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Nanoscaled Molecularly Imprinted Polymers (NanoMIPs) for Specific Recognition of Amino Acids via Inverse Miniemulsion Polymerisation

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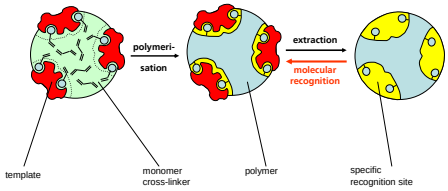
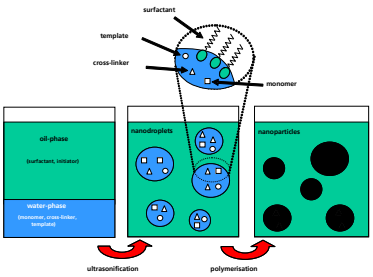
Background and Objective

Molecular Imprinting is a method which allows for the creation of specific recognition sites of a desired molecule (template) in synthetic polymers [1]. A template, a functional monomer and a cross-linker self-assemble by weak interactions e. g. hydrogen bonds prior to the polymerisation. After the polymerisation the template is extracted from the polymer, leaving an imprint i. e. complementary recognition sites in the polymer network. Molecularly Imprinted Polymers (MIPs) have potential for applications in the areas of medical diagnostics, clinical analysis and drug delivery. They often exhibit specificity and selectivity similar to natural antibodies but are capable to withstand drastic conditions like elevated temperature or extreme pH when compared to proteins. Although Molecular Imprinting is a technology which has been known for more than forty years, there are still some challenges to meet. Above all, the imprinting of biomolecules such as proteins and peptides represents one of the most challenging tasks. Biomolecules are water-soluble and the imprinting in aqueous media is quite demanding as water lowers the effectiveness of hydrogen bonds between template and monomers significantly. On the other hand, there is a strong need to synthesise artificial receptors for recognising peptides and proteins in aqueous media in order to create materials which are able to mimic natural processes.

Our objective is the creation of NanoMIPs for specific recognition of amino acids in aqueous media with the view to create artificial receptors for peptides and proteins.

Inverse Miniemulsion Polymerisation

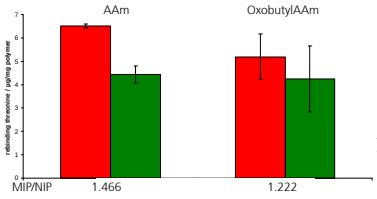




Inverse Miniemulsion Polymerisation offers the possibility to synthesise spherical MIPs in the size range of 50 nm to 300 nm for the application in aqueous media. The first step of synthesis is the formation of the miniemulsion. It consists of an aqueous, dispersed phase formed by monomer, cross-linker, and template and a continuous organic phase formed by surfactant and initiator. The miniemulsion is created via high shearing force applied by ultrasonification. The second step is the photo-initiated polymerisation where MIPs are synthesised from the nanodroplets [2].

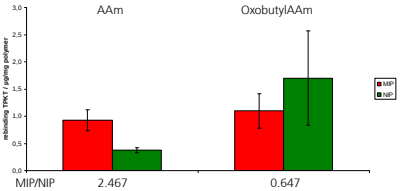
Molecular Recognition

Difference in the adsorption of template on the molecularly imprinted polymers (MIPs) and non-imprinted polymers (NIPs).



Adsorption of threonine on poly(AAm-co-EBA) and poly(OxobutylAAm-co-EBA) particles.

Adsorption of peptide TPKT on poly (AAm-co-EBA) and poly(OxobutylAAm-co-EBA) particles.



→ Poly(AAm-co-EBA) particles shows better rebinding results than poly(OxobutylAAm-co-EBA) particles.

Conclusions

- ✓ Calculation of interaction energy of template-monomer-complexes
- ✓ Synthesis of MIPs imprinted with threonine
- ✓ Preliminary experiments on synthesis of MIPs imprinted with TPKT

Next steps:

- ➢ Selection of further monomers and calculation of the interaction energy
- ➢ Evaluation of methods for imprinting of peptides and proteins

Acknowledgement

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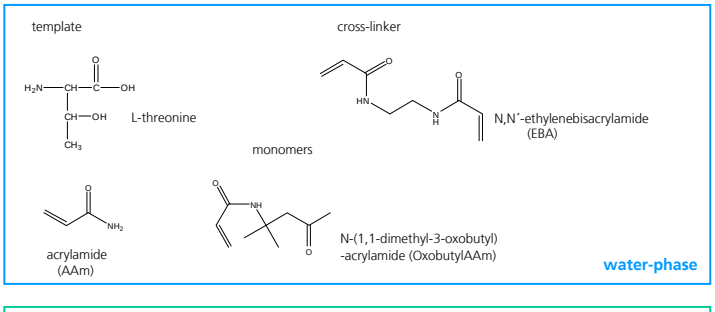
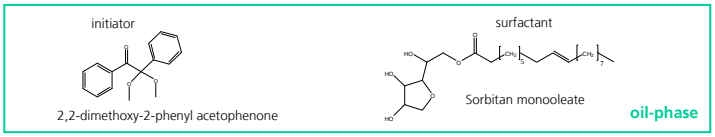
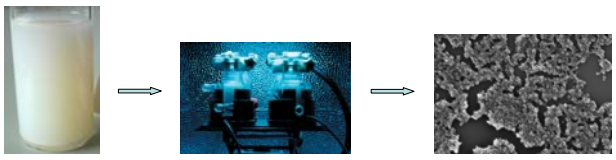
Synthesis



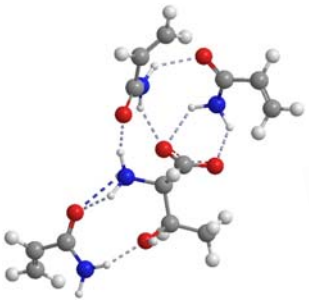




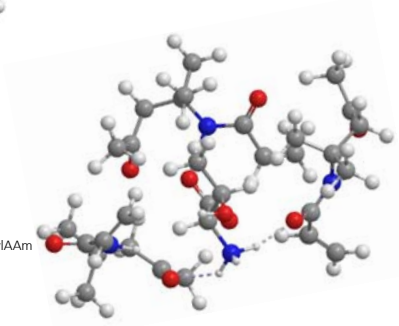
inverse miniemulsion — polymerisation — SEM-image of MIPs

Interactions between Monomers and Template

The stronger the interactions between the functional monomer and the template are, the higher the probability to create MIPs which successful recognise and bind the template.
The interactions between the chosen monomers and the template were calculated with MOPAC software package, which based on semi-empirical quantum mechanics method [3].



Threonine interacts with three molecules of AAm
Δ E= 49.15 kcal/mol



Threonine interacts with three molecules of OxobutylAAm
Δ E= 39.69 kcal/mol

→ Acrylamide exhibits stronger interactions with threonine than N-(1,1-dimethyl-3-oxobutyl) -acrylamide (OxobutylAAm).

Literature

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2. Gruber-Traub, C., et al., Polymer Preprints (American Chemical Society, Division of Polymer Chemistry), 2006. **47**: p. 901-902.
3. Stewart J. J. P., J. Mol. Model., 2007. **13**: p. 1173-1213.