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36 MOLECULARLY IMPRINTED POLYMERS: UNIQUE POSSIBILITIES FOR ENVIRONMENTAL MONITORING

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ABSTRACT

Molecular imprinting provides a useful complement to the use of biomolecules for the development of sensors for the analysis of trace substances on account of their highly selective recognition characteristics. Moreover, the stabilities make them ideal for use in applications not normally suitable for the use of biomolecules. The nature of the technique and its use in a number of analysis formats suitable for use in environmental monitoring are presented.

KEYWORDS

Molecular imprinting, molecularly imprinted polymer, sensor, environmental analysis.

The need for improved sensitivity and robustness are two major factors motivating the development of new analysis techniques. Nature's capacity to produce highly selective recognition systems (*e.g.* antibody-antigen, receptor-ligand, enzyme-substrate) has made the use of biomolecules as recognition elements in analytical techniques, in particular for the determination of trace materials in complex samples, most rewarding. Nonetheless, the stability of biomolecules with respect to their operational tolerances (*e.g.* temperature, pH, ionic strength and organic solvents) is generally limited.

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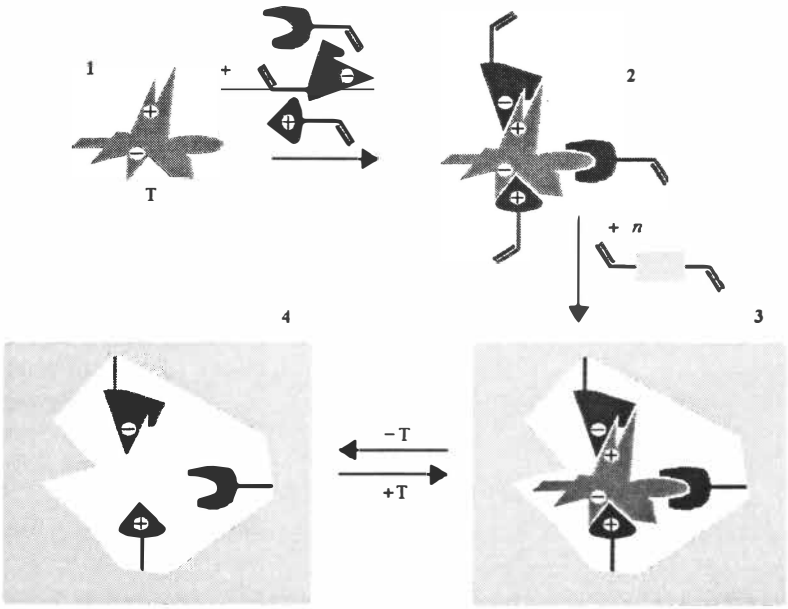

Figure 1: A highly schematic representation of the molecular imprinting process. A monomer (or monomer) mixture with chemical functionality complementary to that of the template (T) is allowed to form solution adducts(2) through the complementarily interacting functionalities (reversible covalent or non-covalent interactions). Polymerisation in the presence of a cross linking agent (3), followed by removal of the template, leads to the defining of recognition sites of complementary steric and functional topography to the template molecule.

Molecular imprinting, Figure 1, is an emerging technique for producing highly selective synthetic receptors for an ever-increasing range of biochemical and chemical structures (1-4). The method involves the formation of cavities in a synthetic polymer matrix that are of complementary functional and structural character to a template molecule. The ability of molecularly imprinted polymers (MIPs) to selectively recognise and bind the template structure in the presence of closely related chemical species has led to them being used in a range of biomedical and biotechnological applications. As antibody combining site mimics, MIPs have demonstrated binding affinities and cross-reactivity profiles comparable to their biological counterparts and have even been employed as substitutes for biological antibodies in environmental analysis and for medical diagnostic assays. They have also been used as highly selective chiral chromatographic stationary phases. More recently, the first real attempts have been made to utilise the highly selective recognition of MIPs for producing enzyme mimics (5-7), following a strategy similar to that used for the production of catalytic antibodies. While molecular imprinting carries strong parallels to the exploitation of the immune system for producing antibodies selective for molecular features it also offers significant advantages, namely: no requirement for laboratory animals, time efficiency, relatively low cost of production, no hapten conjugation protocols and non-immunogenic

substances pose no problem. Moreover, these materials are stable to extremes of pH, temperature and organic solvents (8), and offer significant advantages over the use of biomolecules in terms of the development of robust analytical systems, such as for implementation in the field.

The flexibility of the technique with respect to the choice of template, polymer composition and polymerisation format allows for their ready incorporation into a number of sensor-formats. Furthermore, the resilience of these materials offers significant advantages over. MIPs have been utilized in a number of sensor formats for trace analysis. Optical detection has been the focus of much work, as exemplified by a fluoroimmuno-assay for the detection of 2,4-D and related substances (9) and a surface plasmon resonance method for the detection of drugs used in the treatment of asthma (10). MIP-based quartz crystal microbalances have been developed for the detection of 2-methylisoborneol, a substance responsible for the particular smell of stagnant water (11). A number of electrochemical sensors have been investigated, the most noteworthy being one for the detection of products resulting from the degradation of the nerve gas sarin (12). Competitive binding assays, for example for the detection of triazine herbicides (13), have also been developed.

Collectively, strong argument can be presented for the continued development of these MIPs, and their implementation in sensor development, especially for situations requiring robust analysis procedures such as in industrial and field applications.

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