



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

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ABSTRACT

Layered nano hybrids 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 cognitive technology (CT). In this review, an attempt is made to classify and highlight recent advances in multifunctional nano hybrids based on layered materials and their related application systems; (i) red nano hybrid on life science and health-care sectors, (ii) white nano hybrid on energy and environmental ones, (iii) green nano hybrid 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.

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Contents

| | |
|---|------|
| 1. Introduction | 1443 |
| 1.1. Structural features of layered materials | 1444 |
| 1.2. Lattice engineering routes to layered nano hybrids | 1446 |
| 1.3. Lattice engineering routes to LDH-based polymer nano hybrids | 1446 |

Abbreviations: AFm, mono aluminate ferrite; A549, adenocarcinomic human alveolar basal epithelial cell line; C₃A, tricalcium aluminate; C₄AF, 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-hydroxyethyl methacrylate); PLA, poly(lactide) acid; PLGA, poly(D,L-lactide-co-glycolide) acid; PMA, polymethylacrylate; PMMA, polymethylmethacrylate; 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.

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| | | |
|--------|--|------|
| 1.3.1. | Direct polymer intercalation | 1447 |
| 1.3.2. | Direct monomer intercalation and in-situ polymerization | 1448 |
| 1.3.3. | Intact melt-blending | 1448 |
| 1.3.4. | Surface-modified LDH blending | 1448 |
| 1.3.5. | Surface-modified LDH solution blending | 1449 |
| 1.3.6. | Surface-modified LDH solution blending by in-situ polymerization | 1449 |
| 1.3.7. | LDH–polymer nanohybrids for cement superplasticizers in concrete application | 1450 |
| 2. | Red nanohybrids: life science and health-care applications | 1451 |
| 2.1. | Introduction to red layered nanohybrids | 1451 |
| 2.2. | Bio-layered nanohybrids for medical applications | 1451 |
| 2.2.1. | Drug–inorganic nanohybrids for drug delivery system | 1451 |
| 2.2.2. | Cellular uptake of drug–inorganic nanohybrids | 1452 |
| 2.2.3. | Controlled release of drug from drug–inorganic nanohybrids | 1452 |
| 2.3. | Polymer-layered nanohybrids for red application | 1454 |
| 2.3.1. | Advanced functionalization in drug delivery system | 1454 |
| 2.3.2. | Advanced materials for tissue engineering | 1455 |
| 2.3.3. | New materials design by polymer–inorganic nanohybrids | 1456 |
| 3. | White nanohybrids: energy and environmental applications | 1456 |
| 3.1. | Introduction to white layered nanohybrids | 1456 |
| 3.2. | Electrochemical applications | 1458 |
| 3.2.1. | Electrode for supercapacitors | 1458 |
| 3.2.2. | Electrode for lithium rechargeable batteries | 1459 |
| 3.3. | Photocatalyst applications | 1460 |
| 3.3.1. | LDH-based nanohybrids as photocatalyst | 1460 |
| 3.3.2. | Layered metal oxide-based nanohybrids as photocatalyst | 1461 |
| 3.4. | LDH-based nanohybrids with polymer or carbon | 1462 |
| 3.4.1. | Polymer-layered nanohybrids | 1462 |
| 3.4.2. | Carbon-layered nanohybrids | 1463 |
| 4. | Green nanohybrids: agriculture and food applications | 1464 |
| 4.1. | Introduction to green layered nanohybrids | 1464 |
| 4.2. | Agriculture applications | 1465 |
| 4.2.1. | Controlled delivery system of agrochemicals | 1465 |
| 4.2.2. | Superabsorbent polymer-layered nanohybrids for anti-desertification | 1465 |
| 4.3. | Food applications | 1468 |
| 4.3.1. | Bioavailability improvement of functional food ingredients | 1468 |
| 4.3.2. | Polymer-layered nanohybrids for food packaging films | 1468 |
| 4.4. | Biopolymer-layered nanohybrids as smart label for origin traceability system | 1469 |
| 5. | Blue nanohybrids: aqua and marine applications | 1470 |
| 5.1. | Introduction to blue layered nanohybrids | 1470 |
| 5.2. | Clean-up of radionuclides from aqua and ocean | 1471 |
| 5.2.1. | Natural layered inorganic polymer | 1471 |
| 5.2.2. | Synthetic layered inorganic polymer | 1472 |
| 5.3. | Geological repository | 1474 |
| 6. | Conclusion | 1475 |
| | Acknowledgments | 1475 |
| | References | 1475 |

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

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