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PREFACE

Novel Functionalized 2D-MOF Integrated Hybrid Nanocomposite for Industrial Practice

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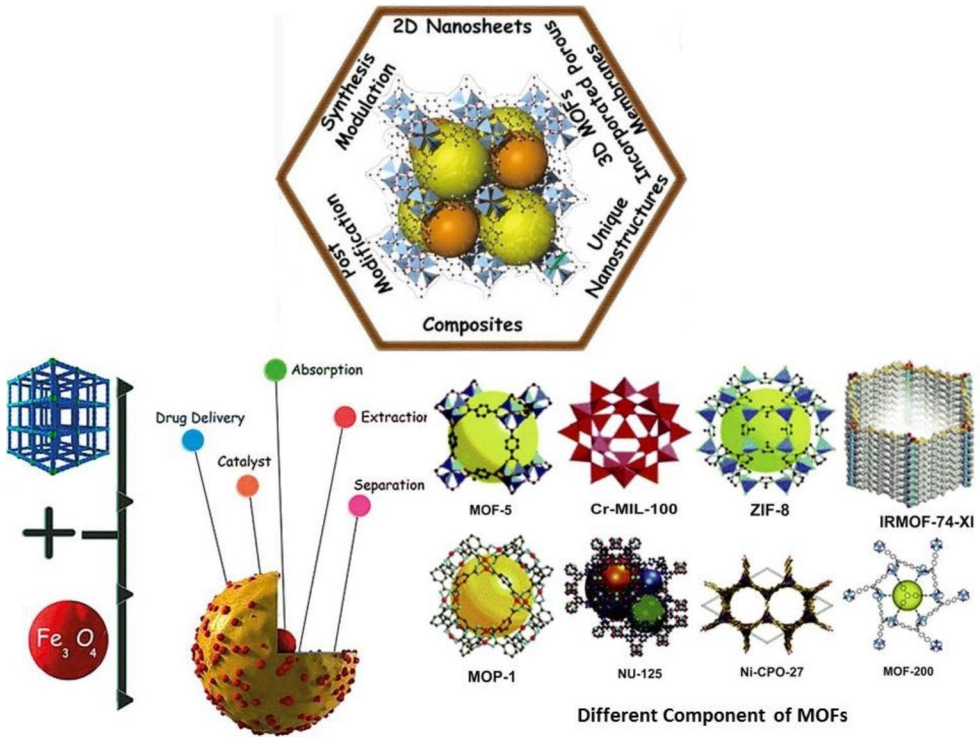
Graphical Abstract



Scheme 1 Application of MOFs and varieties for structural analysis [16, 17] (Copyright©2021, Elsevier; Copyright © European Chemical Societies Publishing, 2020)

Keywords 2D-MOFs · Nanomaterials · Graphene · Polymer · Hybrid Nanocomposites · Spectroscopy

A significant amount of research attention has been devoted to the integration of metal-organic frameworks (MOFs) into 2D structures and their derivatives due to their remarkable properties, including high specific surface areas, adjustable pore sizes, and ease of functionalization. Consequently, they offer unique advantages in various fields such as catalysis, energy storage, optoelectronics, switches, and switchable devices. Some of the recent advances in this field are presented in this special issue and are briefly described below.

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For example, the incorporation of the smart electronic material 'graphene' has facilitated the development of novel two-dimensional nanosheets derived from a variety of traditional metal-organic framework (MOF)-based materials, which are now recognized as a distinct class of porous crystalline materials. MOFs possess distinctive features, such as framework flexibility and chirality, which make them highly attractive when compared to other porous materials, especially for the purification of heavy metals.

In light of these advantages, the development of water-stable MOFs and post-modification technologies has enabled the exploration of MOFs and MOF-based composites for a wide range of liquid-phase applications. In the field of high-performance liquid chromatography, there have been several challenges related to the performance and recent applications of MOF-based core-shell composites as stationary phases.

For example, an innovative research finding by Kirandeep et al. in the field involves novel Cu-MOF-based nanoparticles for the essential nanoenzymatic detection of mercury ions [1]. These ions are well-known for their toxicity; and, their accumulation in the human body can lead to harmful, particularly neurological, diseases. Therefore, investigating them at trace levels using sensor mechanisms is crucial and significant innovations executed in the special issue.

In a typical investigation involving rheological studies [2], Bouider et al. found that non-linear behaviour was observed in PLA nanocomposites indicates pseudo-solid function, which is characteristic of excellent dispersion achieved by utilizing nanofillers. Furthermore, the reduction in cold crystallization enthalpy suggests the high potential utility of these composites in various applications, including gas separation, energy storage, and packaging. The incorporation of MOF-5/GO has significantly reduced water vapor permeation, particularly in PLA/MOF-5/GO composites containing 5% of MOF-5/GO-5. This indicates a clear relationship between structural properties and packaging applications [3] Bouide et al.

Extensive efforts have been made by Vijayan et al. in the synthesis of nanocellulose (NC), modified nanocellulose (pM-NC), and MOF composites (ZIF-8/pM-NC) derived from moringa oleifera seed pods [4]. These materials have been employed in dye adsorption processes, and delignification treatments have been used to obtain cellulose from biomass. Taguchi analysis and the RSM (BBD) method have been utilized for experimental design and parameter optimization. Other examples are the novel geopolymeric mortars by Brandão et al. which are reinforced with carbon nanotubes (CNT) and have exhibited exceptional mechanical properties, chemical durability, and thermal stability [5]. These inorganic polymers offer environmental advantages in production and are considered high-performance materials.

Additionally, the synthesis of nickel dimethylglyoxime (NDG) on γ-alumina (γ-Al2O3) composite photocatalysts was investigated for their performance in degrading methylene blue (MB) and methyl orange (MO). Structural, thermal, magnetic, and photocatalytic characteristics are reported [6] by Abd El-Baki et al.

The formulation of traditional agrochemicals such as herbicides, insecticides, liming agents, pesticides, and fertilizers has been extensively employed in the field to enhance crop productivity. However, their excessive use poses environmental risks. Research by Feba Mohan et al. which is focused on the development of slow and controlled release of nanofertilizers, nanopesticides, and nanoherbicides as a sustainable approach to improving agricultural practices and increasing yields are reported [7].

Moreover, novel hybrid metal-organic framework-based polymer nanocomposites (e.g., ZIF-8/NC-PU) and interpenetrating polymer gel nanocomposites (NC-PU) have been prepared for the adsorption of cationic (Rh-B) and anionic (IC) dyes from aqueous solutions [8]. These adsorbents demonstrated high efficiency in the removal of multiple dyes from wastewater by Abdullah et al. In addition, a casting method was employed to fabricate poly (methyl methacrylate)/hydroxyapatite (PMMA/HA) nanocomposite films incorporated with varying contents of graphene nanoplatelet (0.5, 1, and 1.5 wt%). The dielectric investigations of these materials showed improvements in film properties with increasing GNP content.

Introducing the smart electronic material 'graphene', into conductive polymers (viz. polypyrrole and polythiophene) as nanoparticles is a promising technique to enhance the charge transfer efficiency of the resulting nanocomposites (PPy/PTh/Gr) [8] by Adedoja et al., pal et al. Novel graphene embadeed polymeric nanocomposites executed significant potential applications e.g. energy storage, supercapacitors [9], sensors [10], and photovoltaic devices [11] by Pal et al.

Also, the performance of MOF-5/GO composites in photocatalytic degradation of methylene blue dye (MB) under sunlight was investigated [12] by Bouider et al. These composites exhibit remarkable photocatalytic efficiency compared to pure MOF-5, thanks to a synergistic effect that delays photo generated electron-hole recombination and maximizes charge transfer within the hybrid system structure.

In another study, the composite PPy/GO was effectively fabricated using a polymerization technique, resulted in improved optical conductivity and carbon cluster formation compared to pure PPy [13] by Atta et al.

Current research trends on carbon allotropes by Abdelrazek et al. have focused on multi-walled carbon nanotubes-polycaprolactone/poly (methyl methacrylate) (MWCNTs-PCL/PMMA) nanocomposites and their optical, thermal, and mechanical properties [14]. Structural investigations *via* XRD patterns revealed that the addition of MWCNTs to the PCL/PMMA blend enhanced its amorphous nature, and resulted in improved mechanical properties such as tensile strength and Young's modulus. Additionally, the optical energy band gap of MWCNT-PCL/PMMA films decreased with increasing nanofiller content.

Ettoumi et al. in the novel synthetic route was developed for the fabrication and determination of the optical properties of copper ceramic glasses in CuO-Al_2O_3-P_2O_5-SiO_2. The addition of CuO influenced the material's structure, causing a transition from a dielectric state to a semiconductor state. These materials showed promise for applications in white light-emitting devices [15].

In conclusion, this special issue highlights the versatile advantages and exciting discoveries in the realm of 2D MOFs that are derived from a wide variety of traditional inorganic and organic materials, particularly polymer/graphene hybrid nanocomposites, which are emerging as promising candidates for heavy metal purification. The purpose of this issue is to summarize recent progress in 2D MOFs and their applications in heavy metal purification. The presented article covers the advances in 2D nanomaterials, graphene hybrid components, novel 2D MOFs effective in heavy metal purification, and future research perspectives in modifying interfacial structures.

Additionally, the papers explored by Guo-Rong Xu et al. synthetic strategies to maximize the synergistic advantages of atomically mixed 2D inorganic/organic–graphene-polymeric components, with a focus on their electrochemical sensing activity [16]. These materials have applications in various fields, including catalysis, separation, biomedical engineering, and biosensing; but, their sustainability is challenged by chemical stability issues and limited electrical conductivity. Nevertheless, researchers are making significant progress in developing composite materials. The demand for novel 2D interfacial materials with unique properties continues to grow for future industrial applications.

Metal-organic frameworks (MOFs), their tuneable properties, hybridization, and selectivity, as well as the emergence of materials like covalent-organic frameworks (COFs) and their composites [17], have gained popularity in global research by Aghayi-Anaraki, M. et al. The achievement of a clean and sustainable world hinges on the innovation of the next-generation nano-powered design strategies that can overcome current material challenges.

Entire issue cover up extended research areas in several branches namely spinach derived carbon dots for emerging sensing applications [18] reported Kaur et al., novel poly(lactic acid)/metal organic framework for composite nanoarchitectonics packging applications [19] reported by Bouider et al., key challenges of incorporating reinforcement materials with the polymer matrix composites for three-dimensional (3-D) printing application [20] reported by Abd-Elaziem et al., nickel dimethylglyoxime/γ-alumina composites nanoarchitectonics photocatalytic applications [21] reported by Abd El-Baki et al., anti-Oxidant, anti-microbial, anti-cholesterol, and anti-diabetic applications [22] via Triumphetta Pentandra methanol through green extraction reported by Mwalimu et al., most significant Flavone from Sargassum myriocystum and their potential applications [23] by Vinodkumar et al., Nanocurcumin/Nano Iron Oxide Composite enabled in vitro anticancer applications against DLD-1 Cell Lines [24] reported by Pillai et al., biopolymers based nanocomposites for agrochemicals formulations and applications [25] also reported by Mohan et al. explored throughout the thematic publications in this *Journal of Inorganic and Organometallic Polymer Materials, Springer.*

Declarations

Ethics approval and consent to participate This is to declare that, there are no such reported experiments works done on live vertebrates and/or higher invertebrates for animal or human subjects.

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