Chapter 4

Sustainable Organo-Inorganic Metal Composites for Catalytic Degradation of Industrial Persistent Toxic Substances and Energy Storage

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Abstract

Colossal quantity of wastewater contaminated with persistent hazardous substances and degradable toxic compounds to the atmosphere are generated annually. Amongst the particular pollutant, chemicals, organic dyestuffs are of a considerable significance by virtue of its applications in fibers, fabric, coloring element, printed matter and manuring production. The present chapter comprises a complete perspective of green and sustainable organic-inorganic metal nanocomposites for heterogeneous chemical curtail of precarious organic noxious tinge (Chromotrope-2R, Eosin-Y and Methylene Blue) and energy storage (H_2 and C_2H_4). The nanocomposites were designed by simple strategy adopting nanostructured porous carbon material developed from reasonable pyrolysis fuel oil (PFO) related pitch remains.

Keywords

Economical, Energy Storage, Green Heterogeneous Catalyst, Hazardous Water Pollutants, Organic Dyes

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1. Introduction

Water is a precious reservoir and not a single living creature can live without H₂O. The large quantity discharge of untreated sewage and industrial wastes are polluting the habitation and environment. Contemporary applied industries are practicing the use of organic colouring agents, pigments and dye materials globally. Polymer industry, foodstuff, garments, synthetic leather and pulp industries are the major stock holders of these significant dye materials. The pollutant clearance and toxic waste of these factories is contaminating the water and soil. Ubiquitously, environmental researchers are working on the counteraction of this colouring agent-associated waste materials and its reprocessing [1]. Methylthioninium chloride, also known as methylene blue (MB), is used in medication to treat methemoglobinemia but it is mainly promoted as a dying agent to colour cottons, wood and silk threads. The contamination of methylene blue dye is very harmful to the environmental health [2-4]. Eosin-Y is a xanthene group's red fluorescent pigment. Due to its stability, adaptability, and light absorption nature, it is broadly availed in diverse applications such as., printing, polymer production, sensitizing industry, printing ink, fluorescent dye compounds, nanomaterials, histology, and biomedical research [5-8]. The discharge of Eosin-Y effluents spoils the eco-environment system due to its deep colour and noxious properties. Its structural features, combination of carboxyl group, pyran and benzene, enables carcinogenic vulnerability as a dye waste. Thirdly, the union of aromatic ring, chromophore mono-azo ($-N=N-$), hydroxyl ($-OH$), sulfonyl ($-SO_3H$) functional groups composes unique dye which is represented as a Chromotrope 2R. Due to its

carcinogenic, destructive and venomous behaviour, the effluent of Chromotrope 2R causes serious environmental problems [1, 9-11]. Organic dyes in drain water experienced chemical changes, absorbs dissolved oxygen and ruins marine life. The stain and immense chemical oxygen demand (COD) of these discharges may cause serious natural problems. For future generation environment protection, it is necessary to decompose these pollutant materials. A competent lessening and curing capabilities are therefore required to discard the poisonous or cancerous pigment masses, these colouring agents are a real matter in the area of contaminated water therapy. A large number of scientific researchers have shaped firm attempts to develop various methods and techniques for elimination of dyes and persistent pollutants in drain water. Presently, diverse scientific methods are viable such as molecular concentration, solid eradication, micellar improved active penetration, micro-purification and chemical sorption on the surface of adsorbent, activated farming hard wastage, hybrid carbon matters, magnetic compounds and catalytic decomposition. Lately, several processes have been employed to eliminate or breakdown of the organic dyes from wastewater, e.g., agglomeration, sorption, catalytic redox reaction, living science processes and photocatalysis. These methods failed to produce total elimination or breakdown of organic dye pollutants; however, it offered certain hitches like partial removal, great consumption of chemicals and reagents, pricey, and creation of inferior toxic pollutants. [12]. These organic dye pollutants are chemically fragmentized to smaller molecular weight, simple and readily switchable materials such as oxygenated molecules, acetic acid, propionic acid, ethanol and minerals (CO_2 , H_2O). These decomposed materials are non-toxic and can be easily released in the environment [13]. Nanostructured porous-carbon materials have exhibited huge potential for the elimination of pollutants by using progressive heterogeneous oxidation/reduction reactions. Sustainable, non-pricey and green metallic-carbon nanomaterial acquires united characteristics of basic-organic structure, metals and carbon-establishment together with the probability of customizing the activeness and preferences of nanomaterials. Addition of selective non-carbon/non-hydrogen atoms and transition metal into the nano-porous carbon framework will arouse the composite active sites. In the last decade, several reports of transition metal-associated composites have been published because of its immense fertile function as a solid-catalyst, chemical sorbent, carbon-electrode, power stockpile shell [14]. This chapter comprises a wide-ranging review of green and solid organic-inorganic metal nanocomposites for chemical breakdown of toxic organic dyes such as., Chromotrope-2R, Methylene Blue and Eosin-Y (Fig. 1) along with nanocomposite material's hydrogen and ethylene gas adsorption activity for energy storage. The nanocomposites were prepared by an easy technique using nano-sized porous carbon structure synthesized from cheaper petroleum pyrolysis fuel oil (PFO) based pitch excess. These sustainable catalysts have gigantic

prospective for the operation of purifying hetero-atom dye contaminated H₂O and it was freshly employed for novel sorption purpose as well.

Figure 1. Chemical structures of Chromotrope-2R, Methylene Blue and Eosin-Y dyes.

2. Petroleum remnant as a carbon precursor

The world is greatly understanding the benefits of petroleum resources and its limited reserves. Low-cost petroleum pyrolysis fuel oil (PFO) is a higher boiling point multi-ring non-aliphatic hydrocarbon compound of crude oil residue that are supplied from petroleum distillation process or naphtha cracking process. Naphthalene is one of the binary-ring aromatic products and its derivatives are an essential part of various biologically important naturally occurring valuable chemicals, organic dyes and medicines [15-17]. Valuable naphthalene crystals were separated from PFO by developing innovative and economical solvent extraction methods. PFO based pitch was considered for the higher carbon content source after subsequent separation of valuable products [15, 18]. PFO pitches are applied extensively as precursors for porous carbon framework due to their finest graphitizable character, unique structural-shape, huge carbon amount, thermal flexibility and no burning remains. The particular qualities of carbon precursor are a promising applicant for the preparation of highly functioning carbon nanocomposite by applying a molding technique [19-21]. Schematic diagram of naphthalene separation and isolation of pitch as carbon precursor from PFO is shown in Fig. 2.

The nano silica ball (NSB), homogeneously uniform nano-sized silica sphere template, was prepared by the water based chemical breakdown and condensation of tetraethoxy orthosilicate (TEOS) [22]. Fresh solvent isolated PFO pitch excess was generated as per the report [15]. The prepared pitch paste (1.0 g) was taken in a rectangle-shaped ceramic crucible and heated at 140°C for half an hour until the formation of soft and highly moldable amber coloured semi-liquid. Uniform sized NSB (1.0 g) bed was mixed homogeneously with pitch fluid along with heating until the formation of dark amber coloured dust. The carbonization of the composite was carried out at 900°C in presence of

nitrogen gas atmosphere in a tubular furnace to get nano silica carbon composite (CSC) for 4 hours. The nano-silica content from CSC was removed by stirring the mixture with aqueous 10% HF solution for 24 hours. Finally, the process was succeeded by filter-separation, H₂O washing and de-moisturization at 110°C for 4 hours to achieve a black colour nano carbon cage (NCC) with great carbon turnout (0.62 g). This nano carbon cage (NCC) can be used as a porous host for direct metal doping [18]. The covalent binding of ligand or metal complex makes hybrid composite sustainable and leaching independent. Therefore, the synthesized crude oil pitch originated carbon nano-cage (NCC) was further oxidized in combined presence of N₂ and 5% O₂ gas at 698 K for deep 10 hours to secure NCC-OH. The facet -OH moiety of NCC-OH was refluxed with watery sodium hydroxide (0.1N NaOH) solution for 1 hour under maintained pH condition to form NCC-ONa (Fig. 3). All the three nanocomposites NCC, NCC-OH, NCC-ONa can be directly used as a porous host for direct metal doping or covalent bonding [1].

Figure 2. Schematic diagram of separation of carbon material precursor.

2.1. Organic-inorganic metal nanocomposites

Commercially, activated carbons are generally jumbled with irregular pore-sizes and they regularly have the impurities of the origin source, but nano-porous carbon materials prepared by template methods are highly ordered and have uniform pore size. The requirement of homogeneous metal carbon nanocomposites has been increased considerably in the last few years due to their broad applications in large scale industrial

adsorption, gas isolation, water cleansing and heterogeneous catalysis. In continuation of our development of organic-inorganic hybrid catalyst and chiral stationary phases [23-25], the current study will deliver a comprehensive evaluation of synthesized carbon nanocomposites of gold (**Au@NCC**), copper (**Cu@NCC**), nickel (**Ni@NCC**), potassium and manganese (**K-Mn@NCC**), phosphorous (**P@NCC**), gold-phosphorous (**Au-P@NCC**), molybdenum-vanadium (**Mo-V@NCC**), palladium (**Pd@NCC**), gold-palladium (**Au-Pd@NCC**), tungsten (**W@NCC**) and covalently bonded gold Salen nanocomposite (**Au-Salen@NCC**) and its catalytic activities along with energy storage capacity. The schematic diagram of synthetic route of all the 11 organic-inorganic metal carbon nanocomposites is given in Fig. 4. The characterization of all nanocomposites and products have been accomplished by microanalysis, ^1H & ^{13}C NMR, ^{13}C CP-MAS NMR cross polarized magic angle spinning NMR, FTIR, GC, LCMS, UV-Visible spectroscopy, fine-powdered X-ray diffraction (XRD), thermal gravimetric analysis (TGA), surface analysis, scanning electron microscopy coupled energy dispersive X-ray spectroscopy (SEM/EDS), high resolution transmission electron microscopy (TEM), inductive coupled plasma (ICP) based metal analysis, and solid reflectance UV-vis spectroscopy.

Figure 3. Synthesis route of Nano carbon cage (NCC), Hydroxy nano carbon cage (NCC-OH) and Sodium hydroxy nano carbon cage (NCC-ONa).

All eleven synthesized metal carbon nanocomposites, **Au@NCC** [26, 27], **Cu@NCC**, **Ni@NCC**, **K-Mn@NCC** [18, 27], **P@NCC**, **Au-P@NCC** [28], **Mo-V@NCC** [3], **Pd@NCC**, **Au-Pd@NCC** [29, 30], **W@NCC** [14], and **Au-Salen@NCC** [1], displays not

only the singular physico-chemical essence of involved metal and nanoporous carbon cage (NCC) but also the collective characteristics of the paired composite and the occurrence of new qualities able of promoting brand-new operations (Fig. 4).

Figure 4. Synthesis route of eleven organic-inorganic metal nanocomposites 1-11.

3. Removal process of organic pollutant dyes

To expand the improved awareness of this materials, the following nanocomposites were successfully used as heterogeneous catalytic reaction of Eosin-Y, Methylene Blue, and Chromotrope-2R dyes. They were also utilized as an energy storage adsorbent for the adsorption of hydrogen gas and ethylene gas, and as an electrode for methanol oxidation reaction.

3.1 Catalytical degradation of methylene blue

The heterogeneous catalytic degradation of potentially destructive dye, methylene blue (MB), was effectively investigated by molybdenum-vanadium carbon nanocomposite (**Mo-V@NCC**). The catalytic degradation of MB dye was accomplished by taking 1 g of the recyclable nanocomposite catalyst **Mo-V@NCC** in round-based flask applying 50 ml of methylene blue solution (10^{-4} M, MB) and 50ml 30% hydrogen peroxide (H_2O_2 , 10^{-4} M). The catalytic decomposition was observed by UV-visible and FT-IR spectroscopy [3].

The full range (200-800 nm) and selective (450-800 nm) UV-vis spectra of MB decomposition are revealed in Fig. 5 and 6. The UV-Vis spectrum of MB displayed major absorbance peak at 664 nm initially. The spectrum also shown three additional key projections at 250, 297 and 665 nm because of π to π^* electron alteration of the aromatic cycle and hetero atom multi-aromatic alliance in MB. The intensity of all the peaks was getting weaker and totally disappeared after 60 min catalytic reaction run with **Mo-V@NCC** catalyst. It denotes that the hazardous pigments were absolutely fragmented into small chemical segments. An FT-IR study of MB dye decomposition is show in Fig. 7. Originally, non-catalysed MB shown characteristic peaks of C=N stretching vibration, C=C vibrations, multiple ring stretching vibrations, $\text{C}_{\text{Ar}}\text{-N}$ (the bond between the side aromatic ring and nitrogen atom) stretching vibration and N- CH_3 stretching vibrations 1601, 1544 & 1489, 1398, 1354, 1241 & 1181 cm^{-1} respectively [31]. Subsequently, original untreated MB characteristic bands were disappeared after catalytic degradation reaction which indicated the complete decomposition of pollutant dye. New additional peaks were generated at 1404, 1398 & 1225 cm^{-1} , these peaks mayhap as a result of IR-stretching vibrations of COO^- , NO_3^- and SO_4^{2-} functional groups, respectively. Additionally, new peaks confirmed the presence of carbon dioxide as a chief final product along with some acids. FT-IR spectra also supported the complete oxidative decomposition of MB like UV-vis spectroscopy. The recovered **Mo-V@NCC** was recycled and reused for several catalytical run successfully with no noticeable loss in its activity [3].

Figure 5. Full range UV-vis spectrum of MB degradation by **Mo-V@NCC**.

Figure 6. Selective absorption UV-vis spectrum of MB degradation by **Mo-V@NCC**.

Figure 7. FT-IR spectrum of MB afore and later degradation by catalysts **Mo-V@NCC**.

Moreover, the rapid adsorption ability of **W@NCC** nanocomposite to methylene blue was detected by single outing the discoloration of MB dye content. This swift adsorption characteristics of **W@NCC** lead to the new catalytic oxidation study of MB. The full range UV-Visible spectra MB degradation using **W@NCC** is shown in Fig. 8. The spectrum shown dominant absorbance projections at 665 nm and binary little absorbance peaks at 251 and 297 nm. As we have seen in **Mo-V@NCC** case, similar phenomenon of the peak intensity weakening and disappearing was observed after 25 min vigorous reaction with **W@NCC**. It suggested that the aromatic and hetero-atom multi-aromatic link of MB dye was fully destroyed and entirely fragmented into scaled-down products. The catalytic oxidation of MB using **W@NCC** was also confirmed and supported by FT-IR spectroscopy [14].

Figure 8. Full range UV-vis spectrum of MB degradation by *W@NCC*.

3.2 Catalytical breakdown of chromotrope-2R and Eosin-Y

Jacobsen Salen Schiff base metal complexes have been largely studied because of their important catalytic activity and various organic reaction [32]. Together, several developed redox reactions of toxic waste healing have been rejuvenated amidst inexpensive, eco-friendly and huge productivity to settle the strong requirement of straight sewerage analysis. Less articles have been reported for the chemical reactionary removal Chromotrope-2R and Eosin-Y and from wastewater [1]. Au-Salen compound bonded nano-structured carbon material, **Au-Salen@NCC**, has assured the breakdown of Chromotrope-2R and Eosin-Y dyes with mild reaction modes employing modest oxidant hydrogen peroxide (H_2O_2) for Chromotrope-2R and reducing agent sodium borohydride (NaBH_4) for Eosin-Y and it is found to be highly significance and capable in contrast to available literature report [33].

The catalytic destruction and fragmentation of Eosin-Y lead the formation of simpler acid compounds which were further decomposed to essential mineral compounds. Gas chromatography study recognized four different products viz., (1Z,4E)-1,5-dibromo-3((Z)-

2carboxyvinyl)-6-oxohexa-1,4-dien-2-olate, 2-((2-3,6-dihydro-2H-pyran-4-yl) phenyl)2-carboxylate, 2-(2-formylphenyl)-2-carboxylate and 3,5 dibromocyclohex-5-ene-1,2,4-trione. The GC data was in support of Eosin-Y degradation mechanism [1]. These four intermediate compounds experienced subsequent decomposition to yield oxalic acid and malonic acid which were additionally degenerated to carbon dioxide and water. **Au-Salen@NCC** achieved 98.68 % degradation of Eosin Y within less than 1-hour time at room temperature and ordinary pressure, whilst other reported titanium dioxide (TiO₂) based sunlight-catalyst delivered 96 % decomposition yield under visible light treatment for 3 hours [33]. The Fig. 9 reveals the UV-vis spectrum of Eosin-Y decomposition using nanostructured **Au-Salen@NCC**. The UV-vis spectra of Eosin-Y identified main spectral-absorbance peak at 515 nm. The spectrum strongly suggests that the magnitude of spectral-absorbance bands evolved weaker as the reduction activity proceeded and peaks eliminated completely in 50 minutes.

Figure 9. Full range UV-vis spectrum of Eosin-Y degeneration using **Au-Salen@NCC**.

Catalytic degradation activity of Chromotrope-2R produced few capable acidic compounds as a result of decomposition of residual functional groups such as aromatic ring, $-N=N-$, $-OH$ and $-SO_3H$ [34,35]. GC-MS analysis gave confirmative peaks for oxamic acid,

oxalacetic acid, oxalic and malonic acid as the ultimate outputs that were break-downed to carbon dioxide [1]. Proportionately, 98.8% destruction of Chromotrope-2R was done by **Au-Salen@NCC** nanocomposite in period of one hour with respect to the reported Fenton process [34]. The present catalyst **Au-Salen@NCC** and technique was found to be very efficient, and eco-friendly and time saviour for full destruction of pollutant dyes. The UV-Visible investigation spectrum of Chromotrope 2R using **Au-Salen@NCC** nanocomposite is displayed in Fig. 10. The UV-vis spectrum of Chromotrope-2R dye displayed main absorbance at 508 nm. Usually, the disappearing of major absorbance band peak with course of oxidative catalytic reaction and complete removal after 55 min.

*Figure 10. Full range UV-vis spectrum of Chromotrope-2R degeneration by **Au-Salen@NCC**.*

The solid-catalyst optimization study of **Au-Salen@NCC** nanocomposite was conducted for both Chromotrope 2R and Eosin Y dyes (Table 1). The total conversion of dye treatment was increased reasonably during the catalyst load increment from 1, 3, 5, 8, 10 g in both the dyes. On the basis of research findings, the optimum catalyst amount (5 gL⁻¹) and

maximum conversion time (50 and 55) was found for Eosin-Y and Chromotrope-2R pigments, respectively. Recycled **Au-Salen@NCC** catalyst worked well for four repeated experiment without any leaching and performance loss. **Au-Salen@NCC** was sustainable and adequate compared to past literature reports.

Table 1. Solid-Catalyst load study on degradation of Chromotrope-2R and Eosin-Y.

Solid-Catalyst loading (g L ⁻¹)	Eosin-Y	Chromotrope-2R
	Catalytic Reaction Time (min)	Catalytic Reaction Time (min)
1	90	80
3	70	70
5	50	55
8	50	55
10	50	55

4. Adsorption and energy storage

In the instant energy consumption era, the adsorption and storage of primary gases is one of the crucial concerns for the awareness for power maintenance and undoing the earth surface warming process viz., greenhouse. Few unhealthy volatile matters are supposed to be main suppliers to acidic rainfall, hazardous air pollution and elevated temperature of world. The diminishing fossil fuel reservoir and growing substantial deterioration knowledge have started an exploration for substitute fuel-materials and zero discharge carriers.

4.1 Hydrogen (H₂) gas adsorption study

Hydrogen gas is predicted to play a major part in the forthcoming world energy equilibrium. The efficient storage of H₂ gas is a challenging condition and need for its use as a vehicle fuel. The H₂ gas running cars have good advantage over battery and petrol cars. H₂ gas can be easily produced by electrolysis of H₂O, only release from its succeeding reaction with O₂ in the energy producing phase is H₂O. and H₂ gas has the maximum energy volume (120 MJ/kg) per mass unit [27, 36]. The H₂ gas adsorption isotherms were accomplished by using gravimetric adsorption system (MSB Rubotherm) in four particular stages: black analysis, stowing and activation of specimens, buoyancy study and sorption analysis. Later, the risen mass of the specimen by virtue of H₂ gas sorption was precisely counted by utilizing MSB connected to the sampling site. Normally, 0.2~0.7 g of adsorbent was taken for adsorption experiment. Adsorption isotherms metal carbon nanocomposites

and its precursors, **Cu@NCC**, **Ni@NCC**, **K-Mn@NCC**, **Au@NCC** and non-metal pristine **NCC**, were studied to check the performance of metal-associated carbon nanocomposites. The hydrogen (H_2) gas sorption volume of nanocomposites is articulated in phrase of wt. % (mass of the hydrogen gas energy carrier/mass of the nanocomposite x 100) [27, 29].

Figure 11. Hydrogen adsorption of metal carbon nanocomposites **Cu@NCC**, **Ni@NCC**, **K-Mn@NCC** and **Au@NCC**.

The hydrogen gas sorption study of pure NCC and its metal nanocomposites **Cu@NCC**, **Ni@NCC**, **K-Mn@NCC**, **Au@NCC** were investigated using standard gravimetric adsorption analysis. Nanocomposites **Cu@NCC** and **Ni@NCC** revealed highest H_2 gas adsorption capacity of 0.08 and 0.11 wt % around 40 kilopascal (kPa) pressure, respectively. Also, **Au@NCC** shown higher adsorption with raised pressure (0.13 wt %, 58.5 kPa). While **K-Mn@NCC** isotherm exhibited minimal H_2 gas with pressure rise (0.02 wt %, 37.1 kPa) compare to other nanocomposites (Fig. 11). Contrarily, active H_2 gas sorption was missing for pure NCC sample at physical force up to 5000 kilopascal (kPa) because of weak or no interaction between H_2 gas and adsorbent. The anticipated target

adsorption capacity of NCC is still far lower compared to metal nanocomposites (Fig. 12). The study results revealed that the H₂ gas adsorption capacity of metal carbon nanocomposites were significance compared to pure NCC and it shown moderate to excellent hydrogen adsorption in phrase of the proportion matter captured per unit pressure. The Au-doped NCC can guide to a greater H₂ gas depository compare to pure NCC adsorbent.

Figure 12. Hydrogen adsorption of metal carbon nanocomposite pristine NCC.

4.2 Ethylene gas adsorption study

Chemical adsorption of ethylene gas (C₂H₄) is truly significance in agricultural industry during transportation or depository, several harvested-fruits can generate ethylene (C₂H₄) gas which is capable of diminishing the character and self-survival. Lately, many experimental studies of sorption of ethylene (C₂H₄) gas on a range of active *d*-block metal composite facet have been done using new techniques. These composite materials help to maintain the freshness of the harvested products in the course of transportation and hoarding. The chemical adsorption of ethylene (C₂H₄) gas was determined on the organic-inorganic metal carbon nanocomposites in a moderate pressure auto gas sorption operation using gas chromatography (GC) at atmospheric temperatures. Typically, 0.50 gm of the

five adsorbent materials (NCC, Cu@NCC, Ni@NCC, K-Mn@NCC, Au@NCC) was placed inside a Pyrex sorption unit joined to the adsorption apparatus and exposed to a regular pre-treatment prior to ethylene gas (C_2H_4) adsorption analysis which integrated vacuum dehydrating in a vacuum desiccator and thermal revival in an oven [27].

Figure 13. Ethylene adsorption of carbon nanocomposites Cu@NCC, Ni@NCC, K-Mn@NCC, Au@NCC and NCC.

The ethylene (C_2H_4) gas adsorption abilities of the carbon nanocomposites were achieved by gas chromatography (GC) analysis at atmospheric temperature. Fig. 13 depicts the ethylene adsorption visual representation of five carbon nanocomposites. The corresponding C_2H_4 gas adsorptions on the adsorbents (NCC, Cu@NCC, Ni@NCC, Au@NCC) have been raised remarkably from 0 to 6000 ppm in 3–15 min while K-Mn@NCC displayed a corresponding ethylene (C_2H_4) gas sorption growth starting with 0 to 6000 pm in around 8~15 minutes. The ethylene (C_2H_4) gas sorption was nearly identical for all five of the adsorbents and more or less steady upon sample saturation with time (Fig. 13). The metal carbon nanocomposites had a uniform pore size and a transition-metal attraction which permits the nanocomposites to bind and capture the ethylene alike tinier compounds (3.14 Å) at adsorption sites. These nanocomposites can be broadly used as

efficient and low-priced adsorbents in the time of movement and storage of harvested fruits and vegetables in order to protect the farming product quality by capturing ethylene release.

Conclusion

This chapter describes the evidence for the robust research findings carried out in recent time to project a new and improved techniques for the cleansing of water waste from organic dyes along with energy storage applications. The metal carbon nanocomposites **Au@NCC**, **Cu@NCC**, **Ni@NCC**, **K-Mn@NCC**, **P@NCC**, **Au-P@NCC**, **Mo-V@NCC**, **Pd@NCC**, **Au-Pd@NCC**, **W@NCC** and **Au-Salen@NCC** were prepared by a simple pattern method employing low-cost petroleum based pitch as the carbon creator and nano structures silica ball as hole maker. The green, recyclable and sustainable organic-inorganic metal nanocomposites were applied successfully as a solid-sustainable catalyst for degeneration of toxic organic pollutant pigments (Chromotrope-2R, Methylene Blue and Eosin-Y) and as an adsorbent for energy protection (H_2 and C_2H_4) and environment fixing.

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