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URANIUM REMOVAL FROM AQUEOUS SOLUTION USING TRI-N-BUTYL PHOSPHATE AND DI-2-ETHYLHEXYL PHOSPHORIC ACID FUNCTIONALIZED POLYESTER SHEET AND CHARCOAL AS ADSORBENTS

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1- ABSTRACT

The present investigation deals with the removal of uranium from a nitric acid waste solution (Raffinate solution: produce during yellow cake of uranium production) using the extraction chromatography technique (solvent impregnated material)), where Tri-N-butyl phosphate (TBP) and Di-2-ethylhexyl phosphoric acid (D2EHPA) solvents were impregnated upon polyester sheet and charcoal respectively then the impregnated resin were tested for uranium removal. Thus, the factors affecting the impregnation process namely, solvent concentration, impregnation time, volume/mass ratio, impregnation temperature and diluents type were studied. Secondly the influences of initial uranium concentration, adsorption temperature, contact time, pH on the uranium adsorption on the prepared materials were studied. From the results the isotherm models also calculated to determine uranium adsorption behavior by the prepared TBP and D2EHPA impregnated polyester sheet and charcoal respectively. Both prepared materials were found to be fitted with Langmuir than Freundlich model isotherm.

Keywords: Uranium, Removal, D2EHPA, TBP, Impregnation, Adsorption, Elution

2- INTRODUCTION

Uranium as a key element in nuclear fuel cycle is abundant in aquifers around mining, processing and milling sites, posing a potential environment and health risk to the biosphere due to its radioactivity and toxicity [1-3]. Many methods were used for treating the high concentration radioactive wastewater such as chemical precipitation, ion-exchange, extraction and reverse osmosis process [4–7]. These methods are so cost when they are used to treat the low concentration radioactive wastewater [8, 9]. Liquid-liquid extraction usually used an aqueous phase and an organic phase containing extractants [10-12], and the key point is the extractants [13, 14]. Some alternative methods with similar principles of solvent extraction have been developed for metal partitioning and extraction, such as solid phase extraction (SPE) and ion-exchange chromatography (IEC) [15-17]. Solid–liquid extraction more beneficial in view of their total insolubility of the applied solid in the aqueous phase, its low rate of physical degradation besides, its high sorption capacity as well as its good flexibility and kinetic properties [18, 19]. Uranium nitrate in solution is usually present as cationic species. Consequently it could be selectively separated by ion exchange resins containing cation exchange functional groups. Ion exchange technique is low-cost, highly effective, efficient and easy to operate among the treatment processes. Ion exchange materials are widely used for the hydrometallurgical uranium recovery from acid leach mineral ore bodies [20].

In the present work uranium from nitric acid solution the solid phase extraction by impregnate TBP and D2EHPA upon polyester and charcoal respectively has been done. Thus, the factors affecting the impregnation process namely, solvent concentration, impregnation time, volume/mass ratio, impregnation temperature and diluents type were studied. Then the effects of initial uranium concentration, adsorption temperature, contact time, pH of uranium adsorption on the prepared materials were studied. From the results the isotherm models also calculated to determine uranium adsorption behavior by the prepared TBP and D2EHPA impregnated polyester and charcoal respectively. Abstract finally, the optimum conditions were applied on waste solution sample**.**

3- EXPERIMENTAL

3.1. Materials and analytical procedure:

The liquid waste experimental sample (raffinate solution) used in this study was collected from Nuclear Materials Authority, Egypt its average chemical composition is shown in Table (1). All reagents used were of Analytical reagent grade. D_2EHPA, TBP, Uranyl nitrate were supplied from Riedel–deHaen. Synthetic solutions of the uranyl nitrate were prepared by dissolving the exact amount of uranyl nitrate in distilled water. Uranium concentration was determination spectrophotometrically by UV single beam model SP-8001'', Metretech Inc., version 1.02 using Arsenazo III method [21] at pH 2 [22] and by an oxidimetric titration against ammonium metavanadate method using N-phenyl anthranilic acid indicator (Sigma-Aldrich) [23, 24].

Table (1): Chemical composition of the working raffinate waste sample

Constituent	Concentration
Fe_2O_3	0.60 g/L
HNO_3	1M
U(VI)	100 mg/L
Ca(II)	1.9 g/L

3.2. Preparation of adsorbent materials solvent (Impregnation procedure)

3.2.1. Preparation of the inert materials

The polyester sheet and charcoal macro porous were immersed in 2M HCl for 1 h, washed with distilled water until free of HCl, and air-dried overnight before using. The polyester sheet of 0.5 cm in diameter and 0.50 cm length (average weight = 0.05 g), was cut from a polyester sheet.

3.2.2. Impregnation procedure

To investigate the influences affecting impregnation process, series of impregnation experiments have been performed by shaking 0.25 g of the dry clean polyester sheet and charcoal samples with the properly prepared impregnation solutions of Tri-N-butyl phosphate (TBP) and Di-2-ethylhexyl phosphoric acid (D2EHPA) solvents (in benzene) solution by magnetic stirrers. The amount of solvent impregnated on the polyester sheet and charcoal samples were calculated by the difference between the weight before and after the process as the following equation. The studied factors included solvent concentration, impregnation temperature, impregnation time, mass/volume ratio and diluents type.After the end of the impregnation experiments, the foam is dried in the oven for 1 h at a temperature of 60°C to evaporate the diluent (leaving the diffused solvent into the materials pores).

$$Mass\ Change, \% = 100 \times \frac{m2 - m1}{m1}$$

Where m_1 and m_2 are the dry polyester sheet and charcoal mass before and after impregnation process respectively.

3.3. Sorption Studies

3.3.1. Sorption Procedure

The behavior of uranium (VI) adsorption onto the prepared adsorbent materials was carried out by using batch sorption experiments via shaking 0.05g of impregnated materials with 10 mLof the uranium and synthetic solutions 160 mg/L each individually. The studied relevant adsorption factors are: effect of contact time, initial uranium concentrations, pH and solution temperature. The adsorbed amounts of uranium were calculated by difference between the equilibrium and initial concentrations. The amount of ion retained in the solid phase qe (mg/g) was calculated using the relation:

$$qe, mg/g = (Co - Ce) \times \frac{V}{M}$$

Where C_0 and C_e are the initial and equilibrium concentrations of the metal in the aqueous phase in mol/L, respectively, V gives the volume of the aqueous phase solution in mL and *m* is the weighed dry impregnated resin in g. Where the uptake percent of the metal ion by the impregnated materials was calculated according to the following relation:

$$Uptake, \% = 100 \times (Co - Ce) \times Co$$

3.3.1.2. Equilibration Calculation

All uranium speciation in this study were performed with Hydra-MEDUSA, a chemical equilibrium calculation program [25, 26].

4. RESULT AND DISCUSSION

4.1. Results of the relevant impregnation process factors

4.1.1. Effect of solvent concentration

To determine the effect of TBP and D2EPHA concentration upon the impregnation results, several impregnation experiments were carried out using fixed conditions at temperature 25 ºC, time of 1 h., v/m ratio is 5g /L and diluents is benzene. Different TBP and D2EPHA concentration is ranging from 0.028 up to 0.50 M. From the Fig (1) the impregnation by solvent increased as the solvent concentration increased reach to maximum at 0.45M concentration. Behind the later concentration the saturation of polymer and charcoal by solvent was reached. In other words the surface of the inert support was covered by solvent. Accordingly, 0.45M is the preferred condition for further impregnation experiments for TBP or D2EPHA upon polyester sheet and charcoal.

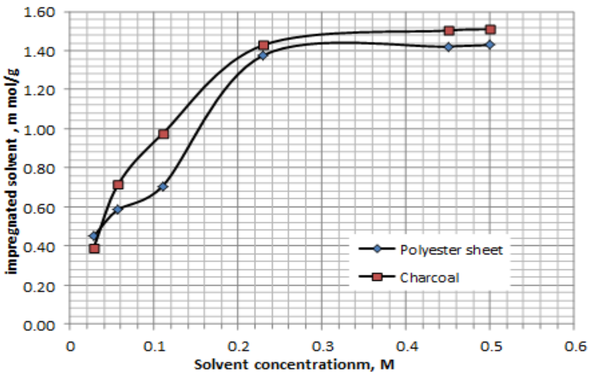

Fig. (1): Effect of solvents (TBP and D2EPHA) concentration upon the impregnated amount onto the dry polyester sheet and charcoal (T: 25 ºC, time: 1 h., ratio: 5/l and Diluents: benzene. Conc.: 0.028 - 0.5 M or Molar).

4.1.2. Shaking Time Effect

To determine the effect of impregnation time or shaking time upon the impregnated solvent amount upon polyester sheet and charcoal, several impregnation experiments were carried out using fixed conditions of temperature 25 ºC, solvents concentration of 0.45M, v/m ratio of 5/1 and benzene as diluent. Shaking time is ranging from 0.5 to 24 hours. From the Fig (2) the impregnated by solvent amount is gradually increased form the first experiment to the fourth one of 5h. After 5 h of shaking time no investigated increase in the impregnated solvent amount. Consequently, 5h is sufficient time to fill of all the surface porous for both polyester sheet and charcoal and the surface are completely coated with solvents under these conditions.

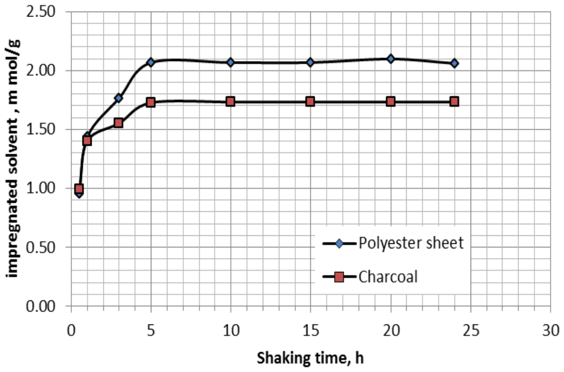

Fig. (2): Effect of shaking time upon the loaded amounts of TPB and D2EHPA onto polyester sheet and charcoal (T: 25 °C, time: 0.5 to 24 h., ratio: 5/l and Diluents: benzene. Conc.: 0.45 Molar).

4.1.3. Effect of mass/volume ratio

To study the effect of m/v ratio upon the amounts of TBP and D2EHPA impregnated onto the working polyester sheet and charcoal samples, two series of impregnation experiments were performed using m/v ratios started from 1/1 up to 1/10. These experiments were performed under fixed conditions of 25 °C impregnation temperature, 5 h impregnation time, 0.5 M solvent concentrations and using benzene as diluent. The obtained results are plotted in Fig. 3. From this figure the amount of loaded solvent onto the polyester sheet and charcoal increased with increasing the impregnation solution m/v ratio. After m/v of 5 g/L the impregnated amount were approximately fixed. From the mentioned above 5g/L m/v ratio were the preferred for both polyester sheet and charcoal.

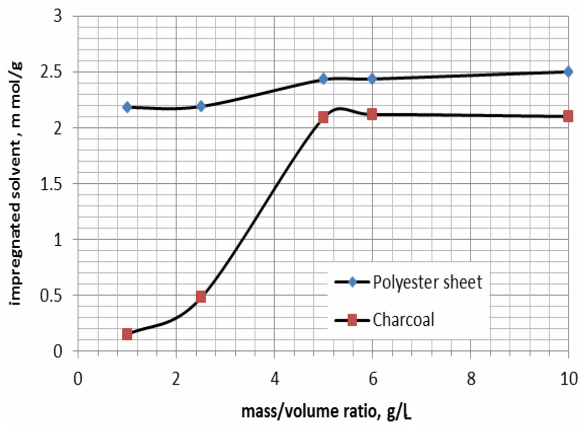

Fig. (3): Effect of impregnation solution ratio upon the loaded amount of TBP and D2EHPA onto polyester sheet and charcoal (T: 25 °C, time: 5 h., ratio: 1/1 up to 1/10and Diluents: benzene. Conc.: 0.45 Molar).

4.1.4. Effect of impregnation temperature

The effect of temperature upon the impregnation process, series of impregnation experiments were carried out using temperatures ranged from 25 to 70 °C. These experiments were performed under fixed conditions of 5 h impregnation time, 0.45 M solvent concentrations, using benzene as diluent and 5g/L. From the obtained results (Fig. 4), the impregnated amounts were decreased as the impregnation temperature increase. This phenomenon could be explained by the shape change of the inert support especially polyester sheet and the viscosity change of both TBP and D2EHPA solvents. Thus the preferred impregnation was room temperature 25°C.

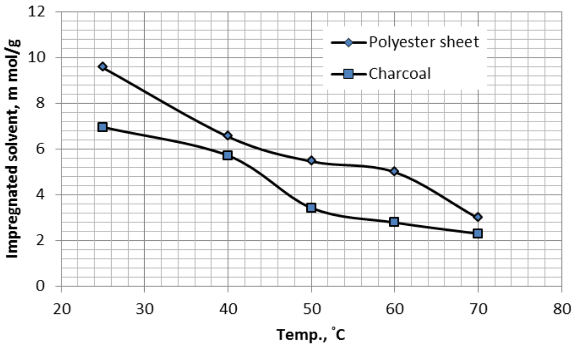

Fig. (4): Effect of impregnation temperature upon the impregnated Amount of TBP and D2EPHA onto polyester and charcoal (Conc.: 0.45 M; t: 5 h., ratio: 5/l and Diluent: benzene).

4.1.5. Effect of diluents type

The impregnation solvents were diluted before its impregnation processes on polyester sheet and charcoal to reducing the solvent viscosity. By reducing the solvents viscosity the solvents extended on the supports surface and filling its interior pores. Different diluents were tested, namely; benzene, toluene, acetone, but-1-ol, and kerosene. The impregnation experiments were carried out under fixed conditions for both materials (polyester sheet and charcoal) of 0.45 M solvent concentrations, 5/1 for mass/liquid ratio, impregnation time of 5 h for and the impregnation temperatures 25°C. Fig 5 shows the obtained results which indicate that highest impregnation amounts were performed in benzene. In this case, benzene will be used as solvents diluent.

4.1.6. Choice of optimum conditions for impregnation :

As it was mentioned before, the impregnation process of TBP and D2EPHA on polyester sheet and charcoal is mainly due to a combination of pore filling as well as surface adsorption i.e. the extractants fill almost all porous system of polyester sheet and charcoal. Owing to the obtained results of the study of the relevant factors affecting polyester sheet and charcoal impregnation, we could safely choice the following preferred conditions; 0.45 M solvents concentration, 5 h impregnation time, 1/5 mass/volume ratio, 25°C impregnation temperature and benzene as diluent.

4.2. Results of equilibrium sorption studies

In order to study the different factors affecting uranium sorption onto the prepared polyester sheet impregnated by TBP (PESIS) and charcoal impregnated by D2EHPA (CCIS), suitable amount (1.5 g) of each materials were treated with the two solvents under the above mentioned preferred impregnation conditions and used for the next studies. The studied factors are effect of contact time, effect of initial uranium concentrations, effect of solution pH and effect of adsorption temperature.

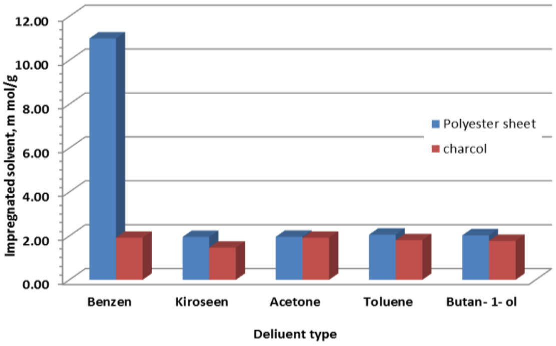

Fig. (5): Effect of diluents type upon the (TBP; D2EHPA) amounts onto the dry polyester sheet and charcoal (Conc.: 0.5 M; t: 5 h., ratio: 5/l and T: 25°C**)**

4.2.1. Effect of contact time

To determine the sorption equilibrium time of uranium by the prepared **PESIS** and **CCIS**, two series of sorption experiments were carried. The experiments were installed by contacting about 0.05 g from each material with the uranium stander solution having concentration of 160 and 220 mg/L for polyester sheet and charcoal respectively. The contact time was ranged from 15 to 300 minutes. The other factors were fixed at temperature of 25 ºC, solution pH of 3.40 and v/m ratio 5g/L The result was summarized in Fig. (6) which shows that the removal efficiency increasing by increasing the contact time from 15 min to about 50 min. beyond the 3th experiment (30min) in case of polyester sheet and 4th experiment (60 min.) in case of charcoal no significant improvement in the sorption efficiency were observed preferred. Accordingly, 30 and 60 min were chosen as contact time for sorption of uranium upon polyester sheet and charcoal respectively.

4.2.2. Effect of pH

To determine the influence of pH value of the working solution upon uranium sorption onto the prepared **PESIS** and **CCIS**, two series of batch equilibrium experiments were achieved using different pH values ranging from 0 up to 7. The experiments were performed under fixed of the other factors of initial uranium concentration of 100 mg/l for each **PESIS** and **CCIS**, at room temperature (≈ 25 ºC), contact time of 30 and 60 min for **PESIS** and **CCIS** respectively. To rich the required pH values different amount of HNO_3 or NaOH were added. The aliquots (samples) of the uranium stander solution concentrations were fixed at 100 mg/L by adding specific quantities of uranium solution to compensate for the change occurred during pH adjustment. The results were plotted in Fig (7). The latter figure indicates that, the sorption efficiency decreasing significantly by increasing the solution pH beyond pH of 4 in both cases of **PESIS** and **CCIS**. This means that the adsorption of uranium is independent on the surface characteristics of the adsorbents at various pH values but may be correlated to the permanent surface negative charge of the prepared adsorbent and the chemical species forms of uranium in the aqueous phase.

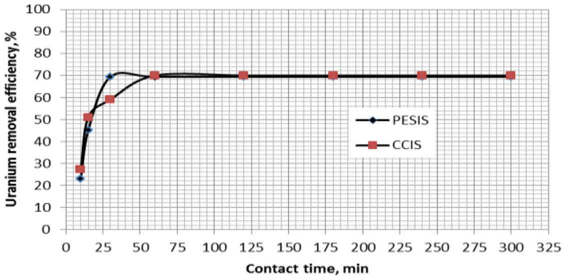

Fig. (6): Effect of contact time upon uranium sorption efficiency onto PESIS (T= 25 °C; pH = 3.08; U conc. = 220 ppm ratio 5g/l) and CCIS (T = 25 °C; pH = 3.40; U conc. = 160 ppm; ratio=5g/l).

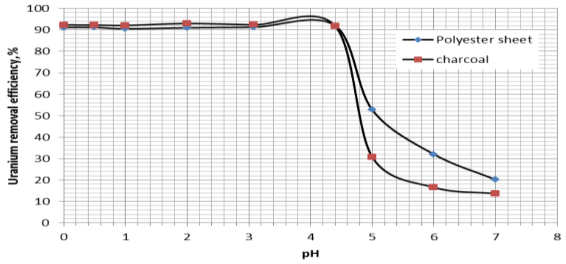

Fig. (7): Effect of solution pH upon uranium sorption efficiency onto PESIS and CCIS

(T= 25°C; U conc. =100 mg/L; ratio=5g/l,).

The aqueous speciation distribution of uranium was calculated using Hydra-Medusa chemical equilibrium database and plotting software [25, 26] and obtained in Fig. 8. The results showed that the complexes of $UO_2NO_3^+$ and UO_2^{2+} were the main species at the pH range from 0 - 4 with mean total percent of about 35% and 65 % respectively. At near neutral and alkaline pH conditions, U-hydroxide complexes start to dominate the aqueous phase. At pH 7, the $UO_2(OH)_2.H_2O$ became the major species with about 100% of total concentration at pH range from 4.5 to 10.5 while at pH 12, $UO_2(OH)_3^-$ became the main species within a total percent close to 70% of the total concentration. The formation of $UO_2(OH)_4^{2-}$ species started to grow after pH 10.

According to the latter identification, the sorption mechanism of uranium on TBP impregnated polyester sheet was mainly solvation reaction. This conclusion was supported by the structural characteristics of TBP that have solvation properties, where the sorption mechanism could be suggested by succeeding equations **[27]**.

$$UO_2^{2+} + 2NO_3^- + 2TBP \leftrightarrow UO_2(NO_3)_2.2TBP$$

$$UO_2NO_3^+ + NO_3^- + 2TBP \leftrightarrow UO_2(NO_3)_2.2TBP$$

In case of D2EHPA impregnated charcoal was mainly pure ion surface complexation reaction. This conclusion was supported by the structural characteristics of D2EHPA that have ion exchange properties, where the adsorption mechanism could be proposed by following equations **[28]**.

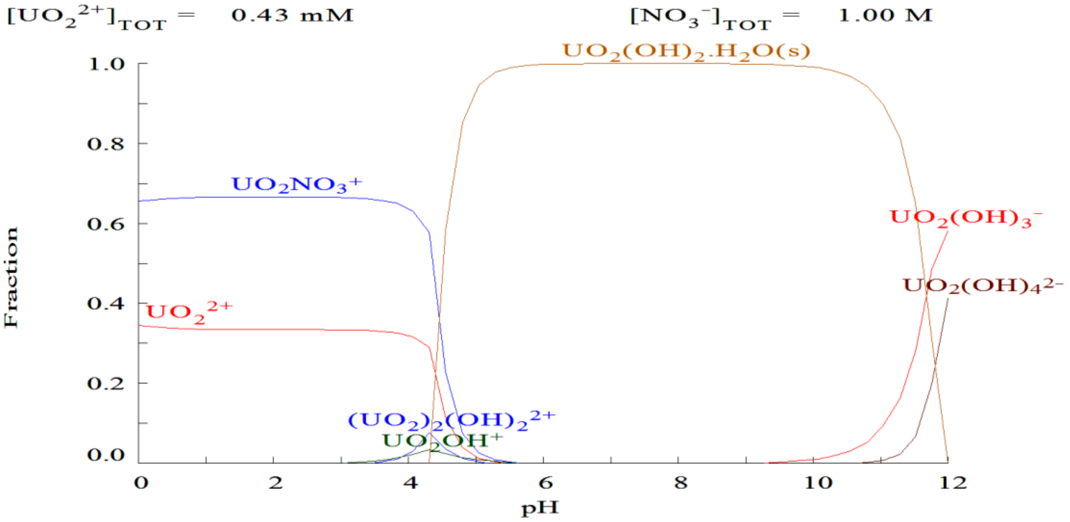

Fig. (8): Predicted aqueous speciation of U (VI) as a function of pH in 1 M HNO_3 (pH of 0) using Hydra-Medusa program

$$2[UO_2(NO_3)]^+ + (HD)_2 \leftrightarrow 2[UO_2(NO_3)D] + 2(H)^+$$

$$2[UO_2(NO_3)]^+ + (HD)_2 \leftrightarrow 2[UO_2(NO_3)D] + 2(H)^+$$

Where (HD) is D2EHPA.

4.2.3. Effect of initial uranium concentration

To examine the effect of initial uranium concentration on the sorption efficiency onto prepared **PESIS** and **CCIS**, two series of experiments were achieved by equilibrating 5g/L of nitrate solutions having different concentrations of the uranium ranged from 60 to 10000 mg/L for 30 and 60 min for **PESIS** and **CCIS** respectively at room temperature (≈ 25 ºC) and solution pH about 1. The result was obtained in Fig. 9 as a relation between uranium sorption efficiency and uranium ion concentration. From the obtained data, it was noticeable that uranium sorption efficiency decreased with increasing its initial concentration. The uranium adsorption capacity of prepared adsorbents materials are about 370 and 260 mg U/g **PESIS** and **CCIS** respectively.

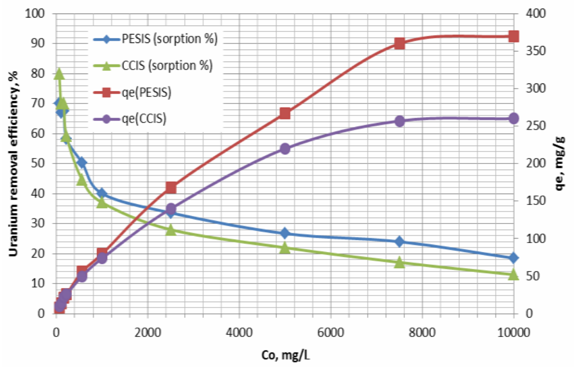

Fig. (9): Effect of uranium concentrations on sorption efficiency onto the prepared PESIS and CCIS

4.2.4. Effect of sorption temperature

To study the impact of temperature upon the uranium sorption onto the prepared **PESIS and CCIS**, two series of sorption experiments were performed using different temperatures ranging from 25 up to 70 ºC. In these experiments the other parameters were kept constant, at an initial uranium concentration of 100 mg/L, solution pH value of 1 and a shaking time of 30 and 60 min. for **PESIS** and **CCIS** respectively. From the obtained results plotted in Fig. (10), it is obviously that uranium sorption efficiency decreased with increasing the temperature. This may due to polyester sheet and charcoal surface change (become more flexible in case of polyester). For this reasons, room temperature (≈25 °C) was chosen as the preferred temperature.

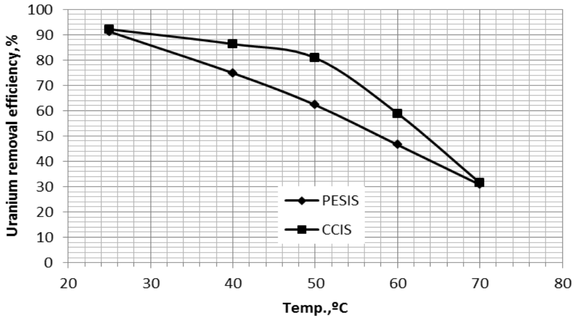

Fig. (10): Effect of solution temperature upon uranium sorption efficiency onto PESIS and **CCIS** (pH = 1; U conc. 100 mg/L and t= 30 and 60 min PESIS and CCIS respectively)

4.2.5. Effect of the ratio of mass/volume ratio

The effect of **PESIS** and **CCIS** mass / nitrate solution on the uranium (100 mg/L) sorption efficiency from nitrate solution was studied in the range from 1 to 10 g/L at sorption time of 30 and 60 min **PESIS** and **CCIS** respectively, solution pH of 1 at room temperature (≈25 °C) was explored. The experimental results were plotted in table Fig.11 as a relation between uranium sorption efficiency and mass/volume ratio. As exposed in this figure the uranium adsorption efficiency percent increases from 40 and 45 to about 92 and 91 for **PESIS** and **CCIS** respectively by increasing the mass/volume ratio from 1 to 5 g/L. Beyond mass/volume of 5g/L there are no significant increasing in sorption efficiency. Therefore, **PESIS** and **CCIS** **mass**/ nitrate solution ratio were kept at 5 g/L during all the experiments.

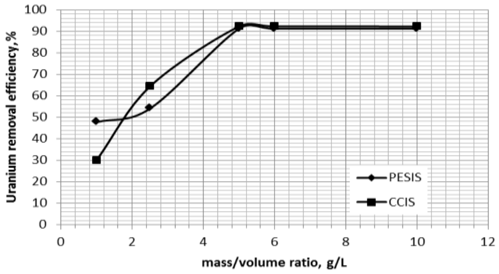

Fig. (11): Effect of solution m/v ratio upon uranium sorption efficiency onto PESIS and CCIS

4.2.6. Sorption isotherms

The general sorption isotherms calculated from the variation of the initial concentration of uranium and calculating the remaining concentration. The distribution of the metal ion on **PESIS and CCIS** surface interfaces at equilibrium has been applied to different isotherms. The Langmuir isotherm was tested by plotting C_e/q_e vs. C_e where C_e (g/L) is the equilibrium concentration of the metal ion; q_e (mg $_{metal}$/g $_{sorbent}$) is the metal ion concentration in Fig. (18, 20) the obtained linear relation indicates that the extraction of U (VI) obeys Langmuir isotherm. **Langmuir equation** can be written as:

$$\mathbf{C_e / q_e = 1/b\, Q^o + C_e / q^o}$$

Where b is Langmuir constant, Q^o (mg $_{metal}$/g $_{sorbent}$) is the maximum amount of metal taken up. From the slope and the intercept of the linear relation obtained in Fig (12, 14) b for U (VI) is 0.0006 and 0.0009 for polyester sheet impregnated with TBP and charcoal impregnated with D2EPHA. Although the **Frundlich isotherm** is usually regarded as empirical, this isotherm is applied by drawing a plot of log q_e vs. log C_e. The logarithmic form of the equation is

$$\mathbf{Log\ q_e = log\ K_f + 1/n\ log\ C_e}$$

Where n, K_f are constants representing the adsorption capacity and intensity of adsorption respectively, they depend on the nature of the adsorbate, adsorbent, and temperature. The extraction of U (VI) was found to follow the Frundlich isotherm due to the linear relation which obtained in Fig. (13, 15) from the slope and intercept of the plot, the Frundlich parameters are calculated K_f found and 1/n to be 1.57 , 2.58 mg/g and 0.621 and 0.5235 for polyester sheet impregnated with TBP and charcoal impregnated with D2EPHA .

SEM Characterization

The surface of the impregnated supports was detected using Scanning Electron Microscope (SEM) in order to illustrate the change in the surface feature of the materials before and after impregnation and after uranium sorption. The obtained SEM was applied at different magnifications of at X100, 200 and 1000 for both adsorbents.

Fourier Transform Infrared Spectrometer (FTIR)

In order to support the pore filling phenomenon, the study polyester sheet and charcoal were subjected to qualitative IR spectroscopic characterization before and after its impregnation with the tri-N-butyl phosphate (TBP) and Di-2-ethylhexyl phosphoric acid (D2EHPA) solvent (Fig. 22 a, b, c) of the spectrum (a) before loading with TBP solvent, (b) after TBP loading and (c) after uranium adsorption. Shows the P=O and C–O–P stretching vibrations at 1227 and 1020 cm^{-1}. The spectrum (c) (after loading with uranium) shows stretching band at 1099 and 1022 cm^{-1} which is characteristic formed complex between uranium and TBP on the polyester sheet.

Figure 23 a, b, c refers to charcoal before impregnation (Fig. 23 a) by Di-2-ethylhexyl phosphoric acid (D2EHPA) and after impregnation (Fig. 23 b) and after uranium loading (Fig. 23 c). In figure 23 a, the characterized spectrum of charcoal at 1081 and 3451 cm^{-1} of O-H and C=O group respectively. After impregnation the characterized bands of P-O-H, P-O-C and P=O at 885, 1032 and 1222 cm^{-1} of D2EHPA. After loading of uranium the D2EHPA characterized bands were shifted to 930, 1034 and 1202 cm^{-1}. These refer to the formation of complex between uranium and D2EHPA on the charcoal surface.

Table (2): Langmuir and Freundlich parameters for uranium sorption onto PESIS and CCIS

	Frundlich isotherm model			Langmuir isotherm model		
	1/n	Kf (mg/ Kg)	R^2	Qm	b (L/ mg)	R^2
TBP	**0.621**	**1.57**	**0.9955**	**434**	**0.0006**	**0.947**
D2EHPA	**0.523**	**2.58**	**0.9951**	**285.7**	**0.0009**	**0.970**

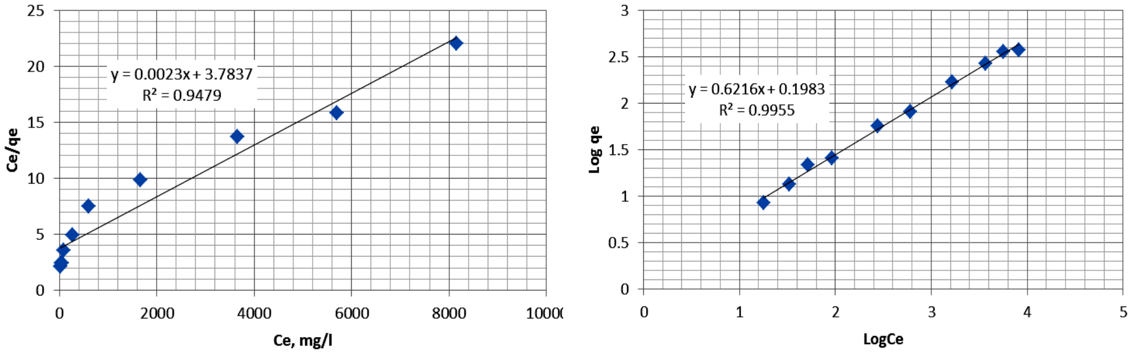

Fig (12, 13): Langmuir and Freundlich sorption isotherms for uranium onto the prepared PESIS

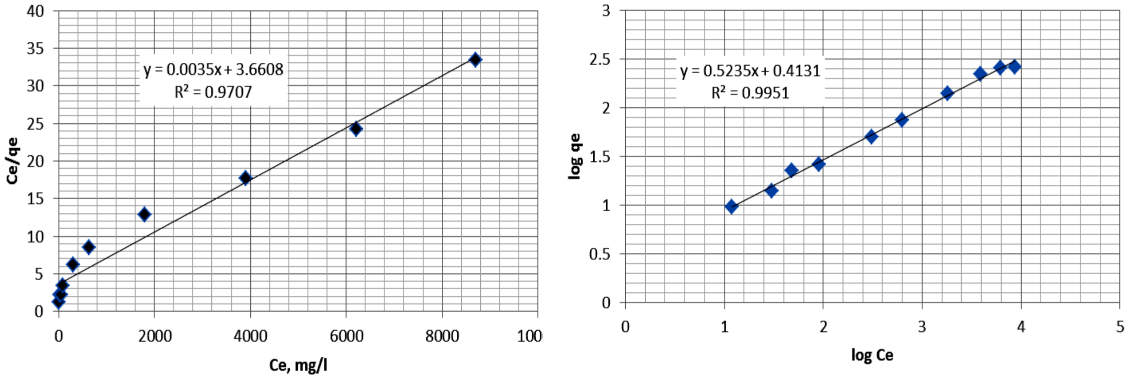

Fig (14, 15): Langmuir and Freundlich sorption isotherms for uranium onto the prepared CCIS

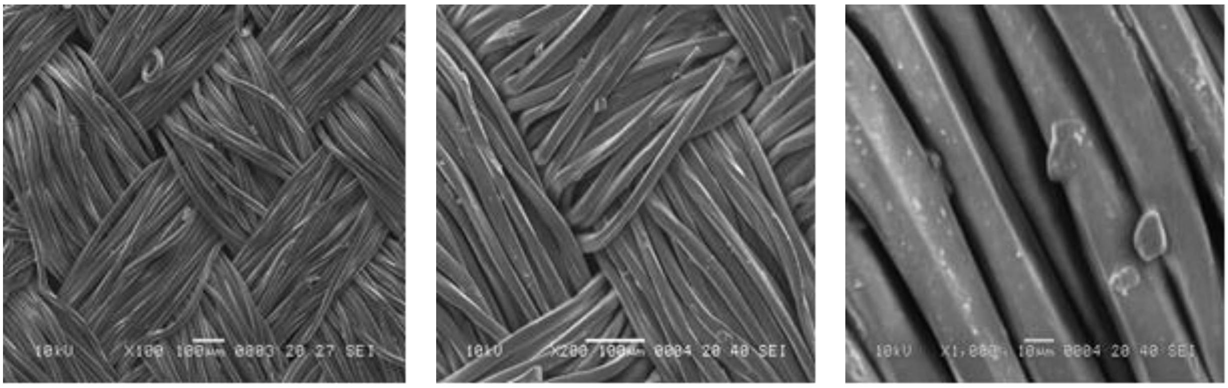

Fig. (16): SEM photographs of the polyester sheet surface before impregnation with TBP

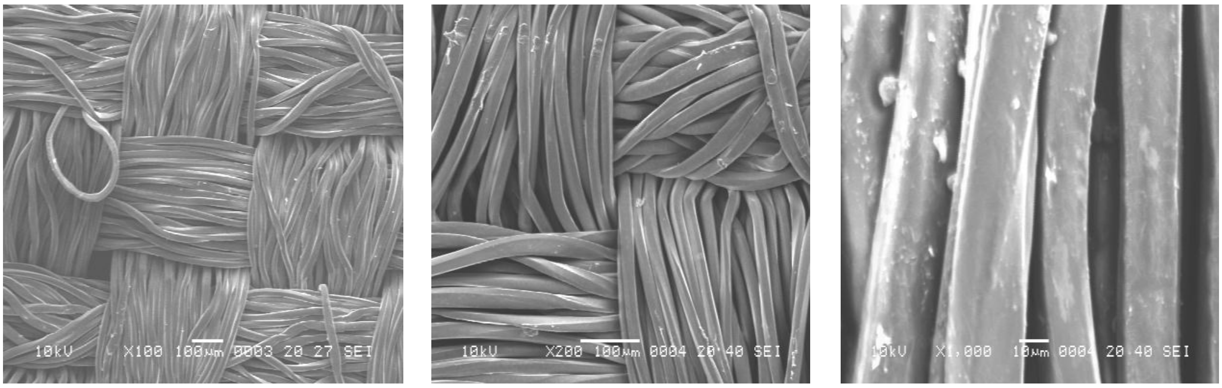

Fig. (17): SEM photographs of the polyester sheet surface after impregnation with TBP

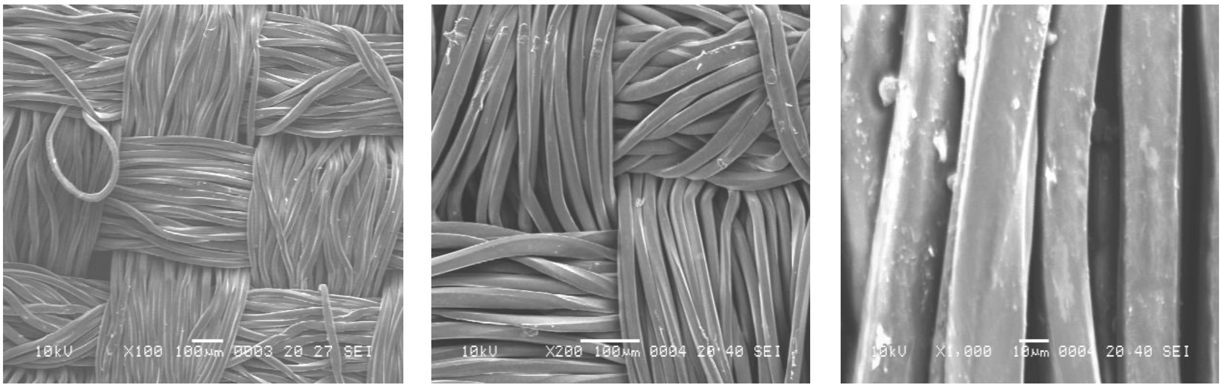

Fig. (18): SEM photographs of the polyester sheet surface after impregnation with TBP after uranium leaded

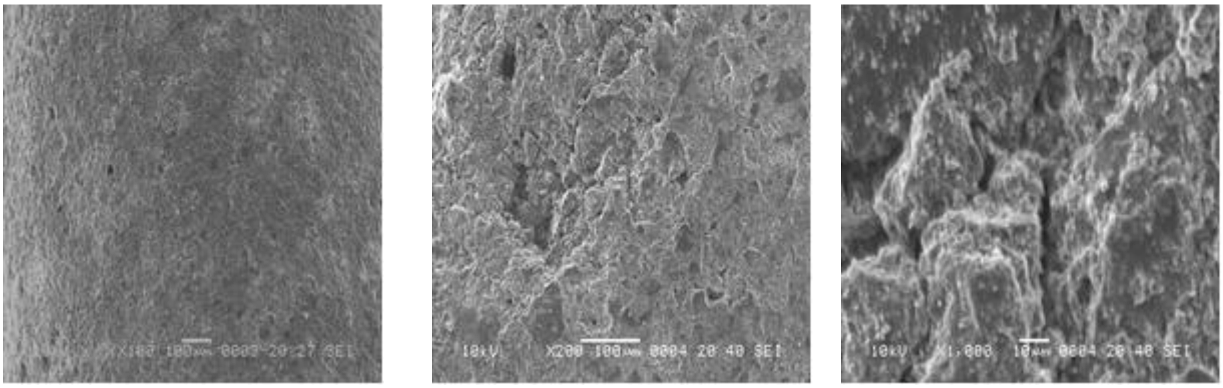

Fig. (19): SEM photographs of the charcoal sheet surface before impregnation with D2EHPA

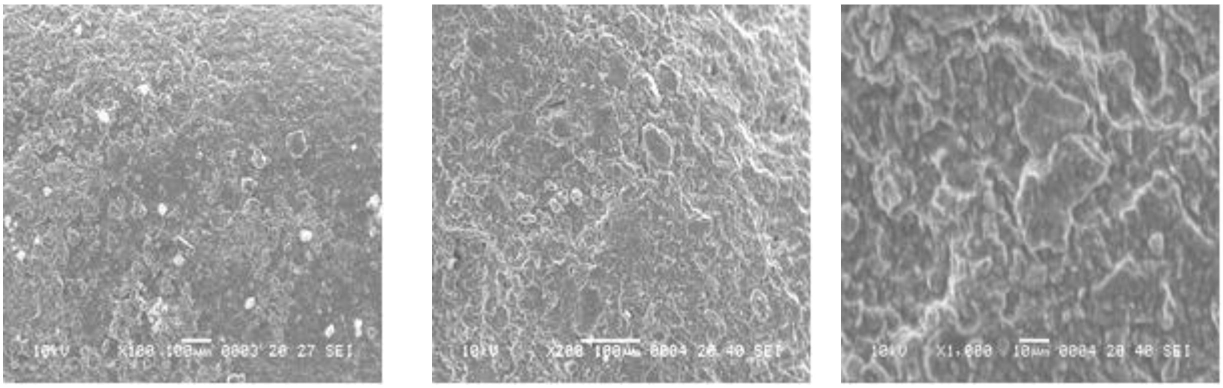

Fig. (20): SEM photographs of the charcoal sheet surface after impregnation with D2EHPA

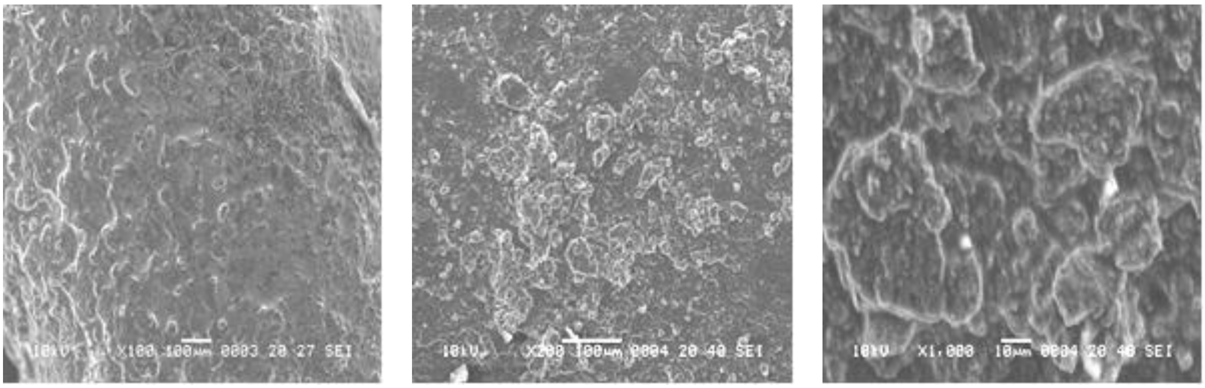

Fig. (21): SEM photographs of the charcoal sheet surface after impregnation with D2EHPA after loaded by uranium

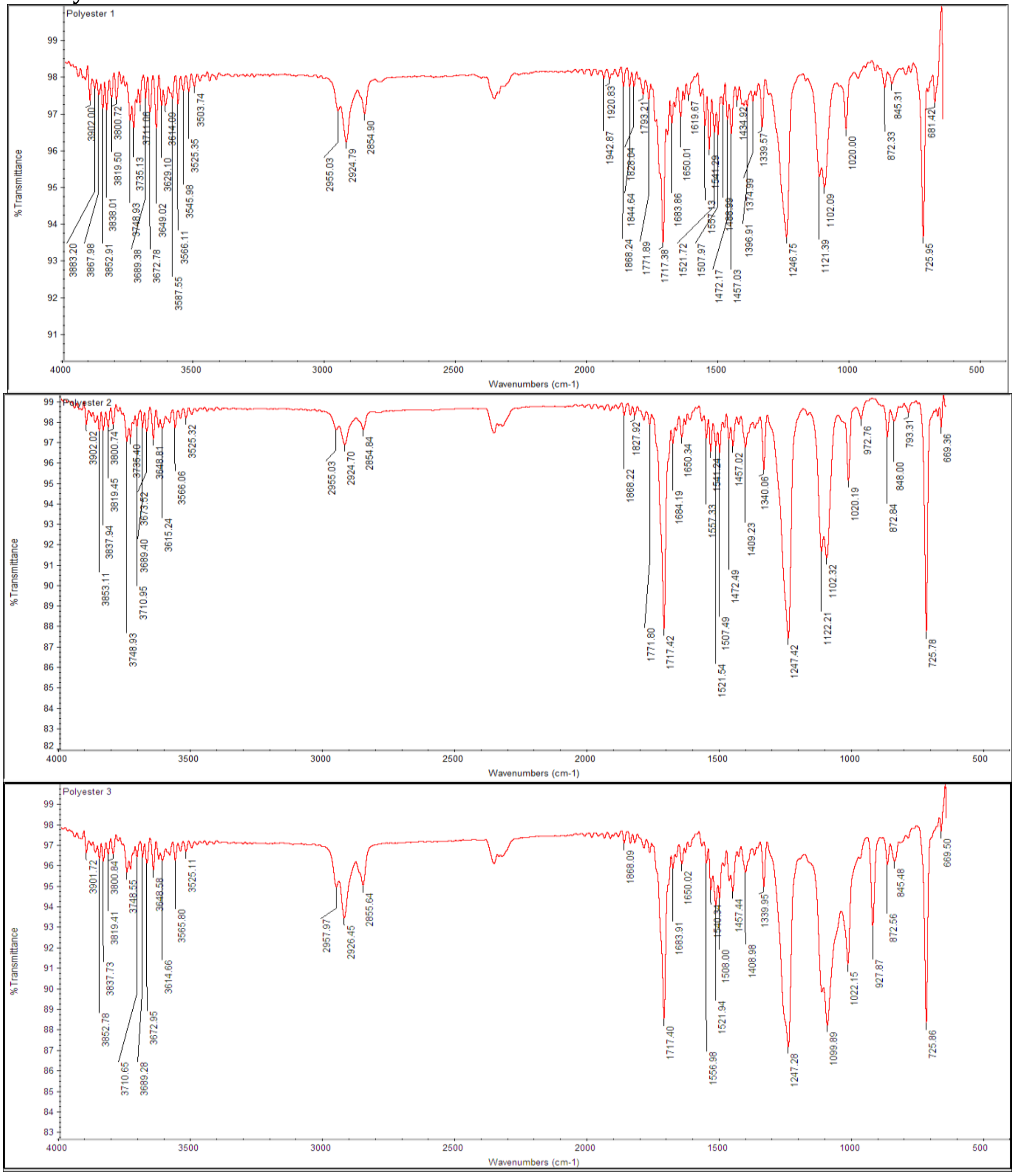

Figure (22): IR photographs of the polyester sheet surface before impregnation, after impregnation by TBP and after uranium loading

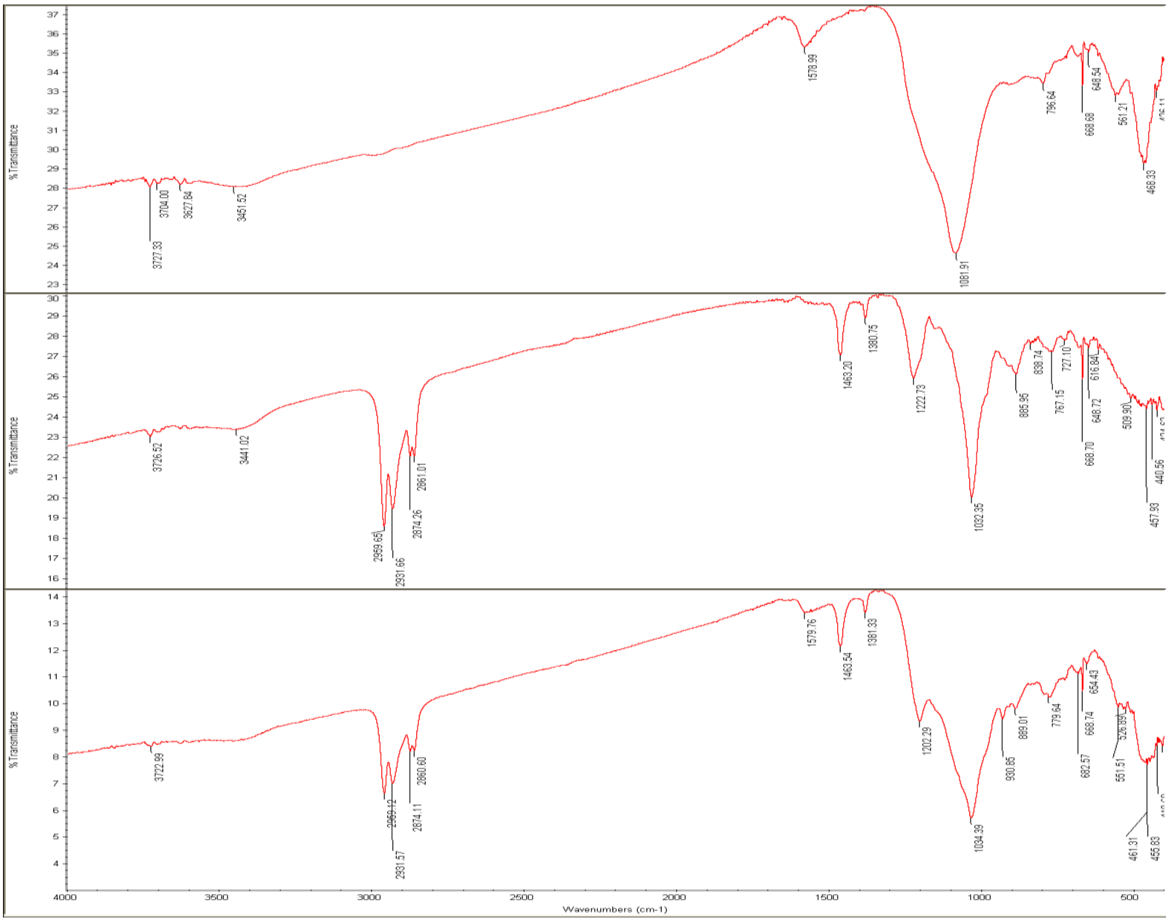

Figure (23 a, b, c): IR photographs of the charcoal surface before impregnation, after impregnation by D2EHPA and after uranium loading.

Elution Studies

In order to achieve maximum uranium elution form the prepared adsorbents, number of elution excrements were carried out to elute the uranium ion from the impregnated polyester sheet and charcoal. Uranium loaded materials were subjected to elution experiments by contacting fixed amount (0.1g) with different eluent solutions (10 ml) of H_2O, 1M NaCl+0.1M H_2SO_4, HNO_3, Tartaric acid, citric acid and Na_2CO_3 with different concentrations to obtain the maximum elution efficiency.

From the obtained results plotted in Fig. 24 and Fig. 25 showed that 1M Na_2CO_3 and 0.1 M HNO_3 elute about 96 and 95% from the loaded uranium on prepared polyester sheet and charcoal.

Case study (Uranium removal from the raffinate solution)

- Uranium adsorption

As previously stated, the prepared adsorbents has uranium adsorption capacity (about 434mg U/g polyester sheet impregnated by TBP and about 285 mg U/g charcoal impregnated by D2EHPA). In the present work, the study of uranium removal from **Nuclear Material Authority, Egypt**, liquid raffinate solution was carried out. Batch experiment was performed by contacting different amounts (0.1g) of prepared polyester sheet impregnated by TBP and charcoal impregnated by D2EHPA.

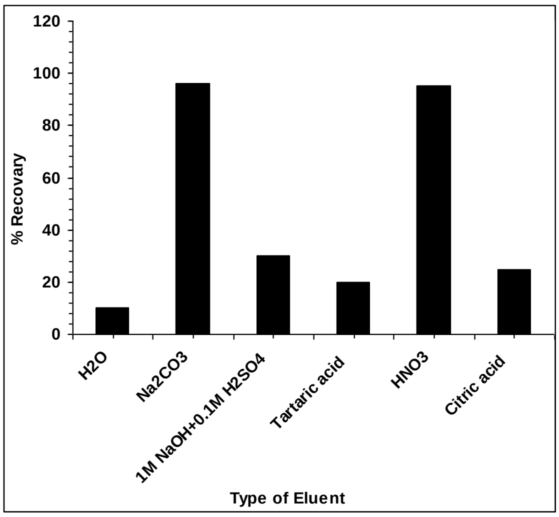

Fig. (24): Effect of different eluent reagents on uranium elution efficiency from polyester impregnated by TBP.

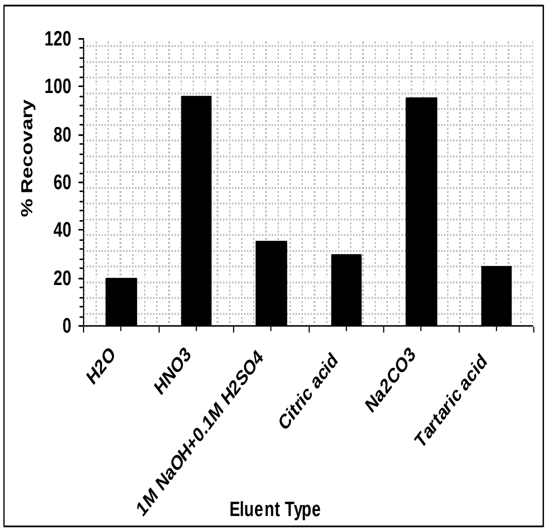

Fig (25): Effect of different eluent reagents on uranium elution efficiency from charcoal impregnated by D2EHPA.

Each 0.1g were contacted with two different volumes (200 mL) of raffinate for 90 min. the calculated loaded uranium content from its analysis in the effluent samples were illustrated in table 3.

- Uranium elution

Using the 1M Na_2CO_3 and 0.1 M HNO_3 eluent reagents about 94 and 93% from the loaded uranium on polyester sheet and charcoal were eluted. By calculating of the eluted uranium amounts revealed that 434 and 285.70 mg uranium/g polyester sheet and charcoal were eluted.

CONCLUSION

The results of this indicate that the polyester and charcoal could by converted into efficient adsorbent materials for uranium removal from aqueous solution by impregnate those materials by different solvents. The maximum adsorption capacity of the prepared impregnated materials are about than 434 and 285 mg/g. Adsorption isotherms indicate the uranium adsorption onto the prepared impregnated materials are a monolayer adsorption process. Resulting test on the uranium ion removal from raffinate solution could serve as potential applicability of these adsorbents in industrial wastewater treatment.

Table 3: Results of uranium removal from real raffinate solution by the prepared materials

Adsorbent material	Raffinate solution, ml	uranium amount, g	Adsorbent amount, g	Adsorbed uranium amount, g	Theoretical adsorbed amount, g/g	Different between theoretical and practical capacities, %	cause
Polyester	200	0.2	0.1	0.184	0.434	42.3	Iron competition
Charcoal				0.170	0.285	59.6	

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الملخص العربي

فى هذه البحث تم عمل مراكز نشطة على سطح الراتنج ذات اختيارية لبعض العناصر وذلك بتحضير بعض الراتنجات العضوية المشبعة (المحملة) بمذيبات عضوية مختلفة عن طريق نقع راتنج خامل كدعامة بوليميرية في محلول المذيب العضوي (محلول التحميل) حتى يتشبع الراتنج. وتم تحميل الدعامه البوليميرية مثل البولى استير، الفحم النشط، باستخدام طريقة التحميل او التشبع الجاف عن طريق الامتزاز الفزيائي على سطح الراتنج وتم دراسة العوامل المؤثره على عملية التحميل. تم استخدام المذيبات عضوية كـ (ثلاثي بيوتيل فوسفات ، داى -٢- ايثيل هيدروكسيل حمض الفوسفوريك) وقد تم اختيار المذيبات عضوية التى تتمتع بخاصية الاستخلاص الاخياري لبعض العناص طبقاً لنوع ودرجة المذيب المستخدم من حيث طول السلسله والفروع الجانبيه وكذلك ملأمتها للعمل في وسط النيتريك وتم دراسة العوامل المؤثره على عملية امتزاز العناصر تحت الدراسة كما تم دراسة اعادة تنشيط الراتنج بهدف استرجاع العناصر وإعادة الاستخدام.