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Recent Applications of Metal-Organic Framework PCN-224 in Medicine, Sensing, and Green Chemistry

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Abstract. Research on the modification and utilization of metal-organic frameworks in various areas has increased in recent years, in response to the development of new materials. One emerging porphyrinic zirconium metal-organic framework, PCN-224, demonstrates high stability and porosity while being highly modifiable. Due to its distinctive properties, PCN-224 has garnered significant recent attention in research on its applications in various fields. In medicine, PCN-224 is utilized in catalytic therapy and drug delivery for treating both cancer and bacterial infections. In sensing, PCN-224 is used for the optic and amperometric sensing of hazardous chemicals for food and environmental detection. In green chemistry, PCN-224 is applied in the catalysis of cascade synthesis reactions and photocatalysis for both the synthesis of sustainable fuels and the decontamination of biohazards. This paper analyses current applications of PCN-224 in these aspects, focusing on the specific modifications and properties used in each case, and provides prospects regarding further implementations of these technologies and possible future areas of inquiry.

1 Introduction

As global productivity rises, versatile, tunable materials become a key point of interest in various applications. Metal-Organic frameworks, or MOFs, an emerging field of hybrid materials composed of metal ions or metal clusters connected with organic linkers to form a semicrystalline porous structure, have shown utility in many fields because of their unique set of attributes, such as in sensing, gas adsorption, gas separation, drug delivery, and catalysis. As the individual components that comprise a MOF can be interchanged and still yield similar structures, MOFs are highly modifiable and can be tailored to specific use cases within applications; such modifications can also be performed post-synthesis. Recently, new applications of MOFs have been developed in existing areas that exploit similar properties to previous applications, though with notable advancements in areas with existing research gaps. One specific 3D MOF PCN (porous coordination network) -224 presents a solution to many issues within the aforementioned fields, as it exhibits catalytic activity, tunable pore sizes and crystal sizes, unique porphyrinic linkers, and high physical and thermal stability. PCN-

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224 consists of Zr_6 clusters connected with tetrakis(4-carboxyphenyl)porphyrin ligands to form a 3-D structure with a (4,6) connected she net topology, as shown in Fig. 1.

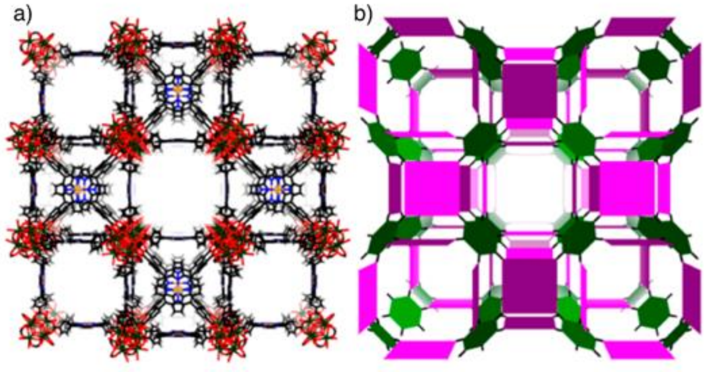

Fig. 1. (a) A model of PCN-224 and (b) a model of PCN-224's topological structure [1].

PCN-224 was first synthesized using a solvothermal method, and this method is still used with modifications based on individual applications [1-4]. PCN-224 is very stable because of the strong interaction between the Zr(IV) and the carboxylate groups, with the OH groups enhancing the physical strength of the Zr_6 core [1]. PCN-224's stability is very useful to most applications, while its other properties are typically advantageous for only specific uses; some of its properties reduce the effectiveness in unrelated applications, such as its photocatalytic properties, causing reduced photostability in sensing applications if it catalyzes the breakdown of residual DMF from synthesis [4]. The areas PCN-224 can be utilized in can mostly be categorized based on the characteristics used, which correspond to specific advantages of PCN-224 distinct from other MOFs and materials used for the same applications.

PCN-224 was shown to be applied in various new situations. PCN-224 is advantageous for catalysis because it has high porosity while also retaining high thermal and chemical stability, allowing its pore size and properties to be more easily tuned while retaining stability for prolonged use [1]. PCN-224, modified both before and after synthesis, can be applied to the catalysis of reactions in new pipelines for green chemistry, with its semiconductive properties facilitating the formation of heterojunctions for more efficient methods of catalysis [2, 5, 6]. In sensing, as PCN-224 has fluorescent porphyrinic linkers, it can be used for optical sensing of different chemicals [4, 7]. PCN-224 can also be used for other methods of sensing and for signal amplification, and the high stability of PCN-224 allows for continuous monitoring [3, 8]. Additionally, many of PCN-224's characteristics can be made use of in medicine. Notably, PCN-224's high adsorption capacity allows for efficient storage of drugs to be delivered via a sustained release, and its easily tunable pore properties allow for a wider variety of deliverable drugs [9, 10]. Furthermore, PCN-224's catalytic properties can also be used for catalytic therapy [11].

This article discusses recent developments made in applying PCN-224 in medicine, food safety, and catalysis for sustainable chemistry, and summarizes previous research gaps and problems they solve. Yet-unresearched problems mentioned in recent materials will also be summarized. Prospects on areas that may be developed in the future are also discussed based on them. In addition, the context of the properties of PCN-224, on which these applications are based, will also be provided, allowing them to be categorized based on both the type of application and the type of property utilized. This article aims to provide a theoretical background to future research in utilizing PCN-224 for these areas.

2 Applications of PCN-224 in different areas

2.1 The application of PCN-224 in medicine

2.1.1 The application of PCN-224 in catalytic therapy

In medicine, PCN-224 is useful for catalytic therapy due to its catalytic properties. For example, the breakdown of endogenous hydrogen peroxide can be catalyzed using PCN-224 to increase the effectiveness of other treatments and to increase the death of tumor cells or bacteria by releasing reactive oxygen species [12]. Additionally, PCN-224 can also be used as a carrier for other catalytic materials owing to its porous nature, and added groups can be engineered to help the particles target specific stimuli for treatment [13].

A recent study by Su et al. (2024) demonstrated a type of biomimetic metal-organic framework (PCN-224)-coated MnO_2-hydrangea nanoparticle (MnPM) for treating orthopedic biofilm infections, which are created by coating MnO_2-hydrangea nanoparticles with PCN-224 by synthesizing them around the particles solvothermally, then coating the particles with a layer of hybrid neutrophil and macrophage membranes. The MnO_2 converts H_2O_2 into oxygen in the acidic biofilm environment to improve the effect of ultrasound-triggered sonodynamic therapy, during which PCN-224 catalyzes the production of ROS, and the Mn^{2+} ions released enhance cGAS-STING pathways within immune cells. The membrane targets infected regions actively, while also allowing the nanoparticles to be retained longer without being removed by the immune system [12].

For treating osteosarcoma, Lin et al. (2026) developed a method to deliver nanosonosensitizer PCN-224@MnO_2@HA (PMH) and antifibrotic agent SIS3 together within a hydrogel, in which the PMH takes a similar role to MnPM of converting H_2O_2 to ROS to kill cancer cells. The Mn^{2+} released also reacts with and depletes Glutathione within tumor tissue. The SIS3 increases the treatment's effect by deactivating cancer-associated fibroblasts and softening the extracellular matrix. For both of these cases, the oxygen produced allows immune cells to infiltrate the tumor and improve the effect of sonodynamic therapy [13].

Another method of treating tumors is through photodynamic therapy. However, as photodynamic therapy requires oxygen, they function less efficiently in similar hypoxic environments. Zhang et al. (2025) synthesized a platinum/palladium (Pt/Pd) dual-modified PCN-224 nanoprobe (PCN-224-Pt@Pd) by first synthesizing PCN-224 particles solvothermally, then depositing a layer of Pt nanoparticles and a layer of Pd nanoparticles to encapsulate the particles. The Pt and Pd nanoparticles display CAT/POD-like activity and help catalyze H_2O_2's breakdown into both Oxygen and ROS. The Pd nanoshell's CAT-like and POD-like activities are both enhanced due to its surface plasmon resonance property when irradiated, and using two shells in tandem increases both oxygen and free radical production. This allows the platform to both supply itself with oxygen and kill tumor cells efficiently to successfully inhibit tumor growth [11].

2.1.2 The application of PCN-224 in drug delivery

Another application of PCN-224 in medicine is for drug delivery. PCN-224 allows for sustained, controlled release of adsorbed drugs. PCN-224 becomes unstable under acidic conditions, allowing drugs to be released in acidic tumor tissue and bacteria-infected environments as PCN-224 breaks down. This is especially important in both treating cancer and bacterial infections to prevent drugs from damaging surrounding healthy tissue. Additionally, PCN-224 can be modified to include parts that allow it to home in on infected areas, facilitating more precise delivery. Furthermore, other properties of PCN-224 can still be exploited for synergistic therapy to improve the treatment's effect [9, 10].

Zhang et al. (2024) synthesized a unique drug delivery platform that consists of ZnS particles partially coated with polyvinylpyrrolidone (PVP), coated with PCN-224, loaded with doxorubicin (DOX), and then coated with Pluronic F-127. The researchers discovered that PVP coats on different faces of ZnS particles with different strengths. PCN-224 can only grow on certain points on the ZnS@PVP complex, causing only one part to be coated. The DOX releases when the platform enters acidic tumor tissue as PCN-224 breaks down in the acidic environment, killing cancer cells. When the platforms are exteriorly illuminated with 630nm red light, the PCN-224 produces negatively charged ions, causing an asymmetric distribution of charged ions between the sides of the platforms that rotates them away from the light. Species of ROS are also produced in this process, aiding in killing cancer cells. As ZnS decomposes in the acidic environment, H_2S is released, propelling the platforms towards deep inside the tumor [9].

In a study conducted by Gao et al. (2025), NM@PCN-TIG, a novel nanoparticle system consisting of PCN-224 particles loaded with Tigecycline (TIG) and coated with a neutrophil membrane (NM), was developed. The nanoparticle system also utilizes PCN-224's sensitivity to acidic conditions, though the NM acts as the main way of preventing collateral damage from the drug as a physical barrier before the particles reach the infection sites. The NM both targets infected sites actively and prevents the particles from being attacked by the immune system. To enhance the effect of TIG's antibacterial properties, the system also incorporates sonodynamic therapy, utilizing PCN-224's sonosensitizing properties to generate ROS, allowing the TIG to enter bacterial membranes more easily, killing more bacteria in tandem. The system effectively treats multidrug-resistant and extensively drug-resistant Acinetobacter baumannii infections in pulmonary tissue, a type of bacterial infection deadly and previously difficult to treat [10].

2.2 The application of PCN-224 in sensing

PCN-224 provides a very powerful sensing utility, as its porous structure facilitates effective adsorption of both gas and aqueous analytes. It has a wide range of properties that can be used to output signals in different ways, with many means to make specific stimuli alter the selected signals due to PCN-224's easy modifiability [3, 4, 8]. PCN-224 is very useful for optical sensing, as its porphyrin linkers are luminescent with an adjustable optical output signal that responds continuously in real-time [4]. In addition, PCN-224's porous structure also allows the light signal to pass through. The intensity and lifetime of the signal can both be useful for sensing a single wavelength, while colorimetric or ratiometric sensing could be used for signals of multiple wavelengths [3, 4, 7]. Additionally, catalytic properties provided by its modifiable structure also make electrochemical sensing possible. Furthermore, PCN-224's luminescent properties amplify other signals in sensors in which other components are used to sense analytes [3]. Since PCN-224 is very stable, it is especially suitable for the detection of chemicals in food safety and environmental science [8].

One example of PCN-224 being modified for food-safety sensing applications is a sensor using Fe@PCN-224 to detect H_2O_2 in fishery products developed by Hu et al. (2021). The researchers first synthesized PCN-224, then reacted it solvothermally with FeCl3 so the Fe^{3+} ions strongly bonded to its center. The Fe@PCN-224 was wrapped with Nafion via ultrasonication, and then the composites were coated onto a glassy carbon electrode to construct the electrochemical sensors after drying. The detection of H_2O_2 can then be performed amperometrically by first applying a potential of 1.0V; the researchers discovered that the amperometric current of the sensor is proportional to the concentration of H_2O_2 present, as the electrogenerated Fe^{4+} ions react simultaneously with H_2O_2 and are reverted into Fe^{3+}, with a higher concentration of H_2O_2 accelerating the reaction. This sensor is useful for detecting H_2O_2 in fish products, as sellers may add H_2O_2 to make fish appear fresher, which can be harmful to health [8].

For applying MOFs in sensing situations, patterning MOFs can be important in some applications. Carbonell et al. (2024) invented a new "DLP-flow: method that utilizes Digital-Light Processing (DLP) and a capillary-assisted stop-flow system to enable multi-material MOF patterning and demonstrated a PCN-224 sensor for food safety that benefits from being patterned using this setup. The researchers developed an MOF-ink that consists of MOF particles suspended in a solvent with a photoinitiator and a mixture of silicone oligomers. During the process, the substrate is first covered with glass to allow MOF-ink to be confined within. The stop-flow system is used to add ink to it, and the DLP system irradiates the ink so the oligomers solidify, trapping the MOFs within. The residual ink can then be withdrawn; the process can be repeated to pattern multiple MOFs. Using this method, the researchers were able to pattern PCN-224 on a flexible poly(ethylene terephthalate) surface in a fish-shaped pattern. By treating the resulting print with HCl vapor to convert the PCN-224 to its cationic form, flexible sensors for biogenic amines are created, as cationic PCN-224 is green and can be converted to orange PCN-224 when in contact with amines. The resulting signal can be monitored colorimetrically using sensors or by observation; the printed stickers can be used in food packaging to monitor biogenic amines generated from spoilage of the contents [8].

PCN-224-based sensors have the potential to also be modified to interact with their analytes in helpful ways. A study performed by Chen et al. (2025) shows a PCN-224-based sensor that simultaneously detects and kills Listeria monocytogenes. The researchers synthesized aptamer-modified PCN-224@AuPdPt@HRP (PAPPH-Apt) by sequentially adding $HAuCl_4$, H2PtCl$_6$, and $PdCl_2$ to an aqueous suspension of PCN-224 in intervals, reacting the mixture with $NaBH_4$ to deposit the metals, incubating the particles within an HRP solution, and then conjugating the particles with an aptamer for Listeria monocytogenes in a solution. To detect the bacteria, a 96-well plate is coated with vancomycin to immobilize and kill the bacteria. Next, it is washed so only the immobilized bacteria remain, and the PCN-224 @AuPdPt@HRP@Aptamer is added. The PAPPH-Apt will bind specifically to the immobilized bacteria on the plate, which facilitates two methods for determining bacterial concentration. By adding 3,3', 5,5'-tetramethylbenzidine (TMB) and H_2O_2 to the plate, the catalytic property of the PAPPH-Apt will accelerate the decomposition of H_2O_2, its products oxidizing TMB to create blue oxidized TMB. When more bacteria are immobilized, more of the PAPPH-Apt is attached, resulting in a bluer color. The supernatant liquid can also be collected after the addition of the PAPPH-Apt. When Fluorescein-labeled deoxyribonucleic acid (FAM-DNA) is added, its fluorescence will be quenched by the porphyrin ligands in the residual PAPPH-Apt. When more bacteria are immobilized, less PAPPH-Apt remains in the supernatant liquid, resulting in a stronger fluorescence [14].

An aspect of PCN-224's high modifiability, less explored in previous research, is the tuning of the optic signal produced through its luminescence. In addition, though PCN-224 has high thermal and structural stability, it tends to photodegrade under certain conditions. Mautz et al. (2025) conducted a study that progresses these areas of MOF sensing by exploring the effects of partially fluorinating PCN-224 pre-synthesis in both the meso- and β-positions of TCPP on its oxygen sensing properties and photodegradation. The researchers synthesized regular PCN-224 solvothermally, and meso- and β-8F-PCN-224 using the same method with TCPP linkers fluorinated in the meso- and β-positions. The β-8F-TCPP was synthesized using expensive 3,4-difluoropyrrole, which may be detrimental to the practicality of using β-8F-PCN-224 in sensing situations. The group also tested the effects of using versions of TCPP metalated with Platinum. The group found that β-TCPP has a notably lower fluorescence quantum yield and decay time, which could lead to suboptimal sensing capability. The metalated linkers displayed a phosphorescent emission of light, and β-8F-PtTCPP similarly showed the lowest brightness. β-8F-PCN-224 is found to possess the lowest sensitivity and decay time, while meso-8F-PCN-224 has the highest sensitivity and decay time. The metalated variants are found to be more useful at sensing small concentrations of O_2, and regular Pt(II)PCN-224 shows the highest effect among them. One important discovery made was that although partial fluorination does not significantly increase the photostability of PCN-224, free carboxylic acid groups in the solution decrease it. Additionally, residual DMF solvent is found to also decrease the photostability of PCN-224 due to its breakdown being triggered by the catalytic properties of its nodes; future synthesis pathways omitting DMF may need to be developed for certain applications [4].

In a study performed by Tian et al. (2025), the use of PCN-224's luminescence for the amplification of a non-PCN-224-generated signal is explored for ratiometric sensing of Hg^{2+}. The researchers synthesized a new Fluorescence-enhanced PCN-224 (FE-PCN-224) by treating PCN-224 with a Tris-HCl buffer solution and incubating it. The group used a 6-carboxyfluorescein-labelled Hg^{2+} aptamer (FAM-Apt) rich in T bases to sense the Hg^{2+} ions because the ions conjugate to the T bases within the aptamer, causing electrons to transfer to the ion when the FAM is excited and quenching its fluorescence. The Fe-PCN-224 is found to enhance the strength of FAM-Apt's fluorescence, allowing its change to be more easily sensed. Additionally, its own fluorescence with a 650nm wavelength is not affected by this property, facilitating ratiometric detection by comparing the strength of its fluorescence and the fluorescence of FAM-Apt; the wavelength of FAM-Apt's emission is 518nm. The group demonstrated that ratiometric sensing has high stability and reliability and can be monitored using mobile phone color analysis software easily, making it useful in food safety and environmental detection [3].

2.3 The application of PCN-224 in green chemistry

PCN-224 is useful for heterogeneous catalysis, as its porous structure allows reactants to reach the catalytic nodes within it easily. Additionally, the catalysis of PCN-224 can be further accelerated due to its high modifiability, as it can be easily incorporated into creating heterojunctions. As part of a heterojunction, PCN-224's porphyrin linkers can absorb light and transfer electrons to the metal nodes when activated, thereby facilitating photocatalytic properties [6]. The added groups in the heterojunction also make other catalysis methods, such as piezocatalysis, possible [5]. Due to these properties, PCN-224-based catalysts create many opportunities in green chemistry, such as in sustainable fuel production and the sustainable production of other chemicals [2, 5, 6, 15].

A study performed by Jin et al. (2021) demonstrates a ZnIn2S4@PCN-224 heterojunction for catalyzing the splitting of water that shows potential to self-eliminate organic contaminants. The researchers reacted pre-synthesized PCN-224 with $ZnCl_2$, $InCl_3 \cdot 4H_2O$, and thioacetamide in an organic solvent to form the heterojunction; the team tested different weight ratios of PCN-224 loadings and found 20% to be the optimal quantity. The resulting sample from this configuration is labeled ZIS@P20. The group loaded the ZIS@P20 with different quantities of co-catalyst Pt with an in-situ growth method by adding H_2PtCl_6 to the ZIS@P20 inside a solution containing KOH, finding that a weight ratio of Pt to ZIS@P20 of 8.0% is optimal. The composites' visible-light-driven photocatalysis properties were tested to have yields higher than many $ZnIn_2S_4$-based photocatalysts, even ones utilizing a Pt cocatalyst. Additionally, using a Pt cocatalyst under the same conditions further increases the hydrogen yield to 12 times greater than without. Moreover, reactive species formed on the catalyst during catalysis are shown to attack the organic contaminant tetracycline hydrochloride, leading to its decomposition. This shows that this catalyst has the potential to be used for the treatment of organically contaminated water and that systems using this catalyst can self-decontaminate [6].

Whereas many other MOF-based catalysts are only able to catalyze simple reactions without many steps, the unique catalyst PCN-224-Cu, synthesized by Qi et al. (2021), can catalyze the synthesis of ethanol from CO_2 using only its components as the reaction sites. This is unlike other chemocatalytic cascades, which mostly combine reactions that happen on reaction sites mutually independent from one another. The researchers first combined TCPP and $CuCl_2 \cdot 2H_2O$ under reflux to form TCPP-Cu, which contained a Cu2+ ion conjugated in the center. The TCPP-Cu is then combined with $ZrOCl_2 \cdot 8H_2O$ to synthesize PCN-224-Cu solvothermally. The group calculated a reaction pathway semi-empirically for CO_2 reacting with H_2 using PCN-224-Cu, which involves the Zr6 cluster functioning to break intermediates, and the TCPP-Cu ligand functioning to assemble intermediates, as shown in Fig. 2.

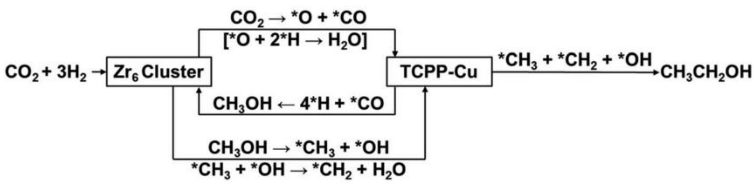

Fig. 2. The determined reaction pathway for the synthesis of ethanol from CO_2 and H_2 [15].

This activity is somewhat like how multistep cascades function in living cells, in which intermediates are commonly not separated. The benefit of this is that semi-unfinished intermediates will be present in lower quantities, facilitating high selectivity for the final product; the selectivity for ethanol in this case is almost 100% [15].

Modifications on PCN-224 that grant multiple synergistic catalysis mechanisms are also possible, one example being the g-C_3N_4/PCN-224 (CP-x) heterojunctions developed by Meng et al. (2024) for catalyzing H_2O_2 production from water and dissolved oxygen, using ethanol as a sacrificial agent. The heterojunctions were created by mixing g-C_3N_4 powder and PCN-224 using a ball-milling process. This forms CP-x heterojunctions that are of a core-shell structure, which the researchers noted may enhance both the light absorption efficiency and the transfer of active charge carriers between the shell and the core. The x in CP-x stands for the mass, in grams, of the PCN-224 used multiplied by 100, and the group found that CP-5 overall had the best catalytic performance through tests on reducing Cr(VI). (The amount of g-C_3N_4 is 0.10 g for all tests.) PCN-224 and g-C3N4 individually each had relatively weak photocatalytic properties, and g-C_3N_4's own piezocatalytic properties are similarly weak. The team found that not only does combining the two components enhance both of these properties, but that the catalytic effect is also greatly enhanced when CP-5's photo and piezo-catalytic properties function in synergy. This effect is promising for green applications such as rainwater processing, using sunlight and externally provided ultrasound vibration to power the efficient production of H_2O_2 [5].

One application of PCN-224 as a catalyst in green chemistry, other than in sustainable synthesis pipelines for chemicals, is in organic contaminant decontamination. Li et al. (2025) developed a new PCN-224/MXene (PM-X, where X corresponds to the mass of MXene used) composite heterojunction able to effectively degrade organic contaminants such as tetracycline and Rhodamine and kill methicillin-resistant Staphylococcus aureus and Escherichia coli. The PM-X composite, consisting of an interfacial Schottky junction in which PCN-224 cubes were anchored onto MXene's delaminated sheets, is synthesized via a one-step solvothermal method. The researchers selected PM-10, as it demonstrated the best degradation capability. PM-10 demonstrates a powerful capability to decompose contaminants using a synergistic catalysis method of three different properties: photocatalytic charge separation from the heterojunction as a whole, photothermal conversion from MXene, and enzyme-mimetic H_2O_2 activation from PCN-224. The complex catalyzes water and oxygen to form ·O_2^- and OH radicals when exposed to light, while its enzyme-mimetic properties can catalyze the breakdown of any H2O2 created during the process into ·OH radicals for further effect. The photothermal conversion facilitated by the MXene decreases the activation energies of both of these processes to increase the reaction rate. The rapidly produced ROS are able to decompose organic contaminants and pathogens effectively. The study presents a scalable strategy for water treatment and proposes future applications in fields such as microplastic fragmentation or heavy metal recovery [2].

3 Conclusion

In conclusion, much progress has been made on using PCN-224 for applications in recent years. In medicine, PCN-224's properties as a sonosensitizer have led to the development of new methods to kill tumor cells and biofilms. Methods utilizing its properties as a photosensitizer have also been explored for similar applications, with the introduction of catalytic modifications for catalytic therapy. Additionally, PCN-224's capacity for drug delivery has also been explored for both the treatment of tumors and bacterial infections, with synergism with both of the sensitizing properties mentioned above. In sensing, many sensors have been developed through modifications of PCN-224, which utilize different properties it possesses. Using the fluorescent or chromogenic properties of porphyrins, new sensors have been developed to provide unique benefits, such as having a flexible substrate for easy deployment in packaging. Furthermore, insights have been made on factors affecting the photodegradation of PCN-224, useful for many applications, along with the development of a new modified PCN-224 for oxygen sensing. Fluorescent or colorimetric sensing utilizing PCN-224 in different ways has also been recently explored, using aptamers for the analyte as sensing elements. PCN-224's fluorescent properties can be used to amplify fluorescent output signals for self-stabilizing ratiometric sensing, and its multiple other properties make dual-mode detection in combination with an aptamer sensor possible. Moreover, PCN-224's catalytic properties also facilitated recent developments in amperometric sensing based on modified PCN-224. In terms of applications of PCN-224 as a catalyst in green chemistry, new PCN-224-containing heterojunction catalysts have been developed for photocatalytic applications, utilizing PCN-224's unique properties in combination with those of the other material for new effects such as piezo‐photocatalytic properties, synergistic photonic-thermal-enzyme catalytic properties, and self-decontamination. In addition, progress was also made in using a modified PCN-224, only containing two types of catalytic sites for the catalysis of a complex cascade synthesis reaction with high selectivity and yields. Some of these developments show high potential for the efficient synthesis of sustainable fuels, while others can be applied in wastewater treatment, with some also providing useful products.

The recent developments in the use and modification of PCN-224, shown in this article, demonstrate various new applications of PCN-224 in the present, while showing promising future applications of PCN-224 in their respective areas. In medicine, combination therapy involving recently developed sonodynamic and photodynamic therapy methods and other treatments can be further developed, along with treatments that utilize other properties of PCN-224. More orientable and drivable carriers may be developed for drug delivery, along with further developments in using them for other types of previously difficult-to-treat localized lesions. In sensing, the pore properties of PCN-224 in sensor patterns patterned using new technology can be potentially characterized to aid the development of new sensors based on it, and more multimodal sensing platforms of it can be developed. New synthesis pathways for PCN-224 on large scales to avoid photodegradation for sensor fabrication may also be of benefit for both sensing and general applications of it in the future. Aptamer-based sensors using PCN-22d that function with multiple aptamers could also be researched in the future. In catalysis, synthesis pipelines utilizing PCN-224-based catalysts for different complex cascade reactions can be further investigated. New PCN-224-based photocatalytic heterojunctions involving other synergistic catalysis methods can also be potentially made possible through the incorporation of more types of semiconductors. Moreover, the recently developed applications of PCN-224 can be actualized in the future to provide more options and solve problems in real-life situations in all the mentioned fields.

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