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Adenine Molecularly Imprinted Polymer-Coated Submicrometer Silica Gel Particles

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Adenine molecularly imprinted material was obtained. Well-defined silica gel particles of submicrometer size were coated with ultrathin polymeric layers, first with a polycationic poly(allylamine hydrochloride) layer that acted as a binder for the second outer layer of a photo-cross-linkable thymine-containing polyanion. Adenine template was adsorbed by the complementary thymine chromophores attached to the polymer and its imprints were created by photo-cross-linking of the outer polymer layer. The imprinted particles have shown the ability to recognize adenine and adenosine, an adenine-based nucleoside, whereas no imprinting effect was observed for purine.

Introduction

Recently, there has been a growing interest in molecularly imprinted materials. They can be used as selective adsorbents with a wide range of practical applications. For example, they are promising materials for highly sensitive and selective detection and separation techniques. These could serve as important tools in rapidly developing biomedical sciences. Considering the high demands regarding the quality of these materials on one hand, and difficulties in their preparation resulting primarily from the fact that the "bio-templates" are usually large and fragile molecules, on the other hand, there is a need for further improvement. A wide variety of molecularly imprinted materials that are selective to biomolecules such as proteins, nucleic acids, and their building blocks, i.e., amino acids and nucleosides, have been developed. Nucleosides, such as adenosine, are a class of biomolecules that are more and more frequently used as template molecules because adenosine and its derivatives are biomolecules of great biochemical importance. For example, being a part of adenosine triphosphate (ATP) and adenosine diphosphate (ADP) molecules, adenosine takes part in energy distribution in cells. There is also a number of reports on its physiological importance, e.g., adenosine and its receptors play a significant role in Alzheimer's disease,[1] intracerebral administration of adenosine was found to decrease damage due to the stroke,[2] whereas infusion of adenosine was found to significantly decrease infarct size.[3] Moreover, modified adenosine and other nucleosides, which are the products of RNA degradation in the organism, were found to be excreted in urine at significantly elevated levels in patients with cancer at different development stages,[4−6] AIDS, and a number of metabolic diseases.[7] Therefore, it was suggested that these compounds may serve as the markers for a number of disorders. Detection and separation of adenosine and related compounds as disease markers may thus be one of the areas where molecularly imprinted materials may prove to be particularly useful. Attempts to obtain MIPs for solid phase extraction of AMP[8] and nucleosides[9,10] have been already undertaken. Recently, an MIP for 1-methyladenosine was obtained using methacrylic acid (MA) as a functional monomer and a mixture of acetonitrile and water as a porogen.[11]

The current studies present an entirely different approach to the preparation of molecularly imprinted material for adenosine adsorption, combining several techniques which are quite rarely applied in molecular imprinting. First, we have applied an "epitope approach", a technique based on imprinting a molecule that constitutes only a part of a molecule of interest. In that case, we have imprinted adenine to increase the ability of the material to adsorb adenosine (see Chart 1). This

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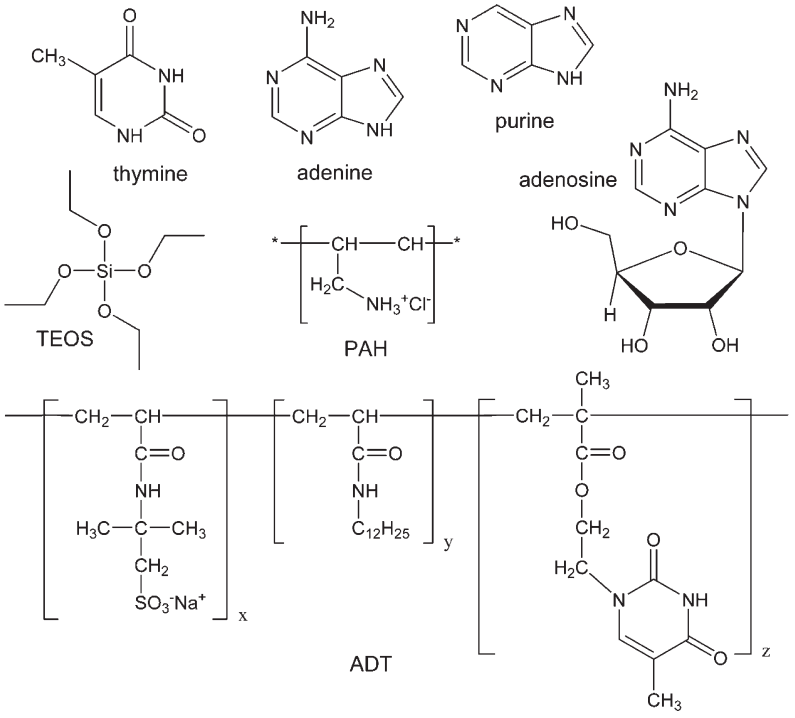
Chart 1. Structures of the Compounds Used in Current Studies



technique has been usually applied to imprint large templates, such as proteins.[12] In our case, it may allow collective recognition of a series of closely related adenine-containing nucleosides, such as those present at abnormally high levels in the urine of cancerous patients.[6] Second, we have used spherical silica gel submicrometric particles of low dispersity and controlled size as supports for ultrathin polymeric films to be used as an imprintable matrix. Silica gel particles were chosen as a support because they are mechanically and thermally stable and can be easily applied as a chromatographic column packing. Two polymer layers were prepared applying the principle of electrostatic self-assembly method (ESA), known also as layer-by-layer (LbL) deposition method.[13] Because of the nanometric thickness of the films, easily accessible imprints can be made on the surface of the silica gel particles. There are only a few reports on molecular imprinting in polymeric multilayers[14,15] and reports on encapsulation of submicrometer-sized silica particles by a thin shell of poly(methyl methacrylate);[16] however, to the best of our knowledge, there is no report on the application of silica gel particles as supports for imprintable polymeric matrix deposited using LbL technique. Third, the polymer forming the outer nanolayer (see Chart 1) deposited on the silica gel particles contains thymine moieties that were incorporated to perform two tasks. The first task of thymine is to induce attractive interactions with the adenine template molecules. Thymine is a pyrimidine base, complementary to adenine, with which it forms hydrogen bonds that enhance adenine adsorption within polymeric matrix. Thus, the polymeric matrix is able to complex the compounds bearing adenine moieties. Moreover, thymine shows ability to dimerize when irradiated with UV light.[17] The second task of thymine chromophores was to enable polymer photocross-linking and adenine imprinting by irradiation of the polymer-coated particles with UV light absorbed by thymine in adenine solution. Thus, we have presented here for the first time the system in which a cross-linker moiety serves also as an adsorbing center within the polymeric matrix.

Experimental Section

Materials. Tetraethyl orthosilicate (TEOS, 98%, Fluka), adenine (≥99%, Sigma-Aldrich), adenosine (≥99%, Sigma-Aldrich), purine (>98.5%, Fluka), cytosine (99%, Sigma-Aldrich), sodium chloride (analytical grade, POCh), ethyl alcohol (analytical grade, POCH), acetone (99,8%, POCh), dimethylformamide (DMF, 99%, Aldrich), ammonium hydroxide (25% G.R., Lach-Ner), 2-acrylamido-2-methyl-1-propanesulfonic acid (AMPS, 99%, Aldrich), 2,2′-azobis-(isobutyronitrile) (AIBN, >98%, Aldrich), and poly-(allylamine hydrochloride) (PAH, Aldrich, average M_w = 15 000 g/mol) were used as received. Water was distilled twice and deionized using Simplicity Millipore Water Purification System (Millipore, Billerica, MA, USA).

Methods. UV/vis spectra were recorded on a Hewlett-Packard HP 8452A diode array spectrophotometer in 1 cm optical path quartz cuvettes in the spectral range from 190 to 820 nm. HPLC chromatograms were obtained using a Waters HPLC

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system (Waters Corporation, Milford, MA) equipped with a Waters 2996 photodiode array detector and a C18 5 μm, 3.9 × 150 mm column. Irradiation of the samples was carried out using a Rayonet photoreactor (Southern New England Ultra Violet Company, Brandford, CT) equipped with up to sixteen 21 W lamps with the emission intensity maximum at 300 nm. Atomic force microscopy (AFM) (Picoforce, Veeco, USA) working in tapping mode was used to characterize the surfaces of particles in air atmosphere. SEM images were obtained using a Hitachi S-4700 scanning electron microscope (Hitachi Company, Tokyo, Japan) with a Noran Vantage microanalytical system.

Synthesis of the Terpolymer of Sodium 2-Acryloamido-2-methyl-1-propanesulfonate (AMPS), *N*-Dodecylmethacrylamide (DodMAm), and Thymylethyl Methacrylate (TEMA) (ADT). Typical procedure of polymer synthesis was as follows: 2-acrylamido-2-methyl-1-propanesulfonic acid (1.99 g, 9.60 mmol) was neutralized by equimolar of Na_2CO_3 in DMF (30 mL). DodMAm (0.709 g, 2.80 mmol), TEMA (0.191 g, 0.80 mmol) prepared according to the literature,[18,19] and AIBN (5 mg, 0.03 mmol) were added to the solution and placed in a glass ampule. The solution was degassed on a high vacuum line equipped with a diffusion pump by six freeze−pump−thaw cycles and then the ampule was sealed. Polymerization was carried out at 60 °C for 30 h. Polymer obtained was purified by 3-fold precipitation from methanol into a large excess of diethyl ether and subsequent dialysis against pure water for 1 week. The polymer was recovered by freeze-drying. Yield: 2.49 g (85.8 g). A series of terpolymers was obtained. In further studies the polymer containing 71 mol % of AMPS, 18 mol % of DodMAm, and 11 mol % of TEMA was used because of the high content of TEMA.

Synthesis of Silica Gel Particles. Silica gel particles were obtained using a Stöber method.[20] To a solution of 0.65 mL of TEOS in 11.35 mL of ethanol 3 mL of a 16.7% ammonium hydroxide solution was added rapidly. The resulting solution was stirred vigorously with magnetic stirrer for 24 h and a suspension of silica gel particles was obtained. Ethyl alcohol and ammonium hydroxide were removed under vacuum and particles were kept in the aqueous suspension.

Deposition of Polymeric Films onto Silica Gel Particles Using a Layer-by-Layer Method. Polymer solutions were prepared as follows: A 0.1 mg/mL solution of PAH (polycation) in 1 M NaCl and a 1 mg/mL solution of ADT (polyanion) in 6.25% NH_4OH were prepared. The suspension of silica gel particles in water was centrifuged at 13000 rpm for 3 min to separate the particles. Water was removed by decantation and the PAH solution was added to the particles. The sample was then sonicated for 5 min at 40 °C followed by centrifugation and decantation of the supernatant solution. The PAH-coated silica gel particles were washed with water by filling the centrifuge tube containing the coated particles with water, sonication for 2 min, centrifugation (13000 rpm, 3 min), and decantation of water. The procedure described above was repeated 5 times. The ADT solution was then added to the PAH-coated particles and the sample was sonicated for 5 min at 40 °C. After that, the particle suspension was washed with water 5 times using the procedure described above.

Imprinting of Adenine in the Polymeric Films on the Particle Surface. Silica gel particles coated with one polymeric bilayer were immersed in 20−30 mL of a 0.022 mg/mL adenine solution in pH 7.0 phosphate buffer and equilibrated for 1.5 h. The equilibrated samples were then irradiated in a Rayonet photoreactor equipped with 4 lamps with broad band emission spectrum in the range of 270−320 nm and emission intensity maximum at 300 nm for 4 h. Then the template compound was removed by washing with water as described above (at that step, however, sample was not sonicated but stirred with magnetic stirring bar). Washing procedure was repeated 9 times. The progress of adenine removal was followed by measurement of UV absorption spectra−the process was completed when there was no adenine present in the solution. The reference (nonimprinted) particles were prepared by irradiating the polymer coated silica gel particles in phosphate buffer (pH 7) for the same time. Because adenine absorbs at much shorter wavelengths than thymine, the rate of photo-cross-linking of thymine moieties in PAH/ADT-coated particles is not affected by the presence of adenine, as was verified experimentally.

Measurements of Adenine, Purine and Adenosine Solution Stability Using HPLC Method. To determine the effect of pH and material of the sample vessel used on the stability of the studied compounds the changes in their concentration in the pH range of 6−8 and in a contact with glass and plastic vials were measured using an HPLC chromatograph equipped with a Symmetry C18, 5 μm, 3.9 × 150 mm^2 column. Chromatographic conditions were as follows. The composition of the eluent: ammonium acetate (3 g), acetonitrile (100 mL), distilled water (1900 mL), flow rate 0.8 mL/min, injection volume 100 μL. The quantitative results were averaged on the basis of 3 injections per sample. It was found that the maximum stability was obtained for pH 7 and polypropylene (PP) vessels. Under these experimental conditions the changes of the concentration of adenine, adenosine and purine solutions are less than 0.5% during 10 days of storage under stirring at room temperature.

Adsorption Measurements. Molecular recognition was studied by measurements of adsorption of the adenine, adenosine and purine by imprinted particles. For comparison, the same experiments were carried out in nonimprinted material. For that purpose a defined amount of molecularly imprinted particles (~0.05 g) was added to 3.5 mL of 3×10^{-6} to 4×10^{-5} M solution of the respective compound in the pH 7 buffer. The suspension was stirred using a magnetic stirrer at room temperature for 2 h. The amount of the compound adsorbed by the particles was determined using HPLC chromatograph equipped with a UV−vis detector from the difference of its concentration in starting solution and in that after adsorption.

Results and Discussion

Preparation of Silica Gel Particles for Molecular Imprinting of Adenine. Silica gel particles of controlled size were prepared from TEOS (Chart 1) using widely known Stöber method as described above. This method is very flexible as far as the size and morphology of the obtained particles are concerned and allows synthesis of particles from 5 nm to 2 μm in size.[21] At the experimental conditions chosen the size of silica gel particles synthesized was about 700 nm, as found from SEM images (Figure 1a).

The SEM photographs revealed that almost perfectly spherical silica gel particles were formed with very smooth surface as found from AFM images (Figure 1b). The

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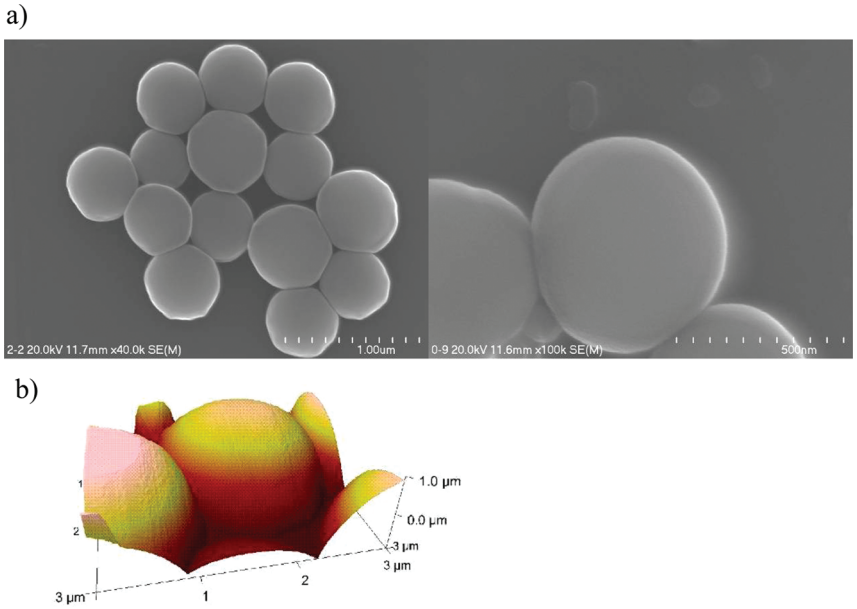


Figure 1. (a) SEM images of silica gel particles formed in Stöber synthesis, (b) AFM image of the particle surface.

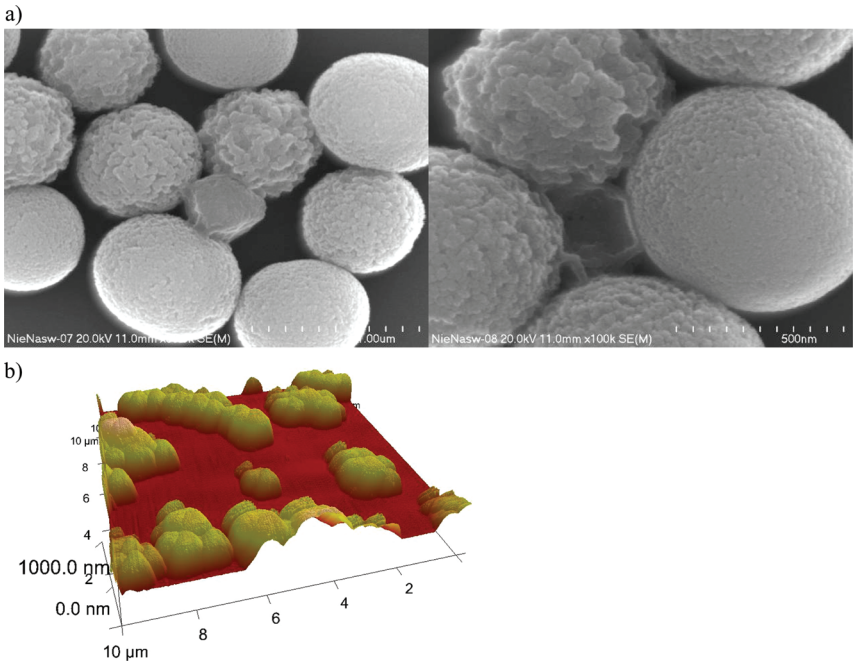


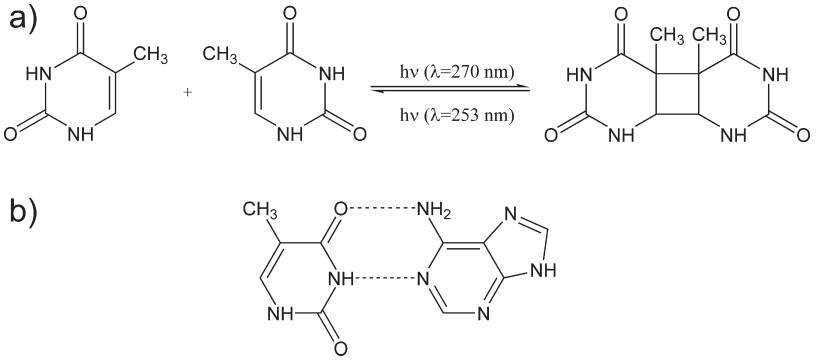
Figure 2. (a) SEM and (b) AFM images of the silica gel particles coated with 1 polymeric bilayer of PAH/ADT (ADT dissolved in NH_4OH).

particles are very uniform in size with no smaller structures agglomerated on their surface.

The negatively charged surface of the silica gel particles could be conveniently coated with polymeric ultrathin bilayer. For that purpose we have used poly(allylamine hydrochloride) (PAH, polycation), which is a photochemically inert polymer and the photoactive terpolymer of AMPS, DodMAm and TEMA (ADT, polyanion) (see Chart 1). The bilayer was applied using a layer-by-layer method with PAH deposition followed by ADT deposition. The polymer deposition on particles was limited to just one bilayer. The function of the PAH layer was to enable adsorption of polyanionic ADT layer to the silica gel surface, which is also negatively charged. The possibility of a PAH/ADT bilayer formation was previously verified using flat quartz plates. The formation of subsequent bilayers on the plates was seen as a gradual increase of absorption around 270 nm, which is due to the presence of thymine chromophores in ADT (data not shown). The formation of the PAH/ADT bilayer on silica gel particles was followed using SEM and AFM techniques. The images obtained (see Figure 2) show that the topology of the polymer-coated particles is very much different from that of uncoated ones.

The porosity of different microspheres as found from AFM measurement (see an image given in Supporting Information showing a few dozens of microspheres) is similar, contrary to what could be found from the SEM

Scheme 1. (a) Photodimerization of Thymine, (b) Adenine−Thymine Base Pair



images, which show microspheres of quite different porosity. However, taking into account that SEM technique requires rather invasive sample preparation and that the sample is placed in vacuum when imaged, the information on microsphere porosity obtained using AFM technique seems to be more reliable. The origin of small rounded features covering the microspheres may be explained as follows. ADT is an amphiphilic polymer that undergoes self-organization in the selective solvent (e.g., water-based solutions) accompanied with the formation of polymeric micelles with hydrophobic cores composed of dodecyl groups and charged sulfonate groups of AMPS forming a hydrophilic shell. Formation of micelles by copolymers of AMPS and hydrophobic-group-bearing methacrylamide monomers has been already well-documented.[22,23] The ADT layer was obtained from ammonia aqueous solution in which micellization of ADT is expected to occur. Therefore, it may be expected that these small objects are ADT micelles, with the size of several nanometers, aggregated on much larger silica gel particles. The images obtained using AFM technique gave information complementary to SEM photographs. Because of the presence of the micelles on the surface of the particles, the adsorptive properties of the obtained material toward adenine and related compounds should be stronger. For adenine, log K_{ow} (where K_{ow} is octanol−water partition coefficient) is 1.09; therefore, it should be expected that it is preferentially solubilized inside the micelles on the surface of the silica gel particles.

As mentioned above, ADT is a photoactive polymer due to the content of the thymine chromophores. Thymine (see Chart 1) is a nucleic acid base known for its ability to photodimerize when irradiated with UV light of the wavelength around 270 nm (see Scheme 1a). This photoreaction can be easily followed because it is accompanied by a decrease in the absorption around 270 nm.

Thymine is also known to interact strongly with adenine by bidentate hydrogen bonding (Scheme 1b). These are the hydrogen bonds which, together with the hydrogen bonds between guanine and cytosine base pairs, are responsible for the tertiary structure of nucleic acids. The thymine chromophores were included into the polymer structure to perform two roles. First, the thymine chromophores in the outer ADT layer of the polymer-coated particles are expected to strongly adsorb adenine. On the other hand, photodimerization of thymine chromophores is expected to result in the photo-cross-linking of the ADT layer. The occurrence of both processes, i.e. adenine adsorption and the photo-cross-linking of the polymeric layer containing adsorbed adenine, in this sequence, results in adenine imprinting. The question arises where the imprinting process takes place, i.e., inside or outside micelles. As discussed above, adenine is expected to be solubilized inside the micelles. Since the calculated value of K_{ow} for the thymine dimer is 1.9 and for adenine-thymine pair is 4.0,[25] one should expect that the imprinting occurs inside the micelles.

However, this concept of adenine photoimprinting may be effective under some assumptions. First, photodimerization of thymine chromophores requires that they have some rotational freedom necessary to adopt proper relative conformation. Whereas in solution photodimerization of ADT thymine chromophores occurs efficiently (data not shown), it was not known if it is possible in ADT film coating silica gel particles because of immobilizaton of the polymeric chains and the sterical constraints and if the content of TEMA in the polymer is high enough to result in sufficiently small distance between thymine chromophores. Therefore, for adenine photoimprinting, we have chosen the polymer with relatively high content of TEMA (11 mol %). To check if the photodimerization of thymine occurs in ADT films, the polymeric PAH/ADT films deposited on the flat quartz plates were irradiated with light absorbed by thymine chromophores. The reaction was followed by the measurements of the electronic absorption spectra of the films. The disappearance of the absorption band at 270 nm indicates that the dimerizaton of the thymine chromophores present in the polymer film occurs (see the Supporting Information). SEM images of silica gel particles covered by the photo-cross-linked PAH/ADT polymer bilayer (see the Supporting Information) show that they seem to have a

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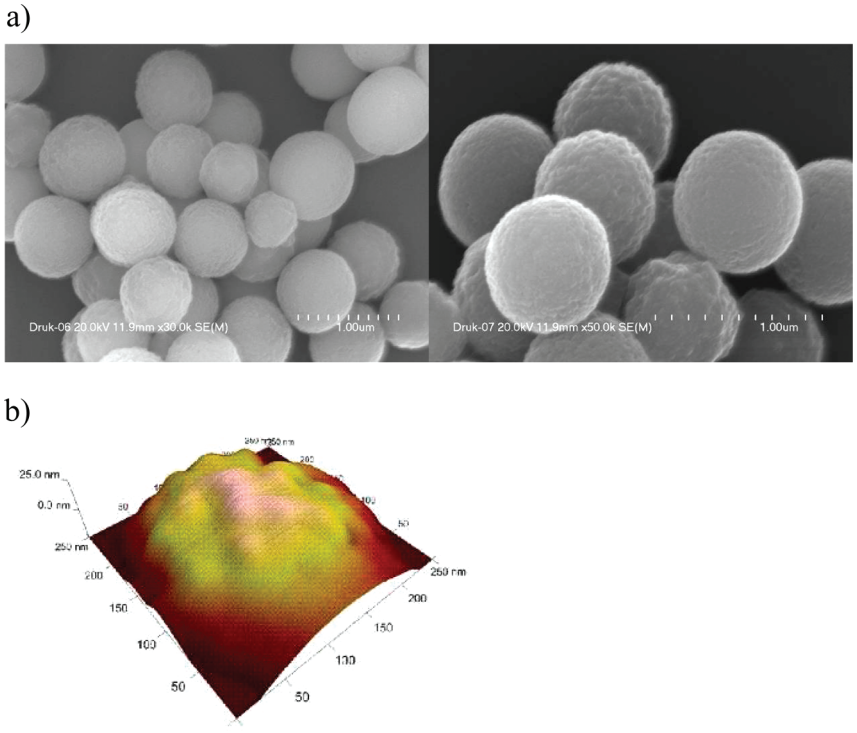

Figure 3. (a) SEM and (b) AFM images of adenine molecularly imprinted silica gel particles coated with one bilayer of PAH/ADT.

smoother surface, on average, than the nonirradiated particles.

The second problem is related to the double role of thymine chromophores. It may be expected that the formation of pairs between adenine and thymine is reversible,[26] so each thymine chromophore located in spatial proximity to another chromophore and possessing enough rotational freedom should undergo photodimerization under long enough irradiation. Although photodimerization of thymine leaves intact the carbonyl and amine groups which take part in adenine bonding (see Scheme 1a, b), the dimers are probably not sufficiently mobile to form a binding site for adenine. On the other hand, high enough density of photo-cross-linking is required for molecular imprinting. Thus, there should exist optimal irradiation time resulting in optimal photo-cross-linking density.

To obtain the adenine molecularly imprinted material, we immersed the particles covered with the photoactive polymer layers in a pH 7 buffer solution containing adenine (0.163 mmol/L) and when saturation was completed, they were irradiated with light selectively absorbed by the thymine chromophores present in the ADT polymer. The adenine was then removed from the cross-linked polymer matrix. Quantitatively, the adsorption of adenine template by the polymer matrix and its removal was followed by HPLC and UV measurements, respectively. The template removal was easy because the adenine molecules are located in a thin polymer layer. In that regard, the system developed here is more promising than these in which the template molecules are trapped inside a bulky polymeric matrix. One can realize that it is difficult to remove template molecules from the interior of the polymer matrix and even if they are removed, the binding sites formed are difficult to access by the molecules of the solute. That is especially important if the compounds used to create templates are large, fragile, or expensive, which is often the case.

Figure 3 shows the SEM and AFM images of the imprinted particles. The surface of the adenine-imprinted particles is much smoother than that of non-cross-linked particles (Figure 2), although not as smooth as that of noncoated particles (Figure 1).

Performance of the Adenine Molecularly Imprinted Particles. The adenine-imprinted silica gel particles coated with one PAH/ADT bilayer, obtained as described above, were tested for their ability to adsorb adenine and two other related compounds, i.e., purine and adenosine, purine being a slightly smaller molecule (there is no amino group at C-6 carbon atom, see Chart 1), whereas the adenosine molecule is much larger. The common fragment in these three molecules is the purine moiety. The decrease of adenine concentration in the bulk was determined after addition of both imprinted and nonimprinted (ca. 10 mg) particles to 3.5 mL of pH 7 buffer solutions containing various concentrations of adenine. After equilibration of the system for 2 h, the particles were removed by filtration followed by centrifugation, and the amount of adenine adsorbed was determined by measuring the residual adenine in the filtrate using HPLC. It was found (Figure 4) that the nonimprinted particles are capable of adsorbing adenine and that the amount of adsorbed adenine increases with increasing initial concentration. The corresponding plot for adenine adsorbed by the imprinted particles is also linear; however,

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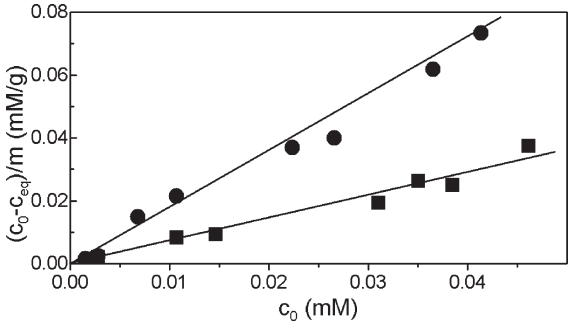

Figure 4. Dependence of concentration decrease of adenine on the initial concentration per unit mass of (■) nonimprinted and (●) imprinted particles.

Table 1. Values of the Slopes of the Plots Showing the Dependence of the Concentration Decrease of the Four Compounds Studied on Their Initial Concentration per Unit Mass for Nonimprinted and Imprinted Particles

	slopes		
compd	nonimprinted microspheres	imprinted microspheres	imprinted/ nonimprinted
adenine	0.72	1,74	2.42
purine	0.64	0.65	1.01
adenosine	0.98	2.27	2.31
cytosine		0.26	

the amount of adenine adsorbed is more than twice as high as that adsorbed by nonimprinted particles (see Table 1).

Such a high increase in adsorption capacity of imprinted particles is possible because of high local concentration of thymine chromophores and because of the fact that the thymine dimers formed during photo-cross-linking are still capable of participating in strong interaction with adenine. Moreover, the adsorption of adenine, by both nonimprinted and imprinted particles, was found to follow the Freundlich isotherm equation (see the Supporting Information).

The results for purine adsorption are, however, very different. As shown in Figure 5, the adenine-imprinted material and nonimprinted one show the same, approximately linear, dependence of the amount of purine adsorbed on its initial concentration in solution. Also, the amount of purine adsorbed increases with its increasing concentration much slower than that for adenine. This indicates that purine is only weakly and nonselectively adsorbed by the polymeric material deposited on the silica gel nanospheres and suggests that the imprinted material should show selectivity toward the adenine molecule.

The lack of imprinting effect (see Table 1) in this case is a very important result indicating the importance of the amino group in position 6 present in adenine in the process of its imprinting. Purine, which differs from adenine only in the absence of this amino group, cannot form bidentate hydrogen bonds with thymine chromophores and therefore does not interact or interacts too weakly with the imprints formed.

On the other hand, for adenosine a great difference in the amount of the compound adsorbed by imprinted- and nonimprinted material is observed (Figure 6), similar to that found for adenine, the amount of the adsorbed compound more than doubled (see Table 1) as a result of

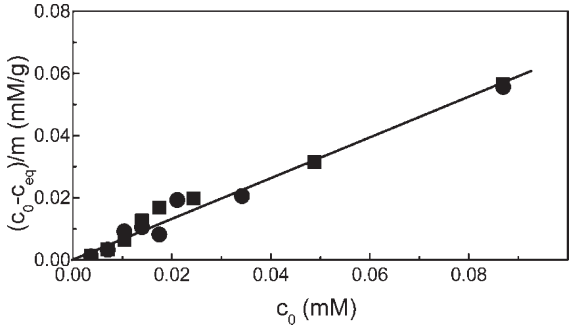

Figure 5. Pot of the dependence of the concentration decrease of purine on the initial concentration per unit mass of (■) nonimprinted and (●) imprinted particles.

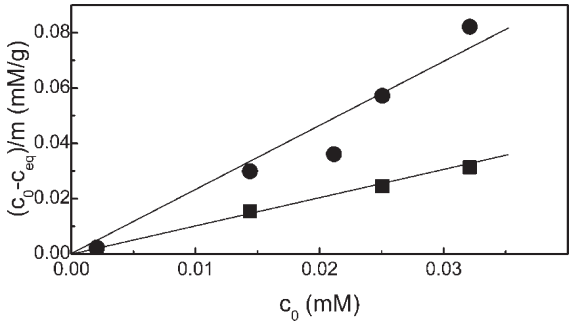

Figure 6. Plot of the dependence of the concentration decrease of adenosine on the initial concentration per unit mass of (■) nonimprinted and (●) imprinted particles.

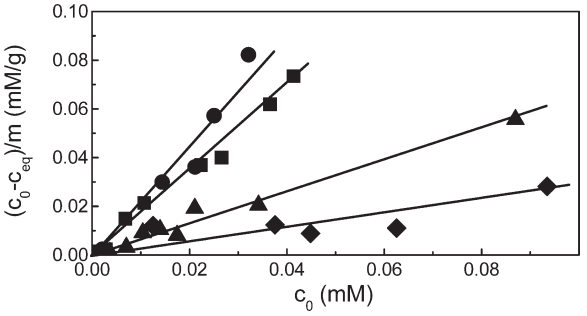

Figure 7. Plots of the dependence of the concentration decrease of adenine (■), adenosine (●), purine (▲), and cytosine (♦) on the initial concentration of these compounds per unit mass of adenine-imprinted microspheres.

imprinting of adenine. The imprinting effect in that case is due to the presence of adenine moiety in the adenosine molecule which perfectly fits to the photoimprinted cavities. Moreover, the amount of adenosine adsorbed is higher than the amount of adenine, both for nonimprinted and imprinted particles. This may be due to the presence of the saccharide moiety in the adenosine molecule, which apparently increases adenosine adsorption.

It may be interesting to compare the plots for adsorption of the above three compounds and additionally cytosine, a nucleobase noncomplementary to adenine, by adenine-imprinted microspheres (Figure 7).

To quantitatively compare the imprinting effect for adenine, purine, adenosine, and cytosine, we calculated the slopes of the plots in the above figures. The results are collected in Table 1.

Table 2. Comparison of the Concentration Decrease of Adenine and Adenosine Adsorbed from Their Mixture per Unit Mass of Imprinted Particles

	$(c_0 - c_{eq})/m$ (mM/g)	
compd	c_0 = 0.026 mM	c_0 = 0.050 mM
adenine	0.023	0.061
adenosine	0.0024	0.011

These data show that the imprinting of adenine results in the greatest increase in the adsorbed substance for adenosine, as could be expected. A slightly smaller but still significant imprinting effect was found for adenine itself, purine was an intermediate case, whereas cytosine was adsorbed very poorly.

We have also determined the decrease in concentration of adenine and adenosine after addition of adenine-imprinted particles to the solution containing both of these compounds. The results are shown in Table 2. These results indicate that the adenine-imprinted particles adsorb 6−10 times more adenine than adenosine. At the same time, the amounts of both compounds adsorbed from their mixture are lower than the respective amounts adsorbed from one-component solutions, which may indicate that they compete for the adsorption by the same imprints. These results confirm that the photo-cross-linkable polymers containing thymine chromophores, deposited in the form of ultrathin film onto silica gel particles, may constitute an efficient system for selective adsorption of compounds containing adenine moiety.

Conclusions

Novel, well-defined adenine molecularly imprinted materials were obtained. Adenine imprints were fabricated using gentle photochemical method within the thin polymeric bilayer deposited on the surface of silica gel particles. The material obtained is mechanically stable and the adsorption sites are easily accessible for the guest molecules. The molecular recognition was demonstrated. The imprinted particles can be used to recognize compounds containing adenine moiety, e.g., adenosine.

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Supporting Information Available: AFM image of polymer-coated silicagel microsphres taken using a 10 μm scanner, UV spectra of quartz plates covered with 10 ADT-PAH irradiated bilayers, SEM images of silica gel particles coated with one bilayer of PAH/ADT after photo-cross-linking, and Freundlich adsorption isotherms for adenine adsorption.This material is available free of charge via the Internet at http://pubs.acs.org.