



Ion-Imprinted Polymer for Selective Separation of Cerium(III) Ions from Rare Earth Mixture

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lon-imprinting polymers (IIPs) materials draw the great recognition because of the powerful selectivity to the desired metal ions. Therefore, the ion-imprinting polymer (Ce-IIP) was prepared by using cerium metal with amidoxime ligand as the complexing agent, in addition ethylene glycol dimethacrylate (EGDMA) and 2,2-azobisisobutyronitrile (AIBN) are crosslinking agent and free radical initiator, respectively. Aqueous HCI was applied to leach the cerium ions from the imprinted polymer for the creation of cavities of template, which is utilized for further cerium ions adsorption with high selectivity. The Ce-IIP was characterized by using ICP-MS, FE-SEM and also solid state analysis by UV-vis NIR spectroscopy. FT-IR study confirmed the complexation of the Ce-IIP was successful. The optimum pH was found to be 6 and the highest adsorption capacity was estimated about 145 mg g⁻¹. Thus, the prepared Ce-IIP gave very good selectivity to cerium ions in the presence of lanthanide ions and also Ce-IIP can be reused 10 times without a substantial loss in adsorption capacity.

Keywords: Ion-Imprinting Polymers, Rare Earth Metals, Selectivity, Adsorption.

1. INTRODUCTION

Molecular imprinting technology (MIT) is a unique technique for the synthesis of molecularly imprinted polymers (MIPs). MIT used to the concept of molecular lock pair with molecular key, which is enable to the binding sites of MIPs paired to the template compounds based on size, shape, and functional groups.¹ Many researches have reported the MIT technique to prepare new pattern of MIPs for versatile applications, such as chromatographic separation, sensor devices, catalysis and in vitro diagnostic.1 Molecular imprinting technology allows us to synthesize the compounds with high specificity and selectivity receptor sites to the target molecule. The molecular imprinted polymers (MIPs) are very specific in identified the size, shape, and functional group of the template.² This technology has been applied in numerous fields of pharmaceutical, biotechnology, biochemistry, chemistry and many more.³ In many years back until now, molecular imprinting has become a well-known method used in the solid-phase extraction, catalysis, design of sensor, protein separation, as receptor, antibody and also in one of the most important application which is in wastewater treatment.⁴ Polymeric nature of MIPs is being used in a wide range of applications. However, identification and selective recognition of metal ions remain challenging for MIPs in a large range of analytical applications.¹⁻⁴ Ion-imprinting technology (IIT) has been used to prepare the ion-imprinted polymers (IIPs) for the sorption of metal ions with high selectivity.3 The IIPs are prepared using an ion as a template to form a cross-linked material with stable and robust properties. Guo et al.5 reported neodymium ion-imprinted polymer (Nd³⁺-IIP) material display adsorption capacity of 35.18 mg g^{-1} towards neodymium ions and having the large selectivity coefficient (over 110) for neodymium ions from the mixture of lanthanide ions (La, Ce, Pr and Sm).

Rare earth elements (REEs) exhibit outstanding physical and chemical nature and have been marked as important material resources for many high-tech applications.^{6–16} However, the separation of REEs from fission products or aqueous media has become a challenging task.⁵

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Some metals-imprinted polymers have been developed for REEs separation.¹⁷⁻²⁰ Thus, europium(III)-imprinted polymer nanoparticles were synthesized by using suspension polymerization.²¹ A new Nd(III)-imprinted polymer with selectivity towards Nd³⁺ in aqueous solutions that contains various lanthanide ions (Ce(III), La(III) and Eu(III) ions) were also reported recently by Ibrahim et al.²² The maximum binding capacity was reported to 14.6 mg Nd^{3+} g⁻¹ and Nd(III) binding with Nd-imprinted polymer was double as compared to non-imprinted polymer.²² Yan et al.²³ used SBA-15 mesopores microreactor as a support for synthesizing a Ce(III) ion-imprinted polymer (Ce-IIP) grafted on Fe₃O₄ nanoparticles. The purification of these elements is attained considerable attention with the increasing need for high-purity rare earth elements.²³ Therefore, a new material is always needed to develop and defeat the constraint of the separation and purification of rare earth metals.

Thus, a new method known as ion imprinted polymers (IIPs) are interested in scientific community due to its capability to remove the desired metals effectively and selectively. Amidoxime is a known ligand easily complex form with transition metals, lanthanides and actinides elements. In this study, we have used cerium ions as the template molecule and the amidoxime as the functional ligand. We are focusing on rebinding of the cerium ions to the template to find the selectivity of the templates towards the metal. The Ce-IIP polymer was used for extraction of target cerium ions real conditions.

2. EXPERIMENTAL DETAILS

2.1. Materials

Allyl bromide (Merck), 4-bromobenzonitrile (Sigma-Aldrich), hydroxylamine hydrochloride (Merck), EGDMA (Aldrich) and chloride form of rare earth such as cerium(III), europium(III), gadolinium(III), neodymium(III), praseodymium(III), samarium(III), neodymium(III), praseodymium(III), samarium(III) from Sigma-Aldrich were used as received. Eethylene glycoldimehylacrylate (EGDMA), 2,2-azobisisobutyronitrile (AIBN) (Aldrich) were used as received.

2.2. Instruments

The characterization of Ce-IIP was carried out by using several instruments. The structure of the intermediate and IIP were determined by spectroscopic method. Perkin Elmer (670) FT-IR spectrometer was used to record the IR spectra. Bruker (DMX500) spectrometer was used to record the proton NMR and carbon-13 NMR spectra. JEOL (JSM-7800F) was used to obtain FE-SEM for the morphology study of amidoxime and Ce-IIP. The solid state UV-Vis NIR spectrophotometer (UV-2600 Shimadzu) was used to determine the absorbance of complex and Ce-IIP. Concentrations of metal ions were determined by ICP-MS (Agilent 7500 series).

2.3. 4-(allyloxy)Benzonitrile (1)

4-Bromobenzonitrile, 5.0 g (17.7 mmol) was transferred to the round bottom flask (100 mL) and fitted with condenser. Dry acetone (55 mL) was poured into the flask to allow the starting material is fully dissolved with slow heat. Then allyl alcohol, 1.39 g (24 mmol) and potassium carbonate 3.31 g (24 mmol) were added to the mixture. Further catalytic amount of potassium iodide was added into the reaction. The reaction was reflux for overnight. The crude mixture was poured into the 100 mL ice-cooled water and dilute HCl was added for neutralization of the mixture. The product was extracted with dichloromethane and the solvent eliminated by rotatory evaporator. The crude intermediate was purified with column chromatography by ethyl acetate and hexane (1:4) as eluent. The solvent was removed by rotatory evaporator and finally compound was recrystallized from ethanol to yield 66% as white solid 1. IR, $\nu_{\text{max}}/\text{cm}^{-1}$ 2926, 2754 (CH₂), 2244 (CN), 1600, 1501 (C=C), 1250, 1145 (CO), 1044 (CH). δ_H (500 MHz; $CDCl_3$; Me₄Si) 7.38 (d, 2H, J = 8.1 Hz, ArH), 7.00 (d, 2H, J = 8.6 Hz, ArH), 5.88 (m, 1H, CH), 5.24–5.26 (dd, 2H, J = 16.5 Hz, CH₂), 4.60 (t, 2H, J = 6.6 Hz, OCH₂). δ_C (150 MHz; CDCl₃; Me₄Si) 72.1, 105.1, 115.3, 115.9, 116.5, 133.1, 133.9, 165.0.

2.4. 4-(allyloxy)-N'-Hydroxybenzamidine (2)

Hydroxylamine hydrochloride, 2.1 g (30 mmol) was dissolved into 50 mL of ethanol:water (4:1) mixture. Sodium hydroxide (50%) solution was poured into the mixture at cool condition until the pH 10.5 and NaCl precipitation was occurred in this condition. The precipitated NaCl was removed by filtration. Then 3.0 g (18.8 mmol) of 4-(allyloxy)benzonitrile was added to the hydroxylamine solution and the reaction was reflux for 6 hrs. Then the mixture was acidified with dilute HCl until pH 4. The precipitate product obtained by filtration and the crude product was purified by recrystallization from ethanol to yield 75% of pale yellow solid 2. IR, $\nu_{\rm max}/{\rm cm}^{-1}$ 3410 (OH), 3320 (NH₂) 2929, 2750 (CH₂), 1600, 1508 (C=C), 1250, 1142 (CO), 1047 (CH). δ_H (500 MHz; CDCl₃; Me₄Si) 7.50 (d, 2H, J = 8.1 Hz, ArH), 6.98 (d, 2H, J = 8.4 Hz, ArH), 5.89 (*m*, 1H, CH), 5.24–5.25 (*dd*, 2H, *J* = 16.6 Hz, CH_2), 4.61 (t, 2H, J = 6.7 Hz, OCH_2), 2.10 (d, 2H, NH_2), 2.0 (s, 1H, OH). δ_{C} (150 MHz; CDCl₃; Me₄Si) 72.0, 114.5, 116.6, 121.2, 127.8, 133.6, 162.2, 164.0.

2.5. Preparation of Cerium-Complex (3)

The cerium-complex **3** was prepared with equivalent molar solution of cerium chloride (1.0 mmol) and 1.0 mmol of amidoxime functional ligand **2**, were dissolved into 10 mL of DMF solvent with stirring for 2 h. The brown colour complex was produced with cerium ions and amidoxime ligand, which was confirmed with the spectrophotometric (UV-vis NIR) technique.

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2.6. Preparation of Amidoxime Ligand-Based Cerium Ion Imprinted Polymer (4)

The free radical polymerization technique was used to prepare the Ce-IIP from the amidoxime ligand-based cerium complex. A solution of complex 3 (10 mL DMF from previous section) was placed into a polymerization reaction tubes, and the N₂ gas was purged for 20 min to remove its molecular oxygen. Then, EGDMA (10.0 mmol) and AIBN (20 mg in 1 mL DMF) poured into the reaction. Again, the N_2 gas was purged into reaction for 20 min. Then, the reaction tube sealed and heated in a water bath at 60 °C for 48 h to complete the polymerization of 4. The ceriumimprinted polymer was precipitated in methanol and ppt. was washed 3 times with methanol. The product Ce-IIP (4) was dried at 50 °C for overnight. After imprinting, the template as the Ce³⁺ ions was leached with 50 mL of 2 M HCl for 3 h duration. Thus, the imprinted cavity polymer as IIP (5) was prepared and used to further adsorption study.

2.7. Complex Adsorption Study

The adsorption study on the cerium ions imprinted cavity polymers (**5**) in aqueous solutions was carried out by batch experiments: Exactly, 20 mL of cerium(III) chloride solution (50 mg L⁻¹) was added to the amidoximebased imprinted polymer **5** (100 mg) at various pH 2–9. The mixture in the plastic viol stirred for 2 h by a small magnetic bar. The solid was then removed and the resultant solution was diluted with deionized water. The total cerium contents in the solutions were determined by ICP-MS. The adsorption of metals on the IIP was calculated by the general Eq. (1), it was expressed as percentage of metal extraction, where C_i is the initial metal concentration (mg L⁻¹) and C_f is the metal concentration after extraction (mg L⁻¹).

Extraction (%) =
$$\frac{C_i - C_f}{C_i} \times 100$$
 (1)

Here, Q is the sorption capacity (mg g⁻¹) of the imprinted metals was determined by Eq. (2), various conc. rare earth metals were utilized e.g., 10, 20, 30, 40 and 50 mg L⁻¹. Here, V is the volume of the solution and m is the mass of imprinted polymer materials (IIP in mg).

$$Q = \frac{C_i - C_f}{m} \times V \tag{2}$$

2.8. Adsorption Selectivity Study

The competitive sorption studies were performed for the recognition and selectivity of **5**. Six mixed lanthanide (Ce, Pr, Nd, Sm, Eu and Gd) solutions (e.g., 20 mL of 50 mg L^{-1}) were added into the IIP **5** (100 mg) at pH 6. The mixtures were poured into the plastic viols and stirred for 2 h by a magnetic bar. All mixtures were filtered and the rare earth metals in each solution were determined by

ICP-MS. The K_d is the distribution ratio (mL g⁻¹) of metals between the Ce-IIP and aqueous solution calculated by Eq. (3).

$$K_d = \left(\frac{C_i - C_f}{C_f}\right) \frac{V}{m} \tag{3}$$

Here, k is the selectivity coefficients for specific rare earth metal relative to other rare earth ions in the solution and k can be defined by the Eq. (4).

$$k_{\rm Ln^{3+}/M^{n+}} = \frac{K_d^{\rm Ln^{3+}}}{K_d^{\rm M^{n+}}} \tag{4}$$

where $K_d^{\text{Ln}^{3+}}$ and $K_d^{\text{M}^{n+}}$ are the distribution ratios of specific rare earth metal and other rare earth metal ions, respectively.

2.9. Desorption Experiment

The desorption of the lanthanide metals on the imprinting polymer (Ce-IIP) were performed by batch experiments: As such cerium ions was pre-concentrated onto imprinted polymer material (IIP) and eluted by 50 mL of 2 M HCl solution with 3 h agitation. The suspension was filtered and then eluent solutions with cerium ions were extracted from the Ce-IIP. Then resulted cerium contents in the solutions are determined by ICP-MS. The percentage of metals adsorbed by IIP was estimated using the Eq. (1).

3. RESULTS AND DISCUSSION

3.1. Synthesis

The 4-(allyloxy)benzonitrile (1) was synthesized from the etherification reaction of 4-bromobenzonitrile and allyl alcohol in presence of potassium carbonate as base with catalytic amount of potassium chloride. Further, 4-(allyloxy)-N'-hydroxybenzamidine (2) containing amidoxime ligand was prepared from 1 under reflux with hydroxylamine hydroxide at pH 10.5. Then ceriumcomplex (3) was produced by compound 2 with DMF as porogen solvent. The dark-brown complex was formed as the cerium-IIP nanoparticles, which is converted into imprinted polymer (Ce-IIP) using free radical polymerization method. In the polymerization procedure, solution complex of 3 with a cross-linker agent EGDMA was stirred at 60 °C for 48 h in presence of free radical initiator (AIBN). The polymer was precipitate in methanol and the Ce-IIP 4 was yielded. The imprinted ion (i.e., Ce³⁺ ion) was leached for cavity formation 5 in the Ce-IIP by 2 M HCl solution. Thus cerium was adsorbed further for reusability study (Scheme 1).

3.2. Characterization Studies

3.2.1. FT-IR Spectra

FT-IR spectra of the amidoxime and Ce-IIP were determined using KBr pellet as shown in Figure 1. The characteristic peaks for the amidoxime compound **2** exhibits two

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Scheme 1. Synthesis of amidoxime ligand based cerium ion imprinted polymer ntific Publishers

peaks at 3201 and 3401 cm⁻¹ for NH₂ and OH stretching bands, respectively (Fig. 1(a)). The compound **2** also show other characteristic bands at 2867 and 2908 cm⁻¹ for CH str. (alkane), 1651 cm⁻¹ for C=N str. (amidoxime), 1611 for C=C str. (alkene), 1567 and 1410 for C-C str. (aromatic), 1518 for N-H bend, 1396 for CH bend, 1214 for C-O str., 1110 for C-N str., 1053 for C-O str., 960 for C-H bend (alkene), 846 for N-H wag. (amine), 755 cm⁻¹ for C-H bend (alkene). In case of



Figure 1. FT-IR spectra of (a) amidoxime ligand 2, (b) Ce-IIP of 4 materials.

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Ce-IIP **4** (Fig. 1(b)), a broad absorption band was present at 3440 cm⁻¹ assigned to O–H stretching band, which is shifted from the 3401 cm⁻¹ due to coordination bonding with cerium ions, in addition 1635 cm⁻¹ also shifted from amidoxime 1651 cm⁻¹ due to coordination with cerium ions. Additional stretching bands for aromatic and CH are retains for Ce-IIP. A cross-linking agent EGDMA having an ester functional group, which was appeared at 1721 cm⁻¹ of C=O for Ce-IIP, which confirmed the formation of polymer complex as shown in Figure 1(b). Generally, IR spectra can be used for the proof of functional groups in the materials.

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3.2.2. FE-SEM Analysis

Scanning electron microscopy study was carried out to find the morphological properties. The synthesized compounds were evaluated by field emission scanning electron microscopy (FE-SEM) to investigate the surface morphological properties. It shows very clearly the morphological difference between the functional monomer as the amidoxime **2** and the polymers **4** and **5**. The FE-SEM images were presented in Figures 2(a)-(c). The micrographs under the magnifications 30,000 clearly showed the crystalline surface of amidoxime compound **2** with some agglomerations of crystalline surface (Fig. 2(a)). The surface morphology of the Ce-IIP **4** shows unsmooth spherical



Figure 2. FE-SEM image of (a) amidoxime ligand (2), (b) Ce-IIP (4) and (c) IIP materials.

shape with variable size due to the compound is polymeric nature in structurally. Thus, Ce-IIP compound **4** possesses distinct morphology compared to organic ligand of amidoxime compound **2**. In case of cerium leached IIP compound **5** shows very similar morphology of Ce-IIP compound **4**.

3.2.3. UV-Vis Absorption Study

The Ce-IIP compound **4** showed stable physical and chemical properties of cerium ions as shown in Figure 3 (orange line). The reflectance spectra of Ce-IIP (**4**) was observed to dissimilar from non-imprinted amidoxime (**2**) as shown in Figure 3 (pink line). Thus, a broad peak at around 718 nm observed for Ce-IIP (yellow line), whereas the amidoxime did not exhibits any peak around 650–900 nm, because no complex formation with compound **2** (pink line). The reflectance spectra of the Ce-IIP showed the new peak at approximately 718 nm due to the cerium ions, which proof the charge transfer (π - π for Ce ions) complex was observed which is strong evidence for the coordinationbonding occurred in the complex.

3.3. Sorption/Desorption Studies

3.3.1. The Effect of pH

The perfect eluent and retained cerium metal were considered for sorption/desorption studies. The Ce³⁺ ion was removed from Ce-IIP (4) with 2 M HCl as aqueous solutions. Thus, the bounded cerium ions was fully desorbed by 50 mL of 2 M HCl solution to obtained the recovery of 99% for cerium ion as estimated from the Eq. (1) as shown in Figure 4. This solution may exhibit polar character, which electrostatically disorder the binding interaction between cerium ions and the IIPs.⁸ The coordination spheres of cerium ions is disordered and cerium ions liberated from Ce³⁺ templates into the desorption agent as aqueous HCl solution. The binding properties of metal ions are greatly pH dependent and binding event is described in the literature.^{17–23} The concentration of soluble metal species are actively influences the precipitation of the metals in the absence of complexing agents. The more general batch adsorption procedure was used to find the effect of pH on the uptake of cerium ions.

Exactly 20 mL solutions containing 50 mg L^{-1} of cerium ions at various pH (2–9) were considered according to the reported procedure.²² Figure 4 shows that the effect of pH on the extraction (%) of Ce³⁺ ions of IIP5. Figure 4 also shows that the adsorption of Ce³⁺ ions is increases with the increasing of pH at 6. At the higher pH beyond 7, precipitation of cerium ions was occurred,



Figure 3. UV-vis absorption spectra of amidoxime ligand 2 (pink colour) and Ce-IIP 4 given in the figure yellow line.

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Figure 4. Extraction of cerium metal as a function of various pH solution.

whereas the protonation of the binding sites of Ce-IIP was increases at lower pH decreases adsorption value. Consequently, either Ce^{3+} with amidoxime complex is not stable at low pH or the aggressive binding of proton and Ce^{3+} ions by the ligands at lower pH values is reduced the performance of extraction.²³

3.3.2. Adsorption Capacity

The adsorption of cerium ion was performed with a fixed amount of Ce-IIP using a batch adsorption method. Adsorption capacity of the IIP (5) was calculated to be 145 mg g⁻¹ for Ce at pH 6 by using Eq. (2). As we observed in this study, the absorption capacity of the Ce-IIP materials is depending on the molar mass of rare earth metals.

Obviously ion imprinted polymers exhibit absorptive property as compare with other absorbent and extraction capacity usually expressed as metal ions adsorbed per gram of IIP 5. The optimum pH 6 was chosen to find the adsorption properties at various concentrations of cerium ions in solutions. The adsorption capacity (O) is defined with metals adsorbed per gram of the IIPs and Q is the important parameter to determine the efficiency of the IIP 5.²² The more general batch adsorption method was used to find the maximum adsorption values of Ce³⁺ on IIP. Thus, 100 mg of IIP 5 was equilibrated with 50 mL of cerium solutions with various concentrations $(10-50 \text{ mg L}^{-1})$ at optimum pH 6. Generally, the precipitation of Ce³⁺ ions at pH 6 does not occur with this limit of cerium concentration. The adsorption behaviour of IIP with these parameters is given in Figure 5.

The maximum Q for the cerium ions on the IIP **5** was calculated to be 145 mg g⁻¹ at pH 6 by using Eq. (2), which was presented in the extraction efficiency. The adsorption of Ce³⁺ ions is expressed as per unit mass of the IIP, and Q was increased linearly with the increasing of concentration of cerium ions in solution up to 50 mg L⁻¹. The adsorption value was lower with the initial concentration of the Ce³⁺ ions as usual, which represents unsaturation of the active cavities on the IIP by cerium ions.

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Figure 5. Effect of the cerium ions concentration on the adsorption of cerium metal by using IIP 5.

Thus, the imprinting procedure plays an important role in the absorption behavior of the Ce-IIP polymer.

3.3.3. Selectivity Study

To find the selectivity of the Ce-IIP to the metal ions, a series of batch adsorption experiments is performed with the Ce-IIP and pairs of Ce³⁺ and coexisting cations (some rare earth metals cations) were extracted by 100 mg of Ce-IIP at pH 6. On the other hand, IIP **5** and pairs of Ce³⁺ with selected cations are also used for extracted the same amount (100 mg) of IIP **5** at pH 6. Simultaneously adsorption property of cerium ions with some cations for IIP particles in their mixture was evaluated under optimum conditions. Thus, the distribution ratios (K_d) and selectivity coefficients (k) for Cu²⁺ ions relative to foreign cations were estimated by the Eqs. (3) and (4), respectively. The results for K_d and k are presented in Table I.

The competitive adsorption property of IIP **5** for Ce^{3+} ions is higher than Ce-IIP-polymer beads due to the nature of ligand atoms accepted electron form cerium ion. However, IIP polymer shows for the competitive adsorption capacity. Table I can be used to compare the selectivity results, which clearly given the scenario of ion-imprinted effect. In this study, the imprinted polymer was produced with cerium metal ions complex as the template, so three-dimensional cavities is formed by cerium leaching with HCl and IPs are more selective for corresponding cerium ions with amidoxime ligand. In principle, the

Table I. Distribution ratio (K_d) and selectivity coefficient (k) values of specific Ce-IIP and different lanthanide cations.

Cation	$K_d \mathrm{mLg}^{-1}$	K
Ce^{3+}	310.5	
Pr^{3+}	16.1	18.1
Nd^{3+}	15.5	22.3
Sm ³⁺	14.2	24.3
Eu ³⁺	18.2	19.0
Gd^{3+}	15.5	22.3
La^{3+}	16.1	21.4

cavities produces with a specific shape and size of the template of the imprinted polymer allows to accommodate the corresponding metals ions. The proposed ion-imprinted polymer showed a high selectivity to the cerium ions and a substantial difference of the binding capacity of the Ce^{3+} ions and competitor metal ions. It was observed that the prepared Ce-IIP can be utilized as a selective adsorbent for extraction of cerium ions in the presence of other rare earth metal cations in the various real and synthetic medium.

In this study, the competitive adsorption capacity of the desired cerium ions using the amidoxime-based IIP is higher due to the nature of ligand atoms accepted electron form lanthanide ions (Table I). The selectivity results show that ion-imprinting effect is attractive by comparing the Table I. The cerium ion complex as the template was prepared in the imprinted polymer with three-dimensional void of cavities formed in the IIP. The cavities act as specific holes of cerium ions in the imprinted polymer, which allows selective adsorption of target cerium ions. By considering the high selectivity coefficient obtained by the amidoxime-based IIP materials and a significant difference between the binding of the cerium ions and competitor ions to the imprinted sorbent. Therefore, the prepared amidoxime-based IIP can be utilized as a selective adsorbent for extraction and separation of cerium ions in the presence of other rare earth metals.

3.3.4. Regeneration and Reusability 5.101.217.114 On: Fri The prepared IIP polymer reusability test used in adsorption-desorption system without significant changing in the absorption capacity is an important feature due to an economic point of view. To determine its reusability, 100 mg of Ce-IIP was used in the adsorption-desorption cycle for 10 times under optimum condition as shown in Figure 6. The results show that the Ce-IIP can be reused in 10 cycle of adsorption-desorption without significant change was observed in the absorption capacity. Therefore,



Figure 6. Reusability studies of the Ce-IIP (4) in several cycles of efficiency.

absorption capacity is decreased about 8% after 10 times using the proposed Ce-IIP.

4. CONCLUSION

In this report, the Ce-IIP was prepared by the cerium ions as rare earth metals and complexing agent as amidoxime ligand with EGDMA as cross-linking agent and AIBN as an initiator. Certainly, the rare earth template is removed by leaching with HCl solution for further adsorption of rare earth metals. The sorption capacity (Q) of Ce-IIP is found to be 145 mg g⁻¹ at pH 6. The imprinting polymers exhibit higher affinity towards selective rare earth ions over other competitor rare earth ions. The Ce-IIP are repeatedly used and regenerated for 10 times without any significant loss in its original strength of recognition and separation performances.

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