supramolecular nanohybrids for red, white, green, and blue applications

Dae-Hwan Park[a], Seong-Ju Hwang[a], Jae-Min Oh[b], Jae-Hun Yang[a], Jin-Ho Choy[a,*]

[a] Center for Intelligent Nano-Bio Materials, Department of Chemistry and Nano Science, Department of Bioinspired Science, Ewha Womans University, Seoul, Republic of Korea
[b] Department of Chemistry and Medical Chemistry, College of Science and Technology, Yonsei University, Wonju, Gangwondo, Republic of Korea

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ABSTRACT

Layered nanohybrids are heterostructured materials composed of two-dimensional inorganic host and intercalating inorganic-, organic-, bio-, or polymer guests. Such materials have been extensively explored to create new multifunctional hybrid systems that integrate nanotechnology (NT), biotechnology (BT), information technology (IT), and even congnitive technology (CT). In this review, an attempt is made to classify and highlight recent advances in multifunctional nanohybrids based on layered materials and their related application systems; (i) red nanohybrid on life science and health-care sectors, (ii) white nanohybrid on energy and environmental ones, (iii) green nanohybrid on agriculture and food ones, and (iv) blue hybrid on aqua and marine ones. In details, the structural features and functions of the layered nanomaterials and their hybrid systems are discussed in each section.

Contents

Abbreviations: AFm, mono aluminate ferrite; A549, adenocarcinomic human alveolar basal epithelial cell line; C_3A, tricalcium aluminate; C_4AF, tetracalcium aluminoferrite; CEC, cationic exchange capacity; CLA, conjugated linoleic acids; CNT, carbon nanotubes; DBS, dodecylbenzenesulfonate; DNA, deoxyribonucleic acid; E, elongation at break; EU, European Union; FITC, fluorescein isothiocyanate; FU, fluorouracyl; GO, graphene oxide; GLA, gamma-linoleic acids; HDSs, hydroxyl double salts; Hep G2, human liver carcinoma cell line; HRR, heat release rate; HT, hydrotalcite; IFR, intumescent flame retardants; IUPAC, International Union of Pure and Applied Chemistry; LDHs, layered double hydroxides; MCPA, 4-chloro-2-methylphenoxyacetic acid; MDF, macro-defect-free; MG-63, human osteosarcoma cell line; MMT, montmorillonite; MTX, methotrexate; MWCNT, multiwall carbon nanotubes; NSAIDs, non-steroidal anti-inflammatory drug; PA6, polyamide matrix 6; PAA, polyacrylic acid; PAA-AM, poly(acrylic acid-*co*-acrylamide); PCL, poly(ε-caprolactone); PCE, polycarboxylate ether; PE, polyethylene; PE-g-MA, polyethylene-grafted-maleic anhydride; PEG-AS, poly(ethylene glycol)-*n*-alkyl-3-sulfopropyl diether; PEG-DC, poly(ethylene glycol) dicarboxylic acid; PEGS, polyoxyethylene sulfate; PHEMA, poly(2-hydroxylethyl methacrylate); PLA, poly(lactide) acid; PLGA, poly(D,L-lactide-co-glycolide) acid; PMA, polymethylacrylate; PMMA, polymethylmetacrylate; PNIPAM, poly(*N*-iso-propylacrylamide); PP, polypropylene; PS, polystyrene; PSS, polystyrene sulfonate; PVA, polyvinyl alcohol; PVC, polyvinylchloride; PVS, polyvinylsulfonate; RGO, reduced graphene oxide; SaOS-2, sarcoma osteogenic cell line; SCM, supply chain management; siRNA, small interfering RNA; SPMA, 3-sulfopropylmethacrylate; TS, Tensile strength; UDCA, ursodeoxycholic acid; VBS, vinylbenzene sulfonate; WVP, water vapor permeability.

* Corresponding author. Tel.: +82 2 3277 4135; fax: +82 2 3277 4340.
E-mail address: jhchoy@ewha.ac.kr (J.-H. Choy).

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1. Introduction

Hybrid is a reflection of the combination of multidisciplinary technologies such as nanotechnology, biotechnology, information technology and cognitive technology resulting in various new multifunctional systems and advanced scientific knowledge [1–5]. Particularly, hybrid materials at nanometer scale have been extensively studied and widely practiced in different fields of life science [6,7], eco-environment [7,8], power generation [9], electronics [9,10], fine chemistry [3], and polymer engineering [10]. At present, these hybrid materials at nanoscale has increasingly penetrated into diverse areas such as bioinspired or biomimetic materials, medical health-care, renewable energy supply, agricultural process, food industry, remediation, or water treatment [11–15]. Therefore, utilization of "nanohybrid" or "nanocomposite" has naturally become a common concept in the development of heterostructured nanomaterials and their combined applications.

Among the heterostructured nanomaterials, layered nanohybrids have received intense attentions in many areas due to their unique physico-chemical and mechanical properties, those which cannot be obtained from other analogous nanohybrids [16–18]. These layered nanohybrids are in general prepared through soft-chemical lattice engineering routes on the basis of intercalation chemistry. According to the definition of intercalation reaction [19,20], it describes the reversible insertion of guest species, whatever they are inorganic-, organic-, bio- or