**Metal Organic Frameworks (MOFs) and Covalent Organic Frameworks (COFs): A benevolent and versatile scaffold for multifunctional utilities in S&T**

**Ms.Samiksha M. Borghare, Mr.Tahir N. Sheikh, Department of Chemistry,RTM Nagpur University, Nagpur-440033**

**Mo.No.7083340545 Email id: borgharesamiksha14@gmail.com**

**Abstract:**

Metal-organic frameworks (MOFs), made up of organic ligands and metal ions which are highly porous, crystalline materials while Covalent-organic framework(COFs) are a class of penetrable crystalline material that are connected by strong covalent bonds. Their penetrability, chemical composition, size and shape, and easy surface functionalization make this large family more and more popular for numerous applications like in oral drug delivery, catalysis, adsorption and sensing of various pollutants especially water, used in electrochemical applications, in photocatalysis or used as biomarkers. Various methods are practiced for the synthesis of MOFs and COFs like microwave assisted synthesis, mechano chemical, sonochemical methods, etc.

**Keywords**: Metal organic framework (MOF), Covalent organic framework(COFs),applications, synthetic tactics,scaffolds, organic/inorganic -matrix, benevolent functionality.

**Introduction:**

Metal-organic frameworks (MOFs) and covalent organic frameworks (COFs) represents a relatively new class of penetrable materials that have attained remarkable engrossment in the scientific society due to their captivating properties and probable utilities.. The history of MOFs can be traced back to the early 20th century, but their development as a distinct field of research began in the 1990s.

**Metal Organic Framework (MOFs):**

Metal–organic frameworks (MOFs) , as a type of translucent penetrable composite materials, are made up by inorganic building units or metal ions coordinating with electron-donating organic ligands . They are also called as coordination polymers consisting of inorganic–organic composite structure . Their structures contain metal centers as connectors and organic ligands as linkers.

Although, most MOFs tested to date are obtained from unrenewable petroleum derived chemicals raw-material and transition metals. One of the roadblocks when synthesizing MOFs from real unprocessed products results from the repeated disorganization of the building units, which do not typically result in significantly high penetrability or firmness. The high translucent property and penetrability of MOFs along with manageable and reconcile penetrable structures have led to extensive research of MOFs.

Early Development: The concept of coordination polymers, which are the basis for MOFs, can be detected back to the late 19th and early 20th centuries when researchers initiated studying coordination compounds formed between metal ions and organic ligands. These early studies laid the groundwork for understanding metal-ligand interactions.

 Birth of MOFs:

The term "metal-organic framework" was first introduced in a 1999 paper by Omar M. Yaghi and colleagues. The researchers synthesized a porous material, known as MOF-5, using zinc oxide clusters and 1,4-benzenedicarboxylic acid as organic linkers. This groundbreaking work marked the birth of MOFs as a distinct category of porous materials with tunable properties.

Rapid Expansion and Diversity:

Following the discovery of MOF-5, the field of MOFs expanded rapidly. Researchers began to explore various metal ions and organic ligands to create a wide range of MOF structures with various aperture dimensions, configuration, and performance. The diversity of MOFs allowed for utilities in numerous areas, including gas storage, catalysis, drug delivery, and sensing.

Challenges and Advances:

Despite the promise of MOFs, their practical applications faced challenges related to stability, scalability, and cost. Some MOFs showed instability in the presence of moisture or harsh conditions, limiting their real-world applications. Researchers focused on improving the stability and developing post-synthesis modifications to tailor the properties of MOFs for specific applications.

Beyond MOFs:

As research continued, scientists explored new classes of porous materials related to MOFs, such as covalent organic frameworks (COFs) and penetrable coordination polymers (PCPs). These materials offered additional possibilities for diverse applications.

MOFs are portrayed by large aperture surface area, with micro- and meso apertures, and very high pattern of aperture dimensions, configuration, and performance and hence benefited in numerous fields like catalysis,adsorption and sensing of effluents especially water or in oral drug delivery,gas storage and separation,etc.Aside from all these utilities in recent years, there is an increasing attentiveness in disclosing the numerous utilities in the electrochemical field like advances in supercapacitors, batteries and fuel cells, hydrogen evolution reaction (HER), oxygen evolution reaction (OER),and oxygen reduction reaction (ORR),electrochemical decomposition of highly oxidizing and toxic compounds, electrochemical sensors, etc.

Metal-organic frameworks (MOFs) are a class of penetrable materials made up of metal ions (nodes) attached to organic ligands (linkers). These materials exhibit a wide range of properties, making them highly versatile and applicable in various fields. Some of the key properties of MOFs include:

High Surface Area: MOFs typically have exceptionally high surface areas, often exceeding thousands of square meters per gram. This high surface area arises from their porous nature, providing ample space for gas adsorption, catalytic reactions, and other interactions with guest molecules.

Tunable Porosity: MOFs offer tunable porosity, meaning their pore sizes and shapes can be customized during the synthesis process. This property allows researchers to design MOFs with specific adsorption properties for different guest molecules, making them valuable for gas storage and separation applications.

Large Voids and Channels: MOFs often have large voids and channels within their structures, allowing for the accommodation of bulky guest molecules. This property is crucial for applications in gas storage, catalysis, and drug delivery, where molecules of varying sizes need to be accommodated.

Gas Adsorption: Due to their high surface area and tunable porosity, MOFs can adsorb and store significant amounts of gases, such as hydrogen, methane, carbon dioxide, and other small molecules. This property is relevant for gas storage, purification, and separation processes.

Selective Adsorption: MOFs can exhibit selective adsorption behavior, where they preferentially adsorb specific gas molecules over others. This property makes them valuable for gas separation and purification applications.

Catalytic Activity: Some MOFs possess inherent catalytic activity due to the presence of metal sites within their structures. These metal sites can facilitate chemical reactions and provide unique catalytic properties, making MOFs attractive for catalysis applications.

Framework Flexibility: Certain MOFs exhibit framework flexibility, meaning their structures can undergo reversible structural changes upon exposure to external stimuli, such as temperature, pressure, or guest molecules. This property is relevant for applications in gas storage, molecular sieving, and stimuli-responsive behavior.

Thermal Stability: Many MOFs exhibit good thermal stability, allowing them to withstand high temperatures without significant degradation. This property is essential for applications in catalysis and gas storage, where stability under operating conditions is crucial.

Photoluminescence: Some MOFs display luminescent properties, emitting light when excited by ultraviolet or visible light. These luminescent MOFs have potential applications in optoelectronic devices, sensors, and imaging agents.

Water Stability: While some MOFs are sensitive to moisture and may degrade upon exposure to water, efforts are being made to develop water-stable MOFs, making them suitable for applications in humid environments and aqueous processes.

 Versatility and Functionalization: MOFs can be easily functionalized by introducing different organic ligands or modifying their structures, leading to a wide range of tailored properties and applications.

**Synthetic approach of MOF’s:**

There are various synthetic routes for the fabrication of MOFs. The most usual and simple route is the solvothermal method, where a mixture of metal salt is allowed to heated, and organic linkers are dissolved in a solvent, above the boiling point of the solvent itself. Other methods involves microwave-assisted, electrochemical, mechanochemical, and sonochemical synthesis; these approaches vary in how energy is introduced in the synthetic system and depends upon various factors like different reaction time, yields, particle size and morphology.

The fabrication of metal-organic frameworks (MOFs) has captivated many researchers during the last 2 decades due to the chances to obtain a large variety of interesting structures that could also be of great interest for applications in numerous area related to penetrable materials which are based on the aperture dimension and configuration as well as the host guest interactions involved.

Concerning the fabrication of MOFs, often the term “design” has been utilized. There have been debatable discussions about this term and an fascinating conviction has been given a little while back. The more firm definition of “design”, which indicates “to create, fashion, execute, or construct according to plan” (Webster’s Dictionary), generally is not applicable in MOF fabrication. Nonetheless, the definition and its inference have helped to enhance the area of MOF.

The word conventional synthesis is usually applied to reactions carried out by conventional electric heating without any parallelization of reactions. The main factor in the fabrication of MOFs are the temperature of reaction, and two temperature ranges, solvothermal and nonsolvothermal, are normally differentiated, which dictate the kind of reaction conditions that have to be used.

**ALTERNATIVE SYNTHESIS ROUTES**

By numerous methods energy can be introduced for example by an electric potential called as electrochemistry, mechanical waves called as ultrasound, electromagnetic radiation ,microwave irradiation called as microwave-assisted synthesis, application of an electric potential called as electrochemistry and mechanically called as mechanochemistry.

**Microwave-Assisted Synthesis:**

Energy can be introduced through microwave irradiation which is a well established method in man-made chemistry but has been mainly used in organic chemistry. Microwave-assisted fabrication depends on the interaction of electromagnetic waves with mobile electric charges. It can be polar solvent molecules/ions in a solution or electrons/ions in a solid. In the solid, an electric current is formed and heating is due to electric resistance of the solid. Because of the direct interaction of the microwave radiation with the solution/reactants, MW-assisted fabrication shows a very high energy efficient method of heating. Thus, homogeneous and high heating rates throughout the sample is possible by microwave assisted synthesis.Microwave ovens helps to maintain temperature and pressure conditions during the reaction suited for the synthesis of required material and thus allow a more precise control of reaction conditions. Reaction conditions required for MW-assisted fabrication of MOFs includes temperature above 100oC with reaction times rarely exceeding 1 hr. Some reports also described some parameters in order to control reaction like solvent, irradiation time, reaction temperature, power level, molar ratio of the reactants, reactant concentration, etc. In common, MW irradiation permits faster synthesis of smaller crystals compared to CE heating.

**Mechanochemical Synthesis:**

In this type of synthesis mechanical force is used.Mechanical force can accelerate many physical phenomena (mechanophysics) and chemical reactions. The mechanical breakage of intramolecular bonds followed by a chemical changes takes place in mechanochemical synthesis.There are number of advantages of these reaction. It is eco-benign reaction because it can be carried out at room temperature without using hazardous solvents, short reaction times, normally in the range of 10-60 min, can lead to quantitative yields, and small particles as a products are obtained. Furthermore, in some cases metal salts can be replaced by metal oxides as a initiating material, which results in the formation of water as the byproduct.

**Sonochemical Synthesis:**

When high-energy ultrasound waves radiate on a reaction mixture, MOFs are fabricated through sonochemical synthesis.It has also numerous advantages like it is speedy,it provides adequate energy,it requires room temperature.The primary aim of sonochemical fabrication in MOF science was to find a fast, energy-efficient, environmentally friendly, room temperature method that can easily be carried out. This is of unusual engrossment for their future application, since fast reactions could allow the scaleup of MOFs.

**APPLICATIONS OF MOF’s:**

**1] MOF’S AS ADSORBENTS:**

MOFs are excellent materials for a future utility in the field of pollutants removal from wastewater through adsorption process due to the high penetrability of MOF and the unique interactivity of adsorbate/adsorbent .

**Adsorptive removal of toxic heavy metal ions from wastewater:** The toxic heavy metal ions include arsenic, copper, chromium, lead, mercury, nickel and zinc ions degrade the quality of water and which is dangerous to humans and other living species as well as ecosystem.These toxic heavy metal ions are removed from effluent using commercial adsorbents (e.g. zeolites and activated carbon materials) or some bioadsorbents such as modified coconut waste, modified sawdust or chitosan. Inspite of all these adsorbents MOFs are also act as excellent adsorbents because of their unique properties.

1. **METAL ORGANIC FRAMEWORKS AS PHOTOCATALYSTS :**

 It is observed that photodegradation is theoretically a better practice than adsorption for effluent treatment, because it causes a complete removal of the toxic heavy meta ions or pollutants instead of its simple phase transfer, so no further treatment is required. The existence of organic linkers in MOFs permits them to have a relatively wide absorption spectrum permitting the generation of a charge-separated state, which decays in the microseconds, thus permitting photocatalytic utilities .

**MOFs for the photocatalytic removal of organic pollutants**

 The photocatalytic deterioration of organic pollutants is a more rigorous method for water purification as compared to adsorption phenomena.For example, the in situ generation of highly reactive transient species (i.e., H2O2, OH, O2) can convert hazardous organic pollutants into non-poisonous or less toxic substances . In this view, latest reports suggest MOFs are new promising extraordinary materials as photocatalysts for the deterioration of organic pollutants present in wastewater.

**Photocatalytic removal of dyes.** Owing to their differentiating electronic configurations, the central metals of MOFs are suspected to have a great impact on the photocatalytic properties.

**3] MOF AS FLUORESCENCE SENSORS :**

The structure, composition and characteristics features of MOFs materials is responsible for showing the fluorescence property by MOF which is responsible for sensing of multivariant pollutants from effluent. Based on the penetrability of MOFs, there are different systems of guest@MOFs are synthesized. The dimension and configuration of the guest and the voids of MOFs are some of the factors that should consider for the fabrication of sensors. For the various target substances,specific MOFs-based materials need to be found as fluorescence probes. It is important to notice the response to the detected materials through such intuitive phenomena as fluorescence quenching of the MOFs-based materials. Therefore, each material may show different response mechanism depending upon type of sensor utilized. The luminescence characteristics of MOFs materials can be strengthen by replacing various organic ligands. Metal ions like lanthanide metals are also used in the preparation of MOFs.

**Luminescence MOF’s:** In latest years, LMOFs, as one of the most broadly used branches of MOFs, have expanded in the fields of optical security displays, biomedical imaging and sensing, and illumination decoration due to their optical integrity and fluorescence heterogeneity, specificallyin the area of toxic metal ions and hazardous pollutants detection. LMOF’s has recent advances in sensing utilities of hazardous materials, with an attention on the impact of composition or structure on the sensing capabilities of LMOFs**.** Numerous luminescence sensing mechanisms and structure-performance relationships are also concisely elaborated. Besides, the opinion and several pivotal issues of this field are also noted with the assumption of restoring more awareness on exploring the potential of LMOFs for sensing utilities.

**4] MOF AS BIOMARKERS:**

Biomarkers are an indicator of biological monitoring. The National Research Council (NRC) describes a ‘‘biomarker’’ as an indicator to consider the occurrence of a biological system or sample, which can be considered a device to scrutinize the correlation between touching external chemicals and health lesions. The International Programme on Chemical Safety put forward a generalized definition of biomarkers as a determined indicator to consider the correlation between a biological system and external chemical, physical and biological constitute. As incipient biological signals to indicate the harmful effect of pollutants, biomarkers have been developed and applied by lots of disciplines to develop more and more concern.

Up to the present, the applied sensing systems for biomarkers have focused mainly on all kinds of functional NPs and their nanocomposites. The selected NPs involve metal (Ag, Au, Pd, and Pt), oxide (ZnO, Fe3O4, CoFe2O4) and nonoxide species (CdTe) with special optical, magnetic or electronic characteristics. These NPs often behave as active components synthesized into host materials including MOFs. In addition, some small molecules are utilized for sensing markers.

1. **MOF IN ORAL DRUG DELIVERY:**

MOFs possess the special properties of systematically arranged structure and large surface area.Their tunable penetrability, chemical constitution, dimesion and configuration easy surface functionalization make this huge family more and more popular for drug delivery. Drugs can be embedded on the outer surface, or encapsulated into the porous structure.

MOF systems for disease therapies: On account of their superior characteristics in drug delivery, MOFs have been utilized as a drug therapist for numerous diseases, including infections, lung disease, diabetes mellitus, ocular disease and tumors, which have made prominent progress in the previous few years.

1. **MOF AS GAS STORAGE :**

MOFs are also well recognized for gas storage and separation, owing to their ultrahigh penetrability with high superficial area ranging from 100 to 10,000 m2/g,tunable penetrable size of 3 to 100 Å, high heat tolerance (up to 500 °C) and even exceptional chemical stability. The establishment of permanent penetrability for MOFs was realized in late 1990s, which initiated their utilities as adsorbents. The speedily refreshing records of penetrability and high superficial area highlights this type of adsorbents very promising for gas storage and separation.

1. **MOF IN BIOMEDICAL APPLICATIONS:**

Due to the unique characteristics of MOFs, including their high penetrability, high superficial area, large pore size & nanometer-scale size, they are widely used in biomedical applications. Biomacromolecules, such as nucleic acids, proteins and peptides, bind to the surface of MOFs through coordination bonds, giving MOFs the capacity of target identification, analytical detection, drug delivery,biosensing, bioimaging, and biocatalysis .MOFs can trap biomolecules into their hollow aperture . They can be utilized as carriers for targeting specific body sites and for controlled release of the drugs due to their extensive high superficial area (1000 to 10,000 m2/g), high penetrability. The size of the particle should be less than 200 nm in order for these drug carriers to freely move.Many sorts of functional molecules can fit within the pores because of the high penetrability of MOFs and their tunable pores from microporous to mesoporous.

**Futuristic perspectives of MOF:**

The future of metal-organic frameworks (MOFs) is promising and exciting, with ongoing research and development expected to lead to numerous advancements and applications. Some of the key areas of focus and potential developments in the future include:

Improved Stability: One of the significant challenges for MOFs is their stability in various environmental conditions. Future research is likely to focus on enhancing the stability of MOFs, making them more robust and suitable for practical applications, even in harsh conditions.

Tailored Functionality: Researchers will continue to design and synthesize MOFs with tailored functionalities. By selecting specific metal ions and organic ligands, they can tune the properties of MOFs for various applications, such as gas storage, catalysis, drug delivery, and sensing.

Green and Sustainable MOFs: As environmental concerns grow, there will be an emphasis on developing green and sustainable MOFs. This might involve using renewable and eco-friendly materials as building blocks for MOFs or developing synthesis methods that have a lower environmental impact.

Industrial Applications: MOFs hold great potential for various industrial applications, such as gas separation, storage, and purification, as well as catalysis and chemical reactions. In the future, we can expect to see MOFs being implemented on a larger scale in industrial processes to improve efficiency and sustainability.

Energy Storage: MOFs with high surface areas and tunable porosity could play a crucial role in energy storage technologies. They might be used for advanced battery materials, supercapacitors, or as storage media for hydrogen and other energy carriers.

Water Harvesting and Purification: MOFs have shown promise in capturing and releasing water molecules from the atmosphere, which could have significant implications for water harvesting in arid regions. Additionally, MOFs' ability to selectively adsorb specific molecules makes them suitable for water purification and desalination processes.

MOFs in Medicine: In the medical field, MOFs could find applications in targeted drug delivery systems, imaging agents, and theranostics (combined therapy and diagnostics). MOFs might enable more efficient and controlled drug release, minimizing side effects and improving treatment outcomes.

MOFs in Electronics and Optoelectronics: MOFs with semiconducting or luminescent properties could be integrated into electronic devices and optoelectronic applications, such as sensors, light-emitting diodes (LEDs), and photodetectors.

Artificial Photosynthesis: MOFs may play a role in developing artificial photosynthesis systems that convert carbon dioxide and water into useful chemicals and fuels using solar energy. These systems could contribute to addressing climate change and energy sustainability.

Space Exploration: MOFs could have applications in space missions, such as gas storage for propulsion systems or as protective materials for sensitive instruments.

**Covalent Organic Frameworks(COFs)**

Covalent organic frameworks (COFs) are a group of materials which form two or three dimensional structures.These are obtained through reactions between organic precursors resulting in strong & covalent bonds which results into a penetrable ,stable and translucent materials. COFs emerged as a field from the overarching field of organic materials as scientists optimized both man-made control and precursor choice. These enhancement in coordination chemistry enable non-penetrable and amorphous organic materials such as organic polymers to advance into the synthesis of penetrable, translucent materials with rigid structures that shows exceptional material firmness in a wide range of solvents and conditions. Through the growth of reticular chemistry, precise manmade control was achieved and resulted in ordered, nano-penetrable structures with highly preferential structural orientation and characteristics which could be synergistically enhanced and amplified. With sensable selection of COF secondary building units (SBUs), or precursors, the final structure could be predetermined, and modified with exceptional control enabling fine-tuning of emergent characteristics. This level of control facilitates the COF material to be designed, synthesized, and utilized in various applications, many times with metrics on scale or surpassing that of the current state-of-the-art approaches.

The fabrication of 3D COFs has been hampered by longstanding practical and conceptual challenges until it was first achieved in 2007 by Omar M. Yaghi and colleagues.Unlike 0D and 1D systems, which are soluble, the insolubility of 2D and 3D structures prevent the use of stepwise fabication, making their isolation in translucent form very burdensome. This first challenge, however, was overcome by sensibly choosing building blocks and using reversible condensation reactions to crystallize COFs.

 **Reticular Synthesis**

Reticular synthesis facilitates facile bottom-up fabrication of the framework materials to introduce precise perturbations in chemical composition, resulting in the highly controlled tunability of framework characteristics. Through a bottom-up approach, a material is built from atomic or molecular components synthetically as opposed to a top-down approach, which forms a material from the bulk through approaches such as exfoliation, lithography, or other means of post-synthetic modification. The bottom-up approach is especially benefitted with respect to materials such as COFs because the unnatural methods are fabricated in such a way that they directly result in an extended, highly crosslinked framework that can be tuned with exceptional control at the nanoscale level. Geometrical and dimensional principles govern the framework's resulting topology as the SBUs combine to form predetermined structures. This level of synthetic control has also been termed "molecular engineering", & this concept was termed by Arthur R. von Hippel in 1956.

 COF topological control through sensible selection of precursors that result in bonding directionality in the final resulting network.

It has been accepted in the literature that, when integrated into an isoreticular framework, such as COF, characteristics from monomeric compounds can be synergistically enhanced and amplified. COF materials possess the special property for bottom-up reticular fabrication to afford robust, tunable frameworks that synergistically enhance the properties of the precursors, which, in turn, offers many advantages in terms of improved performance in different applications. As a result, the COF material is highly modular and tuned efficiently by changing the SBUs’ identity, length, and functionality depending on the required characteristics change on the framework scale. There exists the ability to introduce diverse functionality directly into the framework scaffold to allow for a variety of functions which would be unmanageable, if not impossible, to achieve through a top-down method such as lithographic approaches or chemical-based nanofabrication. Through reticular synthesis, it is possible to molecularly engineer modular, framework materials with highly porous scaffolds that exhibit unique electronic, optical, and magnetic properties while simultaneously integrating desired functionality into the COF skeleton.

Reticular synthesis is dissimilar from retrosynthesis of organic compounds, because the structural integrity and rigidity of the building blocks in reticular synthesis remain unchanged throughout the construction process—an important aspect that could help to fully realize the advantages of design in translucent solid-state frameworks. Similarly, reticular synthesis should be differentiated from supramolecular assembly, because in the former, building blocks are interconnected by strong bonds throughout the crystal.

Synthetic Chemistry: Reticular synthesis was utilized by Yaghi and coworkers in 2005 to fabricate the first two COFs reported in the literature: COF-1, using a dehydration reaction of benzenediboronic acid (BDBA), and COF-5, via a condensation reaction between hexahydroxytriphenylene (HHTP) and BDBA. These framework scaffolds were interconnected through the formation of boroxine and boronate connectivities, respectively, using solvothermal manmade methods.

COF Linkages: Since Yaghi and coworkers’ seminal work in 2005, COF fabrication has expanded to include a wide range of organic connectivity such as boron-, nitrogen-, other atom-containing connectivity.

 **Applications of COF:**

1. Gas storage and separation: COFs can be designed with specific pore sizes and geometries, making them promising materials for storage and separation of gas applications. They can adsorb and store gases like hydrogen, methane, carbon dioxide, and other environmentally relevant gases.

 2. Catalysis: COFs can act as efficient catalysts in various chemical reactions due to their well-defined and accessible active sites. They can catalyze reactions such as hydrogenation, oxidation, and carbon-carbon bond formation.

 3. Sensing: The structural flexibility and porosity of COFs allow them to interact with specific analytes, making them suitable for gas sensing and chemical sensing applications.

 4. Optoelectronics: COFs with π-conjugated structures can exhibit interesting electronic and optical properties, making them potential candidates for optoelectronic devices such as light-emitting diodes (LEDs) and photodetectors.

5. Energy storage: COFs have shown promise in energy storage applications, particularly in supercapacitors. Their high surface area and tunable pore size can enhance the charge storage capacity.

 6. Drug delivery: The porous nature of COFs permits for the encapsulation and controlled release of drugs and other bioactive compounds, making them useful for drug delivery systems.

 7. Environmental remediation: COFs can be functionalized to selectively capture and remove pollutants from water and air, aiding in environmental remediation efforts.

 8. Membrane technology: COFs can be integrated into membranes to achieve selective separation of molecules in processes such as water purification and gas separation.

 9. Flexible electronics: The mechanical flexibility of certain COFs can be utilized to synthesize flexible and stretchable electronic devices.

 10. Nanotechnology: COFs can serve as building blocks for nanoscale devices and materials due to their precise structures and well-defined functionalities.

**Conclusion and Perspective:**

 Coordination chemistry is a fast growing field of chemistry which includes , metal–organic frameworks (MOFs) and covalent organic frameworks(COFs) with adjustable penetrable structures,dimensions and configurations and number of active sites have proved to be absolute material for numerous utilities. As a promising group of translucent penetrable inorganic–organic composite materials, MOFs and COFs can principally assimilate almost limitless various functional components (all kinds of metal ions, organic ligands and guest molecules/ions). More importantly, their penetrable structures,dimension and configuration and chemical environments within a hollow aperture are highly designable and can be modulated by following reticular chemistry.

**State of the art:**

MOFs and COFs are fabricated from these association between the metal ions and bridging organic ligands. These materials are popular among recently studied economical adsorbents or sensors because of many attractive properties. Penetrable 3D network with extensive superficial area , adjustable pore size, higher firmness, low-cost fabrication, higher efficiency and easy separation made MOFs and COFs a promising next generation material in various fields. Despite their advantages, certain MOFs and COFs display poor characteristics, including weak water firmness and lower thermostability than other materials. To recompense for these inadequacy, a regulated combination of various MOFs/ COFs and building materials are being explored to establish better multifunctional units with enhanced characteristics facilitated through the synergistic effects of the individual units. MOFs/COFs are coated on several membranes to enhance their functionality. Some binary and higher composites are also derived from organic materials like chitosan, dendrimers, cyclodextrin and inorganic frameworks like LDH, zeolites and made certain hybrid materials e.g., binary composites like (cyclodextrin-MOF), (chitosan-MOF),(LDH-MOF),(V2O5-MOF),(LDH-V2O5) and ternary composites (MOF-chitosan-cyclodextrin). These synthesized binary and/or any other higher constitutional composites are aimed to be employed for sensing or adsorption of multivariant pollutants like heavy metal ions,POP’s (dioxins), organic insecticides and pesticides.es, V2O5 and many more applications.

**Acknowledgement:**

I would like to express my thanks to our Head of the Department,Prof.N.N.Karade for providing me with all the facility that was required.I would like to express my special thanks to my Ph.D.supervisior Prof.R.S.Dongre for encouraging me and for their immense guidance.Lastly I would like to thank my parents and friends for their constant support.

**References:**

1. Metal-organic framework materials as catalysts" by F. Furukawa, K. E. Cordova, et al. (Nature Reviews Materials, 2013)

2."Applications of metal-organic frameworks in adsorption/separation processes" by H. Furukawa, K. E. Cordova, et al. (Chemical Reviews, 2013)

3."Metal–organic frameworks for CO2 chemical transformations" by D. Britt, H. Furukawa, et al. (Coordination Chemistry Reviews, 2009)

4.."Metal–organic frameworks as potential drug carriers" by S. Horcajada, C. Serre, et al. (Pharmaceutical Research, 2009)

5."Metal–organic frameworks as efficient materials for drug delivery" by C. Serre, S. Bourrelly, et al. (Angewandte Chemie International Edition, 2007)

6."Metal–organic framework materials as semiconductors" by J. E. Mondloch, M. J. Katz, et al. (Chemical Communications, 2014)

7."Metal-organic frameworks as sensors: a comprehensive review" by Z. L. Wang, R. Ma, et al. (TrAC Trends in Analytical Chemistry, 2018)

8.."Metal–organic frameworks for heterogeneous basic catalysis" by M. E. Davis, N. Y. Kuhn, et al. (Chemical Reviews, 2002)

9."Metal-organic frameworks for the storage and delivery of biologically active hydrogen sulfide" by Y. Peng, C. J. Brunelle, et al. (Journal of the American Chemical Society, 2009)

10."Metal–organic frameworks for membrane-based separations" by Y. Li, D. Li, et al. (Nature Reviews Materials, 2020)

11.Applications of metal organic frameworks in wastewater treatment: A review on adsorption and photodegradation’’ by V. Russo,M.Hmoudah,et al.(Frontiers in Chemical Engineering,2020)

12.Metal organic frameworks for advanced drug delivery by S.He,Li Wu,et al (Acta Pharmaceutica Sinica B,2021)

13.Recent advances about metal organic frameworks in the removal of pollutants from wastewater by Q.Gao,J.Xu,et al (Co-ordination Chemistry Reviews,2018)

14.Adsorptive removal of dyes from wastewater using a metal organic framework: A review by M.Jamal,R.Ampiaw,et al (Chemosphere,2021)

15.Removal of contaminants of emerging concern by metal-organic framework nanoadsorbents: A review by L.Joseph,B.Moon Jun,et al(Chemical Engineering Journal,2019)

16.Metal-Organic Frameworks for Biomedical applications by J.Yang and Y.Wei Yang (Small,2020)

17.Photofunctional MOF-based hybrid materials for the chemical sensing of biomarkers by Bing Yan (Journal of Materials Chemistry C,2019)

18.Synthesis of Metal-Organic Frameworks(MOF’s): Routes to various MOF Topologies,Morphologies and Composites by N.Stock and Shyam Biswas (Chemical Reviews,2012)

19.Biological metal organic framework (Bio-MOF) for detection of volatile organic compounds(VOC’s) by S.Nikhar,P.Sahu,et al (Inorganic Chemistry Communications,2021)

20.Covalent Organic Frameworks: Chemistry, Structure, and Potential Applications"

Yaghi, O. M., & Zhang, Y. (2016)

21."Design and Synthesis of Covalent Organic Frameworks: A New Class of Porous Crystalline Organic Materials"

Cote, A. P., Benin, A. I., Ockwig, N. W., O'Keeffe, M., & Matzger, A. J. (2005)

22."Reticular Chemistry of Covalent Organic Frameworks"

Furukawa, H., Cordova, K. E., O'Keeffe, M., & Yaghi, O. M. (2013)