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Mini Review

Biomimetic Material Synthesis and its Application for Emerging Contaminant: Mini Review

Sabir Khan[1,2]*, Victor Douglas Dantas[2], Maria Del Pilar Taboada Sotomayor[2,3]* and Gino Picasso[1]

[1]Laboratory of Physical Chemistry Research, Faculty of Sciences, National University of Engineering, Peru

[2]Institute of Chemistry, São Paulo State University (UNESP), Brazil

[3]National Institute for Alternative Technologies of Detection, Toxicological Evaluation and Removal of Micropollutants and Radioactives (INCT-DATREM), Brazil

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***Corresponding author:** Sabir Khan and Maria DPT Sotomayor, Laboratory of Physical Chemistry Research, Faculty of Sciences, National University of Engineering, Av. Tupac Amaru 210, Lima 25, Peru and National Institute for Alternative Technologies of Detection, Toxicological Evaluation and Removal of Micropollutants and Radioactives (INCT-DATREM), Araraquara, SP, Brazil

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Abstract

Molecular imprinting techniques have proved a substitute method in environmental research for the elimination of emerging pollutants owing to their tiny size, elevated surface area, and selectivity toward target analyte. This review aims at the development of molecularly imprinted polymer as well as magnetic nanoparticles modified with Molecularly Imprinted Polymers (magnetic MIPs). MIP recently evolved to magnetic MIPs (mag-MIPs), these particles have good separation and open a novel perspective to analyze a component in complex matrices. Along with additional advantages, these hybrid materials present superior selectivity, durability, and the possibility to use again. Modern evaluations specify a wide range of possibilities via these remarkable materials. Computer simulation tools have been used for efficient and selective monomers to avoid excessive consumption of time and reagents for each functional monomer. Non-Imprinted Polymer (NIP) is also synthesized for all cases to carry out comparative studies.

Keywords: Molecular imprint polymers (MIP); Intermolecular interaction; Emerging pollutant

Introduction

Molecularly Imprinted Synthetic Polymers known as MIP (Molecularly Imprinted Polymers) accomplish specific recognition by forming special cavities to complementary in size as well as the shape to the analyte. Molecularly imprinted polymers are molecules that selectively combine with template molecules during manufacturing processes throughout a "lock-and-key" mechanism [1,2]. In short, we can say it is a procedure that generates template-shaped cavities in polymer matrices with a memory of template molecules. Molecular printing techniques were reported in 1972 when Wulff [3] and Takagish [4] published the preparation of organic polymers.

Molecular Imprinted Polymer Synthesis

The molecular imprinting synthesis technique is based on the presence of the appropriate functional monomer, cross-linked agent around an analyte, radical initiator, and porogenic solvent. The functional monomer helps in the formation of the polymer, unit by unit. The selection of the most suitable type of monomer is based on the characteristics and functional chemical groups of the template, with which it must form a stable complex. Moreover, the interactions between the template and monomers are important for selective pores in the polymeric structure. The functional monomers are of different types either Covalent or non-covalent functional monomers and computer simulation helps in the selection of the best monomers. Cross-linking agent responsible for generating the three-dimensional structure of the polymer and for providing it with mechanical stability, rigidity and also protect the structure during the washing of template molecule. Selectivity also depends on the type as well as the amount of cross-linking agent used in the synthesis of MIP. In the polymerization of MIP, a template molecule (analyte) is printed in such a way that a polymeric cavity is formed. The target analyte (template) are pesticides, drugs, steroids, hormones, vitamins, metabolites or it may depend on interest. After formation, the polymer is washed to remove the remaining analyte, to obtain the selective cavity in the polymeric structure of MIP, which contains active sites complementary to the shape and size of the analyte of interest. After washing, the clean polymer will have uniformly sized nanocavities capable of selectively retaining the analyte in a complex sample [5,6].

The initiator is responsible for initiating the free radical polymerization process. There are different types of initiators are used depending on the method used during synthesis. While the porogenic solvent is also important to give the morphology, create pores of the selective cavity, and shows characteristics that compound involved in polymerization must be soluble and have low polarity to reduce the interference and selectivity. Similarly, for the comparison study, a Non-Imprinted Polymer (NIP) was synthesized as a control material. The NIP is synthesized without the presence of the template molecule and, therefore, there are no selective cavities [7]. The Schematic diagrams of the synthesis of MIP are presented in Figure 1. Similarly, Magnetic Molecularly Imprinted Polymer (MMIP) has demonstrated an alternative technique in environmental research for the deduction of organic pollutants from water because of its small size, high surface area, and selectivity toward target molecules [8,9]. The schematic diagram of the preparation of the core-shell method is given in Figure 2.

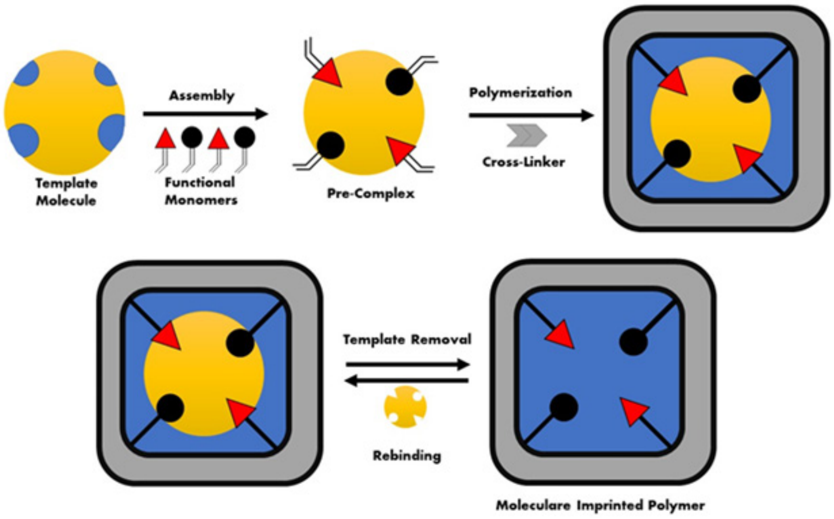

Figure 1: Schematic representation of the molecular imprinting process, source (author).

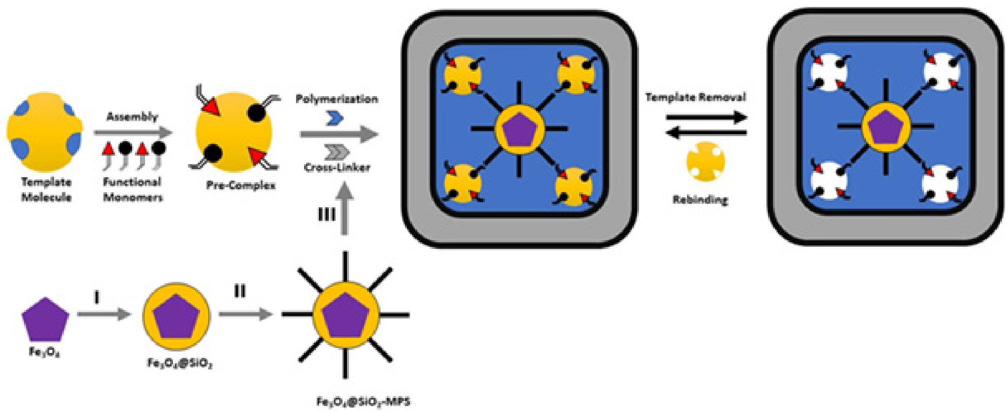

Figure 2: Schematic representation of the magnetic molecular imprinting process, source (author).

Application of MIP in the Detection of Different Analytes

In recent years, research related to these polymers has increased significantly, as they have demonstrated great potential due to their selective recognition of diverse molecules and a wide variety of applications in different samples. MIPs are artificially engineered materials utilized as recognition components due to their higher thermal stability than biological recognition materials, reusability, and selectivity compared to biological recognition receptors. The MIP proficiently removes the organic and inorganic toxic compounds from the fluid phase. The tracing of important contaminations, preparation, and their detection in the real environmental samples via Molecular Imprinted Polymer (MIP) are present in Table 1.

Table 1: Application of MMIPs for selective extraction of analytes from real samples.

	Contaminations	Template/Monomer/Crosslinker/Porogen	Matrix	Ref
Antibiotics	Sulfadiazine	SDZ/MAA/EDGMA/ Chloroform	eggs	[10]
	Tetracycline	Tetracycline/MAA/EDGMA/methanol	Milk	[11]
	Amoxicillin	CPE/MBAA/KPS/water	skimmed milk and river water	[12]
Pesticides	Ametryne	Ametryn/2-vinylpyridine/EDGMA/Methanol	Food samples	[13]
	1-chloro-2,4-dinitrobenzene	CDNB/ bisphenol /MDI/ tetrahydrofuran	water	[14]
Heavy Metals	Cd ions (II)	Cd $(NO_3)_2 \cdot 4H_2O$/ VIN/TRIM/Ethanol	Real water	[15]
	Pb^{+2}	Pb^{2+}/ ACRY/ MBA/water	Sea, Lake water	[16]
Dyes	Acid green	AG16/ 1-VI/ EGDMA /methanol	River	[17,18]
	Methyl green	Methyl green/acrylamide/EDGMA/ethanol	River, industrial	[19]
Vitamin	Folic acid	FA/MA/EDGMA/Ethanol		[20]

Conclusion

This mini review shows that MIP was successfully utilized for the determination of antibiotics, heavy metals, personal care products, pesticides, dye, and emerging pollutants present in very small amounts in the water. Similarly, magnetic-MIP is also viewed as a kind of potential Sorbent for the determination of the various analyte. Magnetic molecularly imprinted polymer and magnetic non-imprinted polymer be synthesized for rapid and selective quantification of emerging contaminants in the real food as well as river water samples.

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