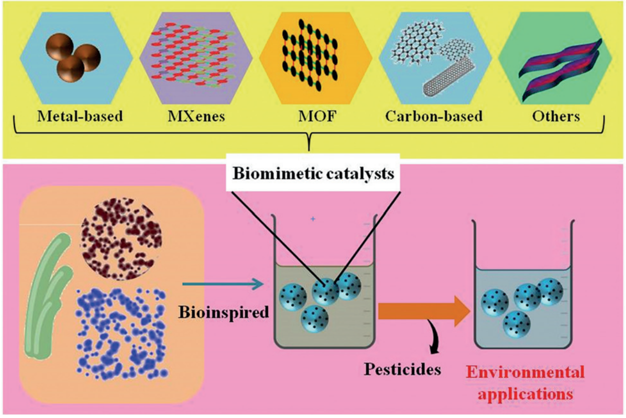
# Science through the Lens of Nature: Recent Advances in Biomimetic Approaches towards Pesticide Degradation

**Shikha Jyoti Borah**[a]
**Akanksha Gupta***[b]
**Prasanta Kumar Sahu**[c]
**Neelu Dheer**[d]
**Vinod Kumar***[a]

[a] Special Centre for Nanoscience, Jawaharlal Nehru University, Delhi, India
kumarv@mail.jnu.ac.in
[b] Department of Chemistry, Sri Venkateswara College, University of Delhi, Delhi, India
akankshachem05@gmail.com
[c] Department of Chemistry, Shivaji College, University of Delhi, Delhi, India
[d] Department of Chemistry, Acharya Narendra Dev College, University of Delhi, Delhi, India



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**Abstract** The increased use of pesticides and the possible accumulation of residual pesticides can clearly have detrimental consequences on different environmental matrices and human health. As a result of this, an urgent need for remediation of pesticides has emerged in the last few decades. A biomimetic approach for the degradation of pesticides can have high potential. Biomimetic catalysts are synthetic chemical molecules which have been inspired by natural processes to mimic their structural and functional properties. This short review focuses on the synthesis of various biomimetic catalysts including metal-based materials and carbon-based materials. In this context, recent advances achieved by such biomimetic catalysts for the degradation of pesticides have been covered. It highlights the importance of adopting a biomimetic approach as it provides a green and efficient method for pesticide degradation. Furthermore, it provides useful insights into the challenges that remain to be addressed and the perspectives that can be adopted for future research.

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**Key words** biomimetic, pesticide, degradation, synthetic catalysts, nanozyme

## 1 Introduction

Use of insecticides, herbicides, fungicides, and growth regulators has revolutionized the agricultural sector which is the largest consumer of these products.[1] In addition to this, pesticides have also been utilized for public health activities such as controlling vector-borne diseases, removal of weeds and grasses, and suppressing pest proliferation.[2,3] In response to the growing use of pesticides, the Stockholm Convention, an international treaty aimed at limiting or eliminating persistent organic pollutants (POPs), was signed in 2001.[4] Aldrin, chlordane, chlordecone, dicofol, dieldrin, endrin, heptachlor, hexachlorobenzene, mirex, β-hexachlorocyclohexane, lindane, pentachlorobenzene, toxaphene, and technical endosulfan and its related isomers have all been listed as POPs that need to be eliminated from production and use.[5] In addition, DDT and perfluorooctanesulfonic acid, and its salts, have been identified as POPs that need to have production and use restrictions.[5] Despite these regulatory measures, the accumulation of residual pesticides still occurs over time and cannot be ignored. In addition to this, the lack of strict supervision in many developing countries remains a major challenge.[6] In a recent spatial and temporal analysis of five different sampling zones along the Ganga River in India, high concentrations of lindane were detected along with other pesticides such as DDT and endosulfan.[7] It is possible that other developing nations, such as Africa, are experiencing a similar problem.[4]

In a recent review, Iqbal, Barceló, Parra-Saldívar, and coworkers extensively covered the different factors related to the toxicological, regulatory, and analytical detection of pesticides.[6] The indiscriminate use of pesticides has a negative impact on humans, animals, and the environment.

## Biographical Sketches

**Ms. Shikha Jyoti Borah** received her Integrated M.Sc. degree from Tezpur Central University, Assam, India. Currently, she is a Ph.D. candidate under the supervision of Dr. Vinod Kumar at the Special Centre for Nanoscience, Jawaharlal Nehru University in New Delhi, India. Her current research focuses on the synthesis of metal oxide nanoparticles and their various applications.

**Dr. Akanksha Gupta** received a Ph.D. in Materials Science from the Department of Chemistry, University of Delhi, India. She completed her M.Sc. and B.Sc. (Hons) Chemistry at Hansraj College, University of Delhi, Delhi, India. She has vast experience in the synthesis, crystallography, and characterization of several mixed metal oxides having potential applications in cathode materials for lithium ion batteries and photocatalysis. Currently, she is an Assistant Professor in Sri Venkateswara College, University of Delhi, India.

**Dr. Prasanta Kumar Sahu** has been an Associate Professor in the Department of Chemistry, Shivaji College, University of Delhi, Delhi, India since 1994. He completed his Ph.D. at the Department of Chemistry, University of Delhi, Delhi, India. He worked on the application of nanomaterials in biological activities.

**Dr. Neelu Dheer** is an Associate Professor in the Department of Chemistry, Acharya Narendra Dev College, Delhi, India. She has more than 26 years of teaching experience at undergraduate level. She completed her Ph.D. at University Delhi in the field of corrosion and her research interests are electrochemistry and nanomaterials and their applications.

Currently, **Dr. Vinod Kumar** is an Assistant Professor in the Special Centre for Nanoscience in Jawaharlal Nehru University, Delhi, India. Previously, he was an Assistant Professor in Kirori Mal College, University of Delhi. He received his Ph.D. in Materials Chemistry from the Department of Chemistry and M.Sc. and B.Sc. (Hons) Chemistry from Kirori Mal College, University of Delhi, India. His research focuses on the 'synthesis, structure and properties of binary/mixed metal oxides nanomaterials' and their applications in water splitting, electrode materials of Li ion batteries, SAW based sensors, water purification, and nanomedicine along with nanotoxicity.

Long-term release of pesticides which can withstand environmental degradation causes severe damage at various trophic levels. In addition to their detrimental effects on human health, POPs also negatively impact the soil,[8] rain and groundwater,[9] and various vertebrates.[10] Exposure to pesticides has been related to a number of diseases, such as cancer, hormone disruption, hypersensitivity, allergies, and asthma.[11,12] It has been estimated that 7446 fatalities and 733,921 non-fatal cases of unintentional acute pesticide poisoning (UAPP) have been reported annually, leading to nearly 740,000 yearly cases.[13] A recent systematic review provided important insights into the current impact of UAPP on human health. They concluded that there are around 385 million cases of UAPP per year, with 11,000 fatalities.[13] This suggests that eliminating residual pesticides should be a primary concern and that the abuse of banned and restricted pesticides, which might still be present in developing nations, cannot be disregarded.

In light of the scientific data directed towards the actual, anticipated, and perceived hazards that pesticides represent to the entire biosphere, the significance of a green simple method for their degradation rises to the level of paramount environmental importance. Pesticides have been effectively degraded using a variety of techniques including bioremediation, photocatalysis, electrocatalysis, with the use of suitable catalysts such as nanomaterials, nanocomposites, heterojunctions, and biomaterials. However, efforts to develop a green, cost-effective, and facile method continue. Amongst these techniques, bioremediation has emerged as an important method for the degradation of pesticide residues utilizing microorganisms, bacteria, fungi, and plants to detoxify or mineralize harmful wastes. The two most widely used microbial-assisted remediation techniques are bioaugmentation (the addition of microorganisms) and biostimulation (the supply of nutrients to activate native microbes). However, the degradation process is hampered by a number of issues, including a dynamic and susceptible environment, toxicity, bioavailability, monitoring, and the survival of the microbial degraders.[14] Thus, alternative methods still need to be investigated.

The use of biomimetic chemistry, a branch of organic chemistry that studies the ability of organic compounds to imitate natural biological processes, opens up new opportunities and perspectives.[15] A simplified flowchart of the biomimetic method used to create bio-inspired systems is shown in Figure 1.[16] A wide range of issues can be covered by biomimetic chemistry, such as the creation and study of synthetic enzymes (nanozymes) and the self-assembly of small chemical compounds in a way akin to that of biological self-assemblies.[17] Researchers have strived to utilize the fundamental concept of biomimetic chemistry in order to develop materials that can imitate the key features of natural enzymes. This has, therefore, evolved into the concept of 'biomimetic catalysts' which possess enhanced catalytic properties such as higher stability, selectivity, and activity.

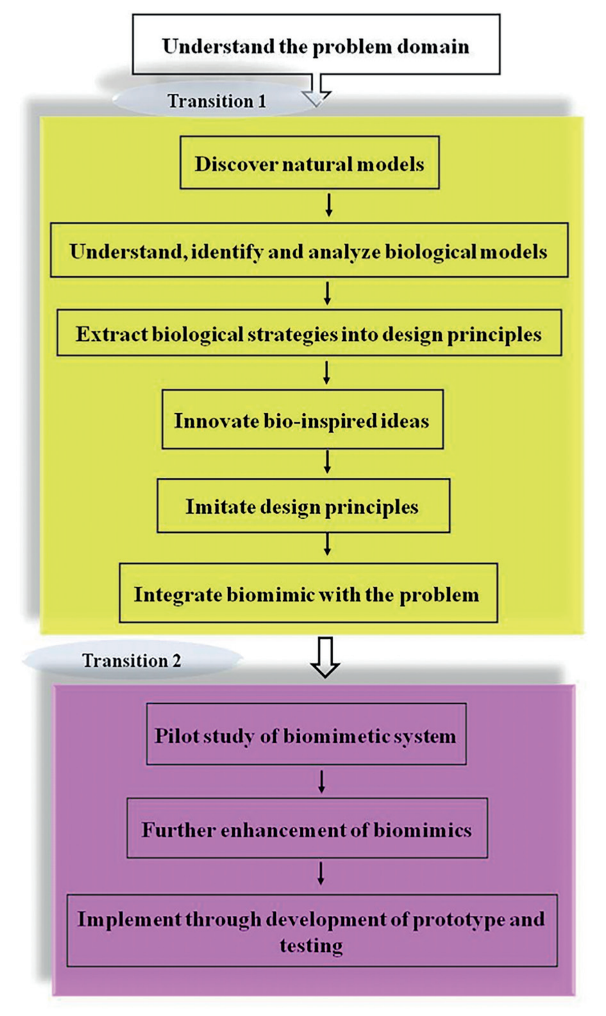

**Figure 1** A flowchart showing the steps involved in biomimetic design and assessment

Table 1 is a brief list of some of the biomimetic catalysts that have been synthesized in recent years. Bioinspired catalysts can replace conventional catalysts in processes that degrade harmful organic pollutants including dyes, pesticides, and pharmaceutical waste through a more environmentally friendly route.

A large section of our economy is dependent on the agriculture sector which requires continuous pest management to obtain high yields. In response to this high demand and supply chain of agriculture-based products, it is quite impossible to ban the use of pesticides globally. Thus, efforts have been made to eliminate pesticide residues through many conventional and new techniques over recent years to resolve this problem.[23–25] However, given the need for sustainable development, a green way to degrade pesticide residual should be prioritized. In this context, this short review provides insights into the recent materials that have surfaced as important biomimetic catalysts for

**Table 1** Lists of Biomimetic Catalysts Incorporated in Pesticide Degradation

| Biomimetic Catalysts | Biomimic technique | Synthesis | Pesticide | Ref |
|---|---|---|---|---|
| MOF (CA-Cu) | catecholase- and laccase-like activity | solvothermal method | phenolic pesticides | 18 |
| $Fe_1$@CN-20 | laccase-like activity | calcination of aniline-modified zeolitic imidazolate frameworks | phenolic pesticides | 19 |
| $Ti_3C_2$ MXene/MIL-100(Fe) hybrid | biomimetic oxygen transportation | Fe-protoporphyrin bridging | thiacloprid | 20 |
| imidazole-Cu nanozyme | laccase- and catecholase-like activity | water-induced precipitation of imidazole and $Cu^{+2}$ | 2,4-dichlorophenol | 21 |
| hemin-$Bi_4Ti_3O_{12}$ (HBTO) nanocomposite | enzyme mimetics | solvothermal method | tetracycline hydrochloride | 22 |

pesticide degradation. Additionally, it discusses the ability of various materials including metal oxides, carbon-based materials, metal-organic frameworks, and other biomimetic catalysts that have been developed based on a biomimetic approach. To the best of our knowledge, this review is the first of its kind to assemble these data. It is hoped that this concise study will help in cultivating a better perspective, thereby encouraging researchers to explore and venture into this exciting field of research.

## 2 Biomimetic Catalysts

### 2.1 Metal Oxides

Metal oxide nanoparticles (MONPs) have emerged as important catalysts owing to their unique properties that lead to potential application in the field of green and renewable energy. In addition to this, MONPs have captured the interest of researchers due to their outstanding photocatalytic activity towards the degradation of various organic pollutants such as dyes and pesticides. A green approach that has replaced the synthesis of these MONPs using toxic chemical precursors is the widely accepted biomimetic method. Choudhary, Sharma, and co-workers demonstrated one such green, cost-effective, and facile biomimetic preparation of Ag-ZnO heterojunctions through a precipitating agent known as fennel seed extract (FSE), obtained from fennel (*Foeniculum vulgare*) (Figure 2).[26] The FSE consists of polyphenolic compounds that act as natural precipitating and reducing agents, thereby triggering the formation of the Ag-ZnO heterojunction. It should be emphasized that the fennel seeds used to make the Ag-ZnO heterojunctions are also economical, easily accessible, safe, and environmentally benign. Figure 3 depicts the possible mechanism in this process.[26] The FSE largely comprise of active

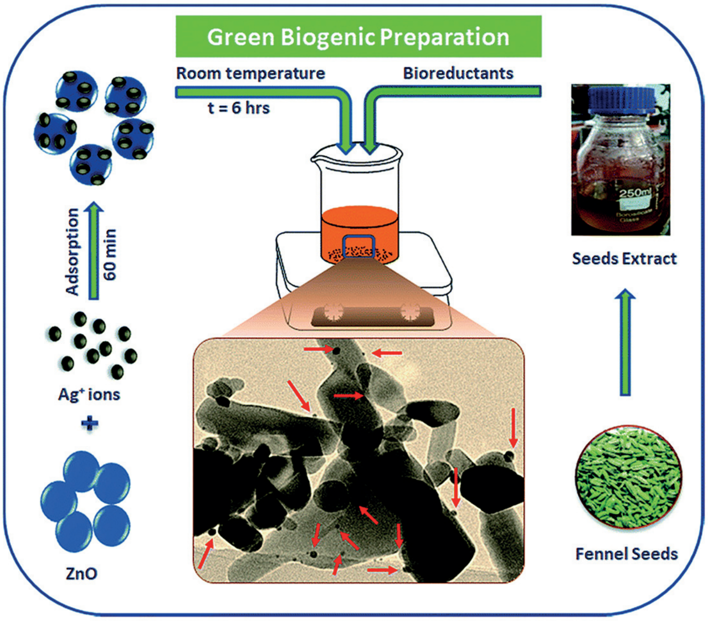

**Figure 2** Scheme involved in the biomimetic synthesis of Ag-ZnO nanocomposites by using fennel seed extracts as natural reducing agent. Reprinted with permission from ref 26. Copyright 2019 The Royal Society of Chemistry.

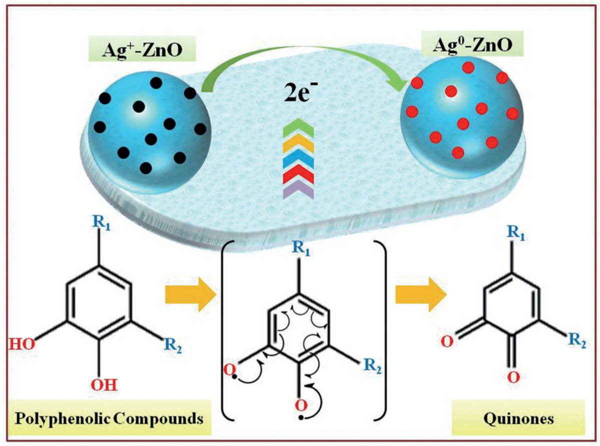

**Figure 3** Schematic mechanism of synthesis of Ag-ZnO heterojunction using fennel seeds consisting of polyphenolic compounds

*ortho*-dihydroxy aromatic compounds, such as rosmarinic acid and chlorogenic acid, and flavinoids, such as apigenin. The *ortho*-dihydroxy aromatic compounds have antioxidant properties, as a result of which they donate electrons to $Ag^+$, reducing it to $Ag^0$, which is adsorbed onto the ZnO nanostructures. Such a green strategy holds great significance in the formation of binary/ternary heterosystems with an additional advantage of developing easy carrier charge-transfer through the interface via the generation of strong Schottky junctions. These biogenically synthesized nanocomposites were capable of efficient degradation of the widely used pesticide chlorpyrifos, and the dye rhodamine B. Photocatalytic degradation was successfully observed with an excellent efficiency of 98% in 18 min and 90% in 40 min for rhodamine B and chlorpyrifos, respectively.[26]

Chlorpyrifos is still frequently employed in developing nations, such India and China, despite its use being banned in many developed nations.[27] Less than 0.1% of the chlorpyrifos utilized as a pesticide successfully reaches the intended target.[28] When biological and abiotic factors work synergistically, the breakdown of chlorpyrifos results in the accumulation of 3,5,6-trichloropyridinol (TCP). TCP inhibits the formation of local microbial colonies and possesses antibacterial capabilities, which limit the possibility of chlorpyrifos biodegradation.[29] It should be noted that the microbial degradation of chlorpyifos has been successfully achieved. In a recent review, Chen and co-workers discussed the increased use of bioremediation for the degradation of chlorpyrifos, demonstrating it as an ecofriendly and economical strategy with high efficiency.[30] The rationale behind the preference for bioremediation over metal-oxide photocatalysis is that use of the latter may be limited by secondary contamination caused by metal leaching. As a result, substitutes such carbon-based nanomaterials or bionanomaterials have also been considered in the removal of pesticide residues.

## 2.2 Metal Organic Frameworks

The utility of materials having high surface area for adsorption of pesticides has given a boost towards pesticide remediation. Adsorption has surfaced as a green method owing to its advantages such as low energy consumption, cost-effectiveness, and minimal operational requirements.[31] When combined with porous materials possessing high surface area and biocompatibility, this method has excellent potential. Porous metal organic frameworks (MOFs) have generated considerable developments as efficient adsorbents due to their commendable porosity which can be further tuned and functionalized for achieving desired adsorption efficiency.[32] In this context, various MOF have been fabricated together with other active components forming superior composites for pesticide degradation. However, the synthesis of such MOFs using toxic precursors may produce secondary pollution and hence current research is concentrating on developing a greener route for their application. For instance, Carmona, Barea, and coworkers demonstrated a water-based microwave synthesis of $[Zr_6O_4(OH)_4(\text{trimesate})_2(\text{formate})_6$ (MOF-808) that was capable of degrading the organophosphorus pesticide methyl paraoxon by capturing phosphate ions, exhibiting at least three successful cycles. In addition to this, a noteworthy feature of these MOFs is their ease of recoverability through bicarbonate treatment followed by regeneration with HCl (Figure 4).[33]

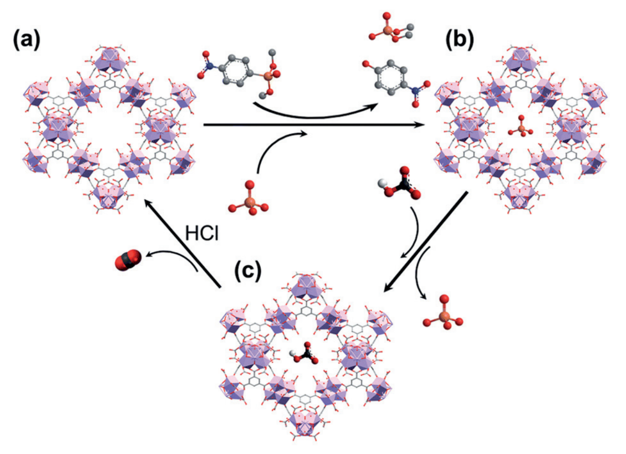

**Figure 4** The P-circular economy: (a) MOF-88 captures phosphate group and simultaneously degrades methyl paraoxon; (b) phosphate is recovered via bicarbonate treatment; (c) MOF-88 is regenerated by hydrochloric acid treatment. Reprinted with permission from ref 33. Copyright 2022 The Royal Society of Chemistry.

The utilization of biomimetics in MOFs has also been considered in recent years. One such biomimetic model is laccase which is an enzyme present in plants, bacteria, and fungi. Laccase enzymes have multiple Cu active sites that result in efficient catalytic oxidation of various organic and

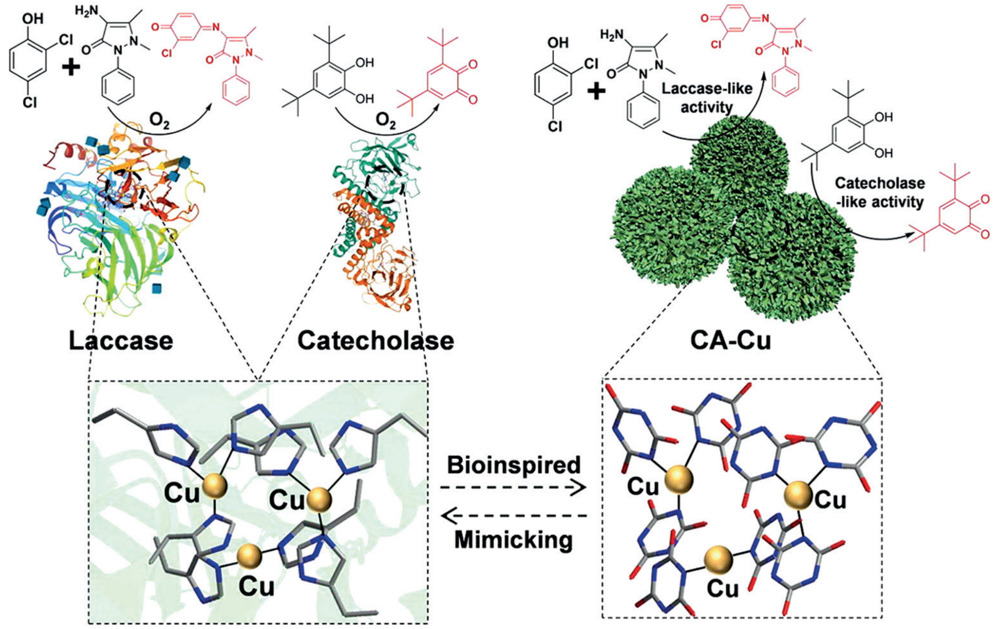

**Figure 5** Amorphous MOF (CA-Cu) capable of displaying activities of similar to laccase and catecholase. Reprinted with permission from ref 18. Copyright 2022 Elsevier B.V. All rights reserved.

inorganic substrates. These multi-copper oxidoreductases facilitate one-electron oxidation, subsequently to transfer four electrons to the catalytic Cu, which is further utilized for the reduction of $O_2$ to two water molecules.[34] Inspired by such enzymes, researchers have come forward with biomimetic models. In recent work, Huang and co-workers synthesized a novel amorphous MOF (CA-Cu) conjugate via a simple solvothermal method.[18] This MOF (CA-Cu) demonstrated catecholase- and laccase-type activity. It was observed that the reaction between cyanuric acid and $Cu^{+2}$ could mimic the N–Cu coordination between imidazole and $Cu^{+2}$ (Figure 5). The workers reported excellent recyclability, stability, and activity, meaning that such a system has high scope for application in the degradation of phenolic compounds that may be present in pesticides.[18]

## 2.3 Carbon-Based Materials

Applications of carbon-based nanomaterials (CNMs) include carbon nanotubes, graphene, fullerenes, graphene oxide, carbon dots, graphene carbon dots, and carbon nitride. Many such CNMs have proven to mimic natural enzymes. Such biomimetic models should have an impact in the area of pesticide degradation due to their excellent stability under extreme conditions. In addition, being metal-free, they provide a greener alternative to other catalysts that may produce secondary pollutants.

Bioinspired CNMs have been reported to have environmental and biomedical applications.[35,36] These catalysts have been incorporated as effective functionalized electrodes displaying high catalytic efficiency, cost-effectiveness, excellent stability, chemoselectivity, and ease of production.[35] Table 2 lists the various enzyme activities that can be mimicked by catalytic CNMs.[36] However, the mechanisms involved in these biomimetic models are not completely understood due to lack of sufficient studies. Thus, further in-depth theoretical and experimental investigations must be conducted to develop a better understanding.

The degradation of pesticides has been successfully carried out by functionalized CNMs; whereas the application of non-functionalized CNMs has been less studied. For instance, inspired by the laccase enzyme, Zhang, Lu, and coworkers demonstrated the application of biomimetic CNM by anchoring Fe single atoms on N-doped carbon ($Fe_1$@CN-20).[19] This laccase mimic is more stable, recyclable, and cost-effective compared to natural laccase itself. It showed excellent stability over pH ranges between 2–9, high temperatures, and long storage periods (2 months). The usage of such a biomimic can be fruitful for the degradation of phenolic compounds present in pesticides.[19] In addition to degradation, various nanocomposites developed with CNMs have also emerged as excellent sensors for pesticide detection.[43–45]

**Table 2** List of Various Enzyme-like Activities Shown by Different Carbon-Based Nanomaterials

| Natural enzyme activity | Function | Carbon-based biomimetic material | Ref. |
|---|---|---|---|
| catalase-like | $H_2O_2$ decomposition into $H_2O$ and $O_2$ | graphene oxide quantum dot | 37 |
| oxidase-like | produces $H_2O$ through redox reaction involving $O_2$ and $H_2$ as electron acceptor and donor, respectively | porous carbon hybrid with Co and N doping (Co,N-HPC) | 38 |
| laccase-like | one-electron oxidation | Cu-doped carbon dots (Cu-CDs) | 39 |
| peroxidase-like | oxidation of electron donor and simultaneous reduction of hydrogen peroxide | carboxyl-modified graphene oxide (GO-COOH) | 40 |
| superoxide dismutase (SOD)-like | catalyzes conversion of free radical oxygen into molecular $O_2$ or $H_2O_2$ | fullerene $C_{60}$ molecule | 41 |
| hydrolase-like | catalyzes chemical bond cleavage by using water | graphene oxide and carbon nanotubes | 42 |

## 2.4 MXenes

MXenes are two-dimensional inorganic materials consisting of atomically thin layers of metal carbides, nitrides, or carbonitrides and have distinct physicochemical characteristics. They are considered as next-generation two-dimensional materials with applications in photocatalysis, electrocatalysis, lithium ion batteries, as supercapacitors, and in biomedicine. In a recent study by Zhao and co-workers, a novel $Ti_3C_2$ MXene/MIL-100(Fe) hybrid synthesized via Fe-protoporphyrin bridging was applied to the degradation of thiacloprid and showed excellent efficiency.[20] A synergistic system developed from the Schottky junction between MXene and MIL-100(Fe) along with the biomimetic oxygen transportation from Fe-protoporphyrin was largely responsible for $H_2O_2$ generation. As a result of this, successful *in situ* generation of $H_2O_2$ facilitated the photo-Fenton catalytic degradation of thiacloprid. The $Ti_3C_2$ MXene/MIL-100(Fe) hybrid showed a 12 times higher $H_2O_2$ generation rate and a 24 times higher thiacloprid degradation rate as compared to MIL-100(Fe). As many as 10 cycles could be carried out and the catalyst showed good stability along with nearly 80% thiacloprid removal within 120 min.[20] Such a biomimetic approach solves one of the major hurdles in the degradation of organic contamination; that of external supply of $H_2O_2$.

## 2.5 Other Recent Advances

In addition to biomimetic catalysts, several other materials have also been recognized to mimic natural processes. For instance, glycerophosphodiester-degrading enzyme GpdQ, obtained from *Enterobacter aerogenes*, is a widely known bioremediator for organophosphate pesticide degradation. Mirams *et al.* prepared a biomimetic Cd catalyst $[Cd_2((HP)_2B)(OAc)_2(OH_2)](PF_6)$ {$(HP)_2B$ = [2,6-bis([(2-pyridylmethyl)(2-hydroxyethyl)amino]methyl)-4-methylphenol]}, which demonstrated an ability to mimic the asymmetrical nature of the coordinated metal ion present in the GpdQ active site.[46] In another work by Huang and co-workers,[21] oxidase-like activity was observed in a novel amorphous imidazole-Cu nanozyme (I-Cu) synthesized by water-induced precipitation of imidazole and $Cu^{+2}$. This biomimic catalyst displayed high catecholase- and laccase-like activity by mimicking the N–Cu coordinated center in their active sites. A possible catalytic mechanism involves initial substrate binding and oxidation which is followed by oxygen binding and oxygen reduction. An efficiency of 98% after 10 h for degradation of 2,4-dichlorophenol was reported (Figure 6). In addition to its application in bioremediation, this I-Cu nanozyme was also able to detect dopamine with detection limit of 0.412 μM.[21]

In nature, porphyrins are highly attractive chemical compounds that are found as the active center in proteins responsible for the transportation of oxygen, oxidation of substrates, and electron transport.[47] Therefore, metalloporphyrins have been recognized as important synthetic biomimetic systems. In a recent review, Martins and co-workers[47] carried out an in-depth literature study on the various synthetic porphyrins capable of degrading pesticides including carbamates,[48] organophosphorus[49] and organochlorine compounds,[50] triazine derivatives,[51,52] and others.[53,54] However, major challenges which continue to persist in this field are difficulties in reproduction of *in-vivo* porphyrin structures, toxicity of reagents, cost-effectiveness, and rational design in functionalization of materials for pesticide degradation.[47]

Currently, most biomimetic models strive to develop catalysts capable of mimicking a natural process that can be further used for degradation of pesticides. However, in the future, biomimetic approaches may transcend into direct full-scale implementation for pest management instead of pesticide degradation. Essentially, this approach will provide a green alternative to pesticides themselves. Pombi and co-workers have eloquently discussed the possibility of using biopolymers through a proposed innovative approach termed ‘biomimetic lure-and-kill’. This new attractive model allows biopolymers selectively to lure desired pests by replicating specific environmental conditions, which is then followed by killing them through mechanical action or secretion of a natural biopesticide.[55] Such innovative envi-

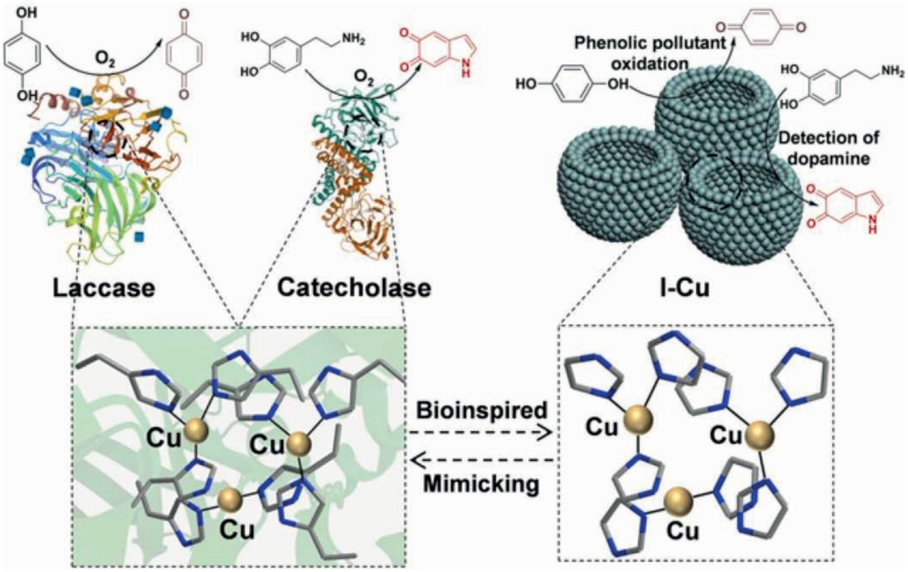

**Figure 6** Laccase- and catecholase-like activity shown by the biomimetic novel imidazole-Cu nanozyme showing excellent oxidation efficiency for environmental phenolic pollutants and dopamine detection. Reprinted with permission from ref 21. Copyright 2022 Elsevier B.V. All rights reserved.

ronmentally benign biomimetic approaches could be cost-effective and would certainly help in improving on conventional methods currently used for pest management.

## 3 Challenges

As discussed in the preceding sections, numerous biomimetic catalysts have emerged as possible candidates for pesticide degradation. However, it should be stressed that imitating natural enzymes is not an easy task. While retaining a green sustainable method, developing such biomimetic catalysts may be a difficult and drawn-out procedure. The challenges that must be overcome to understand biomimetic catalysis better are outlined in this section:

(a) The lack of knowledge regarding the precise mechanism underlying in the development of biomimetic catalysts, as well as their properties and interactions with pesticides, is currently a major impediment to future developments.

(b) More than one type of enzymatic activity can be present in the materials used to create biomimetic catalysts. For instance, catalase, superoxide dismutase, and peroxidase-like catalytic activities can be observed in Au nanoparticles.[56] This suggests that the presence of numerous enzymes simultaneously can affect the expected catalytic activity. To avoid such reduced catalytic activity, proposed biomimetic catalysts must be thoroughly assessed.

(c) The reduced catalytic activity of some biomimetic catalysts compared to their natural enzyme analogues is frequently attributed to the lower substrate binding affinities of biomimetic catalysts and may be overcome through surface functionalization.[57]

(d) For any future industrial full-scale implementation, synthesis must be cost-effective and simple. Even though several biomimetic catalysts have been developed through affordable pathways, their synthesis is still more complex when compared to conventional catalysts that are used for pesticide degradation.

## 4 Conclusions

Chemists have made great progress in the last few decades in the design and synthesis of biomimetic catalysts, which successfully mimic valuable enzymatic properties that aid in effective catalysis. These mimics have been employed to catalyze a wide range of organic processes. However, the application of biomimetic catalysts in pesticide degradation has been only incompletely explored. Inspired by natural enzymes, such as laccase and catecholase, attempts to design biomimetic metal and metal oxide nanomaterials have been resulted in materials able to degrade phenolic and other organic contaminants. In addition, carbon-based materials, metal-organic frameworks, and biopolymers have been found to exhibit strong catalytic activity towards the breakdown of pesticides, hence minimizing the potential formation of secondary pollutants. These biomimetic catalysts exhibit higher stability as compared to their respective analogous natural enzymes. Furthermore, application of biomimetics can be extended into detection of pesticides and development of green alternatives for pest management. However, only a handful of such biomimetic catalysts for pesticide degradation have been developed. Being a sustainable, green, and cost-effective method, innovations of bioinspired catalysts have a high scope and potential as future research.

## Conflict of Interest

The authors declare no conflict of interest.

## Funding Information

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