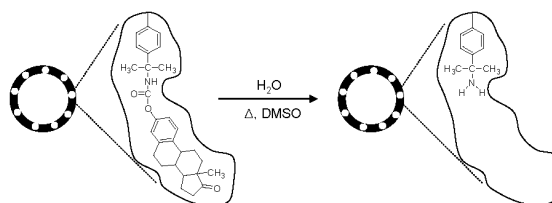


Polymeric Materials for Molecular Recognition

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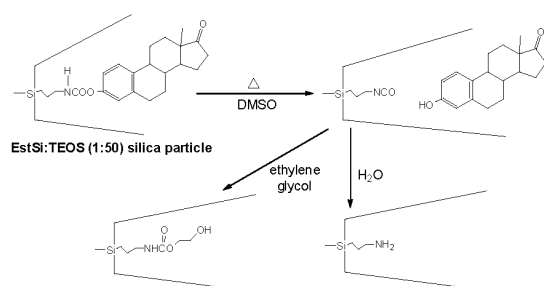
Scheme 2

Introduction

Molecular imprinting constitutes a valuable method of preparing polymeric materials with specific binding properties, which have potential uses in applications such as chemical sensors, microreactors mimicking enzymes, stationary phases for high performance chromatography, catalysts, and membranes for separating toxic chemicals. The most conspicuous merit of molecular imprinting is that structurally three-dimensional recognition sites can be introduced into a polymer matrix with ease and low cost when compared with the complicated process of biological system for antigen and antibody. In the molecular imprinting process, a target molecule (template) is first complexed with a functional monomer and then frozen into a matrix by polymerization. The formation of a stable complex before polymerization is crucial for the imprinted polymer to have high rebinding ability. So most templates reported so far have functional groups which react or interact strongly with a monomer. We used a thermally reversible urethane bond for the preparation of the monomer-template complex, which allowed us to remove the template easily by means of a simple thermal reaction and to simultaneously introduce various functional groups into the cavity. This method is especially propitious for developing artificial receptors for molecules lacking strongly interactive groups.

Results and discussion

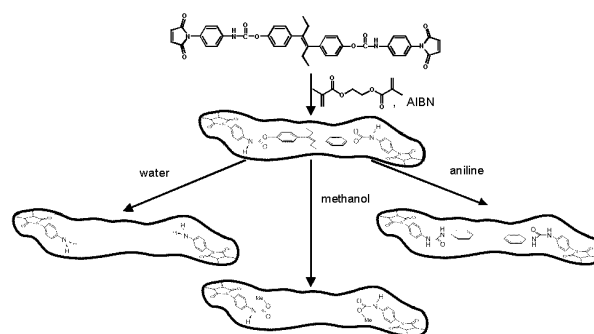
Molecularly Imprinted Silica Sphere. We prepared molecularly imprinted spherical silica particles with controlled sizes.¹ Since silica materials have crosslinked rigid structures, they are highly suitable for the formation of a delicate recognition site. The monomer-template complex (EstSi) was prepared by the reaction of 3-(triethoxysilyl)propyl isocyanate with estrone in the presence of dibutyltin dilaurate. The reaction occurred between an isocyanato group of the monomer and a phenol moiety of estrone, forming a thermally cleavable urethane bond. It is known that the urethane bond formed between an isocyanate and a phenol is stable at room temperature, but reversible cleavage occurs at elevated temperatures. With EstSi and TEOS spherical silica particles with their sizes of 1.5–3 μm were obtained. Control silica particles that had the same sizes and shapes were made with aminopropyltriethoxysilane and TEOS. The template molecules were removed by means of a simple thermal reaction in the presence of a nucleophile to generate estrone recognition sites in the silica particles (Scheme 1). Their recognition ability and selectivity were characterized by HPLC. The estrone imprinted silica particles showed 15.7 times higher recognition ability than controlled silica particles and 4.9 times higher selectivity for estrone than testosterone propionate. These results originated from the amino groups in the cavity which were able to form hydrogen bonds with estrone and the shape of cavity which resembled estrone.



Scheme 1

Molecularly Imprinted Polymeric Nanocapsule. A molecularly imprinted nanocapsule was prepared, which showed excellent site accessibility and potential in delivery applications.² The monomer-template complex (Est-Vinyl) was synthesized by the reaction of 3-isopropenyl- α,α -dimethylbenzyl isocyanate with estrone, where the template was linked to a polymerizable vinyl group via a thermally reversible urethane bond. Microemulsion polymerization of Est-Vinyl, styrene and divinylbenzene was carried out in water and octanol by using potassium persulfate as an initiator to produce a nanocapsule having a cross-linked polymeric wall. The hollow structure of the nanocapsule was confirmed by transmission electron microscopy. The template was removed from the polymeric wall by means of a simple thermal reaction (Scheme 2). In aqueous media, the imprinted nanocapsule solubilized hydrophobic pyrene. When the imprinted nanocapsules were previously incubated in a template (estrone) solution, pyrene could not transfer effectively into the interior of the nanocapsules, suggesting that the imprinted sites were blocked by the template molecules.

Two Point Binding Molecularly Imprinted Polymer. Two phenylmaleimide molecules were attached to diethylstilbestrol (DES, template) through a thermally reversible urethane bond. After the polymerization in the presence of a cross-linking agent, the polymer was refluxed in 1,4-dioxane in the presence of a nucleophile such as water, methanol, or aniline. In this extraction step, the template molecules were removed from the polymer matrix, and simultaneously the isocyanato groups, which were generated by the thermal cleavage of the urethane bond, were converted to amino, urethane, or urea groups through their reaction with water, methanol, or aniline, respectively (Scheme 3). The specific recognition ability of the imprinted polymers for the template and its structural analogs was dependent on the space between the two binding points, as well as on the nature of the functional group.³



Scheme 3

Conclusions

We used a thermally reversible bond for the preparation of the monomer-template complex in molecular imprinting, which allowed us to introduce various functional groups into the cavity. We demonstrated the possibility of modifying the selectivity of imprinted polymers by chemical modification of the binding sites.

References

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