



Uranium/Vanadium Separation from El-Sahu Carnotite-Bearing Kaolin, Southwestern Sinai, Egypt

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Abstract

A working sample of the lower Carboniferous carnotite-bearing kaolin of wadi El Sahu, Southwestern, Sinai assaying 2.6% uranium and 1.2% vanadium species is subjected to sulfuric acid pug leaching. The extraction behavior of both metal values was first studied from their combined synthetic solution using DEHPA and Aliquat-336 extractants. The obtained results are then applied upon El-Sahu sulfuric acid leach liquor where after proper oxidation of the leach liquor, uranium was selectively extracted as cationic ions by DEHPA solvent, while the vanadium left behind was subsequently extracted as anionic ions using Aliquat-336.

Keywords: Uranium; Vanadium; Sinai; Carnotite

1. Introduction

Although uranium is actually the principal fuel for working the nuclear power reactors, its assay in the earth's crust is about 4 ppm. Besides being polyvalent, uranium is characterized by several physical and chemical properties that make its geologic distribution and in turn its dispersion almost ubiquitous. These properties include its large atomic radius, chemical reactivity and the relative solubility of many of its hexavalent compounds in aqueous solutions. Contrary to uranium, vanadium is a relatively abundant element in the earth's crust having an average of 150 ppm, however, it rarely occurs in discrete mineral species.

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Alternatively, vanadium is actually found as a constituent of several rock-forming minerals and their alteration products. Vanadium is indeed required for several industries where it is mainly used specialty in the manufacture of steels and super alloys as well as a catalyst in several industrial operations [1]. It is also considered a favored material for fuel cladding and as a structural material for liquid-metal-cooled fast breeder reactors (LMFBR). Similar to uranium, vanadium is also multivalent; however, its tetra- and pentavalent states are the most important in its hydrometallurgical treatment.

Due to their common occurrence in mineral ores, uranium and vanadium are generally leached together whether by direct acid leaching agitation or pug) besides selective or combined leaching using a salt roasting step before water, acid or alkali leaching. Difficulties in applying the latter technique [2], renders its direct acid leaching using sulfuric acid to be the preferable procedure. In the latter, uranium exists in its hexavalent state in the form of the uranyl cation UO_2^{2+} or as the uranyl sulfate anions $[\text{UO}_2(\text{SO}_4)_2]^{2-}$ and $[\text{UO}_2(\text{SO}_4)_3]^{4-}$. On the other hand, vanadium can be acid leached either as its tetravalent vanadyl cation VO^{2+} or as its pentavalent anions VO_3^- and VO_4^{3-} [3].

Uranium/vanadium separation is generally achieved during their recovery from their combined leach liquor. While ion exchange resins could be applied, the common practice is to apply the solvent extraction technique [4, 5]. In the latter, two procedures have widely been used; namely the di-ethylhexyl phosphoric acid (DEHPA) [6], and the amines e.g. the quaternary amine Aliquat-336 [7]. By proper controlling the oxidation states and the pH of the leach liquor, either solvent can indeed extract uranium and vanadium whether simultaneously (followed by selective stripping) or successively [8].

In Egypt, a combined occurrence of U/V has been discovered at *Wadi El-Sahu* area (*Sinai*) where a mineralization of the two minerals carnotite $[\text{K}_2(\text{UO}_2)_2(\text{VO}_4)_2 \cdot 3\text{H}_2\text{O}]$ and metatorbernite $[\text{Cu}(\text{UO}_2)_2(\text{PO}_4)_2 \cdot 8\text{H}_2\text{O}]$ have been found in the kaolin rock of the lower member of *Um Bogma Formation* which hosting Mn-Fe ore lenses [9]. A successful pug leaching using concentrated sulfuric acid on this mineralization has been carried out by [10] at 200°C for 8 hr curing resulting in a leaching efficiency of 90 and 96% for vanadium and uranium respectively. Another working sample of this ore material assaying 2.6% U and 1.2% V has been provided for the present work and has indeed been also subjected to pug leaching to prepare sulfuric acid pregnant liquor.

Due to possible problems of applying one solvent for U/V separation, concerning proper adjustment of the pH and Eh values, it was found more convenient and economic to apply the two solvents. Thus, in a first step, DEHPA would be applied for uranium extraction after proper oxidation of the leach liquor to ensure that vanadium would completely exist in its non-extractable anionic pentavalent state. This would directly be followed by applying Aliquat-336 to the uranium-barren leach liquor for vanadium extraction.

2. Experimental procedures

2. 1. Materials

2.1.1. Preparation of El-Sahu U/V Leach Liquor

The working ore material of El-Sahu area with composition presented in **Table (1)** has been subjected to acid pug leaching under the previously determined optimum conditions [11]. Prior to proper water leaching, the determined optimum conditions include the following:

- An ore /conc., H₂SO₄ acid; w/v phase ratio of 1/1
- Curing the mixed ore/acid at 300 °C for 4 hr
- Grinding the input ore ; -200 mesh size

After water leaching, the obtained leach liquor was found to assay 2054 ppm U and 1020 ppm V.

Table (1): Analytical results of major and trace elements content in El-Sahu carnotite-bearing kaolin

Component	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	CaO	MgO	TiO ₂	Na ₂ O	U ₂ O ₃	V ₂ O ₅	K ₂ O	L.O.I A
Wt. %	51.4	16.4	11.1	2.2	0.69	1.7	0.83	2.6	1.2	1.09	10.5
Trace element	Cr	Ni	Cu	Pb	Zn	Zr	Ga	Sr	Ba	P	Y
ppm	932	51	133	336	267	n.d. ^B	98	n.d.	1075	218	333

A) L.O.I: loss of ignition at 1050 °C

B) n.d not detected

2.1.2. Preparation of Synthetic U/V Solution

For optimization of the experimental conditions required for U/V separation from *El-Sahu* leach liquor, a proper U/V synthetic solution has first been used. The latter solution has been prepared by dissolving a proper weight (2.11 g) of pure uranyl nitrate UO₂(NO₃)₂·6H₂O and a proper weight (2.3 g) of ammonium metavanadate NH₄VO₃ in 10 ml conc. H₂SO₄ acid and then made up to one liter volume to have a concentration of 1000 ppm U and 1400 ppm V.

2.1.3. Preparation of DEHPA and Aliquat-336 Organic Phases

Different molarities of the working two solvents (DEHPA and Aliquat-336) have been prepared by proper dissolving the required amounts of either solvent in kerosene as diluent.

2.2. Extraction Procedures

All the extraction experiments were performed in separating funnels by mixing the two phases for a certain time under different extraction conditions. After phase separation, uranium and vanadium were analyzed in the aqueous phase and their contents in the organic phase were calculated by difference. From the latter values, the distribution coefficients and the extraction efficiency would be calculated.

2.3. Analytical Procedures

Uranium concentration in all the stream aqueous solutions was analyzed by using the titrimetric assay procedure developed by **Davies and Gray, (1964) [12]** against ammonium metavanadate after its proper reduction. On the other hand, vanadium in all the stream aqueous solutions was analyzed by atomic absorption using a Unicam 969 Atomic absorption spectrophotometer (AAS).

3. Results and discussions

3.1. Optimization of Uranium Extraction Factors by DEHPA

For optimization of the extraction conditions required for selective U extraction from El-Sahu U/V leach liquor while leaving V behind, several extraction experiments have first been performed upon the prepared synthetic solution (1000 ppm U and 1400 ppm V). However, before systemically studying the relevant extraction factors, two preliminary extraction experiments have been performed upon the prepared non oxidized synthetic solution (pH 0.91) using 0.1M DEHPA at 1/1 O/A ratio. Using 10 min. contact time, it was found that the extraction efficiencies of U and V attained 95.0 and 52.8 % respectively while increasing the contact time to 20 min. has slightly decreased the U extraction efficiency to 91.5% and slightly increased that of V to 56.6 %. From these results, it was ascertained that both the pH and the oxidation state of the U/V solution are quite important for attaining complete U/V separation

3.1.1. Effect of pH/Oxidation State

To endeavor the effects of both pH and oxidation state, 3 experiments have been performed using only 5 min. contact time and adjusting the pH values to attain 1.5, 2.0 and 2.5 besides adding H₂O₂ to extent of 50% volume to the synthetic solution for V oxidation into its pentavalent (non-extractable) anionic form with DEHPA. From the obtained results shown in **Table (2)**, it is clearly evident that both the oxidation state and a pH value ≥ 2 of the aqueous phase are quite important to realize complete U extraction and nil V extraction.

Table (2): Effect of pH and oxidation upon U/V extraction efficiencies by DEHP from the prepared synthetic solution

pH	Extraction efficiency, (%)	
	U	V
1.5	100	14.0
2.0	100	nil
2.5	100	nil

(DEHPA: 0.1 M, O:A ratio 1:1.5, contact time 5 min.)

3.1.2. Effect of DEHPA Molarity at pH 1.5

Having ascertained the importance of both pH and the oxidation state of the aqueous U/V solution for their separation and while the above experiments have been performed by 0.1 M DEHPA, it was found necessary to study the molarity effect of the working extractant. This is due to the fact that relatively high DEHPA molarity might result in the formation of the pentavalent vanadium cation pervanadyl (VO_2^+) and in the turn would be extracted. Accordingly, it was thus found necessary to study the effect of DEHPA molarity in the organic phase upon U extraction from the synthetic solution. However, this effect was studied under both normal and oxidizing conditions using H_2O_2 .

3.1.2.1. Experimental Results under Normal Condition

To study the effect of DEHPA molarity under normal condition, 3 experiments were performed using 0.01 to 0.05 M DEHPA in kerosene and the obtained results are graphically plotted in **Fig. (1)**. From the latter, it was found that U and V extraction efficiencies at 0.01 M were found to attain 87.4 and only 7.2% respectively. Increasing the DEHPA molarity to 0.02 M did not affect the U extraction while that of V was increased to 27.6%. Further increase in the DEHPA molarity to 0.05 has increased the extraction efficiencies of both U and V up to 94.5 and 34.0% respectively. These results indicate clearly that under the working non oxidizing condition, both elements are extracted; however, the distribution coefficient of UO_2^{2+} is much higher than that of VO^{2+} .

3.1.2.2. Experimental Results under Oxidizing Condition

From the above experiments, it was clearly evident that V is present in the working synthetic solution under both the tetravalent cationic and the pentavalent anionic states. Therefore, another 4 extraction experiments were performed using DEHPA molarity of 0.01, 0.02, 0.05 and 0.1 M at pH 1.5, however after oxidation of the working solution by H_2O_2 and the obtained results are shown in **Table (3)**. From

the latter, it was found that V has not been extracted except when using 0.1 M DEHPA at which its extraction efficiency attained 14%.

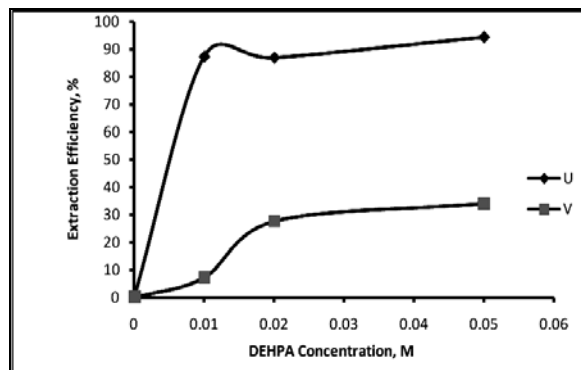


Fig.(1): Effect of DEHPD concentration at pH 1.5 upon U/V extraction efficiencies from the prepared non-oxidized synthetic solution (O:A ratio 1:1, contact time 5 min.)

Table (3): Effect of DEHPA upon U/V extraction efficiencies from the prepared synthetic solution

DEHPA,(mol)	Extraction efficiency, (%)	
	U	V
0.01	100	0.0
0.02	100	0.0
0.05	100	0.0
0.10	100	14.0

(pH 1.5, O:A ratio 1:1.5, contact time 5 min)

3.1.3. Effect of DEHPA Molarity at pH 2.5

3.1.3.1. Experimental Results under Normal Condition

Similar to the working procedure at pH 1.5, the study of the effect of DEHPA molarity (0.01 to 0.05) at pH 2.5 has first been performed under normal condition. From the obtained results shown in (Fig. 2), it was found that the U extraction efficiency (from about 90 and 96%) and that of V (from about 10 to 36 and then to about 31%) are almost comparable to those performed at pH 1.5 under similar conditions. These results are indeed due to the fact that V exists in both its tetravalent cationic and pentavalent anionic states regardless of the pH value. Accordingly, V co-extraction with U has prevented U from complete extraction. This is most probably due to inadequate DEHPA concentration. In other words,

these results confirm indeed the necessity of proper oxidation of the aqueous phase to ensure the complete presence of V in its non-extractable pentavalent state.

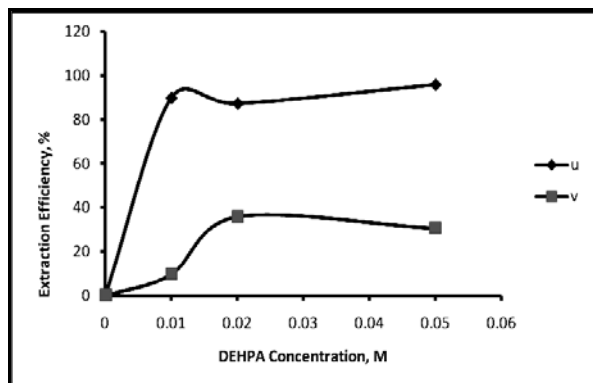


Fig.(2): Effect of DEHPD concentration at pH 2.5 upon U/V extraction efficiencies from the prepared non-oxidized synthetic solution (O/A ratio 1:1, contact time 5 min.)

3.1.3.2. Experimental Results under Oxidizing Condition

To study the U/V extractability at pH 2.5 under the oxidizing condition, the above 3 experiments have been repeated, however, after proper oxidation of the aqueous phase with H_2O_2 and where the applied contact time was also 5 min, A/O ratio was increased to 1/1.5. The obtained results revealed complete U extraction without any co-extracted V. Increasing DEHPA concentration to 0.1 M has also resulted in nil V extraction while that previously performed with 0.1 M DEHPA at pH 1.5 has however resulted in the co-extraction of 14% V. This result ensures the importance of working at a pH value higher than 1.5 in order to avoid V co-extraction.

3.2 Selective SX Recovery of U/V from El-Sahu Leach Liquor

In the light of the studied optimum condition for selective U extraction by DEHPA from a synthetic U/V solution, the factors affecting DEHPA selective U extraction from the prepared pug leaching solution of El-Sahu working sample (2054 ppm U and 1020 ppm V) have been studied. However, a prior oxidation of the latter was applied using 50% of its volume by H_2O_2 and therefore the U/V assay has been decreased to 1370 and 680 ppm respectively.

3. 2.1. Selective Uranium Extraction using DEHPA from El-Sahu Leach Liquor

3.2.1.1. Effect of pH

To study this effect, 5 extraction experiments have been performed in which the pH was varied between 1.3 to 3. From the obtained results plotted in **Fig. (3)**, it was found that increasing the pH from 1.3 to 2.5 has progressively increased the distribution coefficient from 8 up to 90 and the uranium extraction efficiency from 89 to 99% respectively. In the latter, the U assay has sharply been decreased

down to only 15 ppm in the working leach liquor. Increasing the pH to 3 has resulted in uranium-barren liquor, however a pH of 2.5 would be considered as the optimum value and counter-current extraction could result in nil uranium in the resultant effluent (V-bearing leach liquor) as will later be shown.

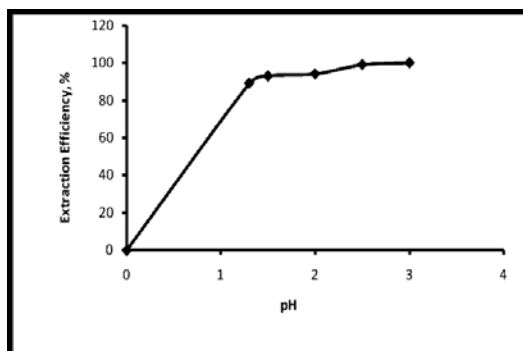


Fig.(3): Effect of pH on selective U extraction by DEHPA from El-Sahu U/V leach liquor. (O:A ratio 1:1, contact time 5 min., 0.05M DEHPA)

3.2.1.2. Effect of Contact Time

This effect was studied in the range of 3 to 15 min and from the obtained results (**Fig. 4**) it was shown at 3 min contact time, complete uranium extraction has actually been achieved. However, behind 3 min the U extraction efficiency was progressively decreased to 99, 95 and 91% at 5, 10 and 15 min respectively. These results indicate that uranium back-extraction occurs by extending the contact time behind 3 min. From these results, 5 min contact time would be considered as the optimum value at which 99% uranium could be extracted and attaining complete U extraction would result through counter-current extraction as mentioned above.

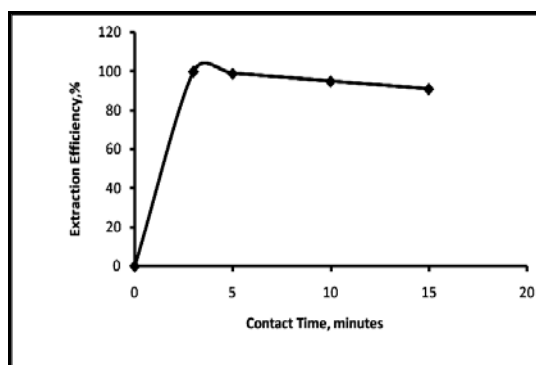
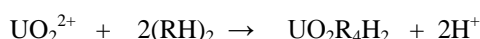


Fig.(4): Effect of contact time on selective U extraction by DEHPA from El-Sahu U/V leach liquor. (O:A ratio 1:1, pH 2.5, 0.05 M DEHPA)

3.2.1.3. Effect of DEHPA Concentration

The effect of DEHPA concentration on the selective uranium extraction from the working El-Sahu U/V leach liquor was studied in the range of 0.01 to 0.10 M. From the obtained results plotted in **Fig. (5)**, it was shown that at DEHPA molarity of only 0.01, a distribution co-efficient of 13 was obtained corresponding to a U extraction efficiency of up to 93%. Further increasing the DEHPA molarity to 0.02 and 0.05 at the mentioned conditions has increased the latter to 96 and 99% respectively while using 0.1 M DEHPA has resulted in complete uranium extraction. Referring to DEHPA stoichiometric reaction of uranium extraction; viz:



from which 4 M of DEHPA are required for extraction of 1 M of uranium i.e. at 1/1 O/A ratio, 1L of 0.05 M DEHPA can stoichiometrically extracted 0.0125 M U (about 3g U/L). Working with 1.37g U/L indicates that the applied DEHPA molarity is quite adequate for complete uranium extraction. In the meantime and according to the given reaction, 0.01 M DEHPA would extract not more than 0.0025 M U i.e. 0.595 g U/L. However, the applied 0.01 M DEHPA has extracted about 1.27 g U; a matter which would indicate that 1 M U would only need about 2 M DEHPA i.e. UO_2R_2 .

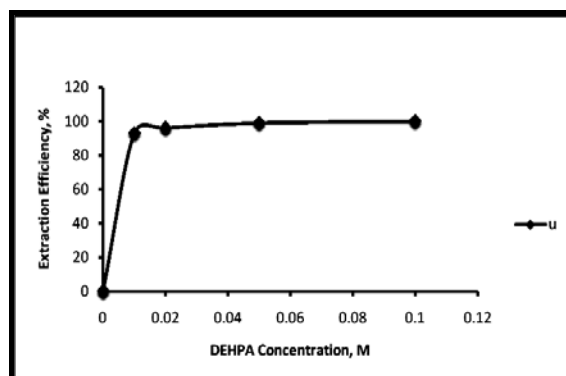


Fig.(5): Effect of DEHPA concentration on selective U extraction by DEHPA from El-Sahu U/V leach liquor. (O:A ratio 1:1, contact time 5 min, pH 2.5)

3.2.1.4. Effect of O/A Phase Ratio and Construction of McCabe-Thiele Diagram

To calculate the number of theoretical stages required for almost complete uranium extraction by DEHPA from El-Sahu leach liquor in a counter-current technique (mixer-settler system), different O/A ratios have been applied ranging from 4/1 down up to 1/4. The obtained results shown in **Table (4)** and **Fig. (6)** demonstrate that complete uranium extraction was obtained at both O/A ratio of 4/1 and 3/1 and at which the uranium assay in the organic phase was only 343 and 457 ppm respectively. However, the uranium extraction efficiency has afterwards started to decrease at O/A ratio of 2/1 until

down to 1/4 where about 91% of uranium was extracted. At the latter ratio, the uranium concentration in the organic phase has amounted up to 4.98 g/l at the working 0.05 M DEHPA concentration; a matter which suggest the possibility of the ability of 2 M DEHPA to stoichiometrically extract 1 M uranium to form the extracted complex UO_2R_2 .

Table (4): Effect of O:A ratio on selective uranium extraction by DEHPA from El-Sahu U/V leach liquor

O:A ratio	Uranium, (mg l ⁻¹)		D _a ⁰	Extraction efficiency, (%)
	Aq. phase	Org. phase		
4:1	0.0	343	α	100
3:1	0.0	457	α	100
2:1	5	683	137	99.6
1:1	15	1355	90	98.9
1:2	80	2580	32	94.2
1:3	100	3810	38	92.2
1:4	125	4980	40	90.9

(Contact time 5 min, pH 2.5, 0.05M DEHPA)

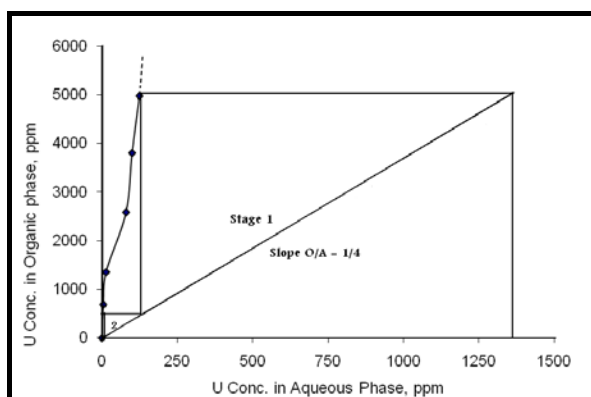


Fig.(6): McCabe-Thiele extraction diagram for the selective U recovery from El-Sahu leach liquor.

(Contact time 5 min, pH 2.5, 0.05M DEHPA)

To construct the McCabe-Thiele extraction diagram, the equilibrium data obtained at different O/A ratios have then been plotted as the equilibrium isotherm of the working system (**Fig. 6**). An operating

line of a slope (O/A) attaining about 1/4 was then fitted to the equilibrium curve; a matter which is due to the high extraction efficiency of the working DEHPA concentration with respect to the input aqueous uranium concentration. The latter was thus found to result in only two theoretical counter-current stages which would deplete the aqueous phase and obtaining a uranium concentration in the organic phase reaching about 5 g U/L.

3.2.2. Aliquat-336 Extraction of V from El-Sahu U-Barren Leach Liquor

From the above results of DEHPA selective U extraction from the oxidized El-Sahu U/V leach liquor, it has been possible in one contact by using the extraction condition of 0.1 M DEHPA, an O/A ratio of 1/1 at pH 2.5 for 5 min contact time. However, by applying the counter current technique, it would be possible to completely extract the U values in 2 stages using 0.05 M DEHPA at pH 2.5 for 5 min contact time and using an O/A ratio of 1/4. However, to study the extraction conditions of V anionic species from El-Sahu U-barren leach liquor, it was found convenient to ensure complete uranium removal in one contact using the above mentioned conditions. Accordingly, the quaternary amine extractant aliquat-336 was then applied upon the U-barren El-Sahu leach liquor to study the relevant extraction conditions that would control anionic V extraction.

3.2.2.1. Effect of pH

The pH effect upon vanadium extraction from the U-barren El-Sahu leach liquor (680 ppm) was studied between pH values 1.3 and 2.5. From the obtained results graphically shown in Fig. (7), it was ascertained that at pH 2 to 2.5, vanadium was completely extracted while at the lower pH values of 1.5 to 1.3, its extraction efficiency was decreased to 99 and 94% respectively. Accordingly, pH 2.5 was considered as the optimum value and which has also been chosen for the prior uranium extraction by DEHPA extractant.

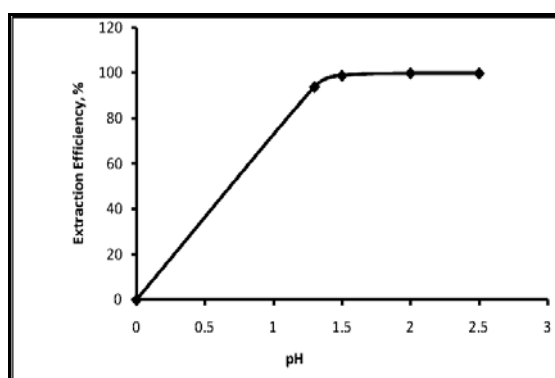


Fig.(7): Effect of pH on V extraction by Aliquat-336 from U-barren El-Sahu leach liquor. (O:A ratio 1:1, contact time 5 min, 0.1 M Aliquat-336)

3.2.2.2. Effect of Contact Time

Having ascertained the applied high Aliquat-336 of 0.1 M for V extraction from El-Sahu leach liquor, the effect of contact time was studied using 0.05 M Aliquat-336. From the obtained results plotted in Fig. (8), it was found that only a slight decrease in the V extraction efficiency from 100 to 98% by decreasing the Aliquat-336 concentration from 0.1 to 0.05 M at the same other conditions. Increasing the contact time to 10 and 15 min has resulted in complete V extraction; whereas in case of U extraction by DEHPA, increased contact time has led to lower efficiency.

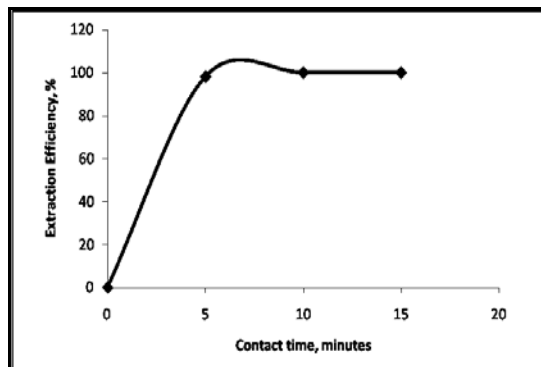


Fig.(8): Effect of contact time on V extraction by Aliquat 336 from U-barren El-Sahu leach liquor. (O:A ratio 1:1, pH 2.5, 0.05 Aliquat-336 conc.)

3.2.2.3. Effect of Aliquat-336 Concentration

The effect of Aliquat-336 molarity on V extraction from the working U-barren El-Sahu leach liquor of a pH adjusted at 2.5 was studied in the range of 0.02 to 0.20 M. From the corresponding results (Fig. 9), it was found that in case of 0.02 M Aliquat-336, the V extraction efficiency attains up to 93% equivalent to a distribution co-efficient of 12. Increasing the extractant concentration to 0.05 and 0.1 M, the V extraction efficiency was increased to 98 and 100% respectively. In this regard, it is interesting to refer to the stoichiometric reaction of V with Aliquat-336 which can be represented as follows:

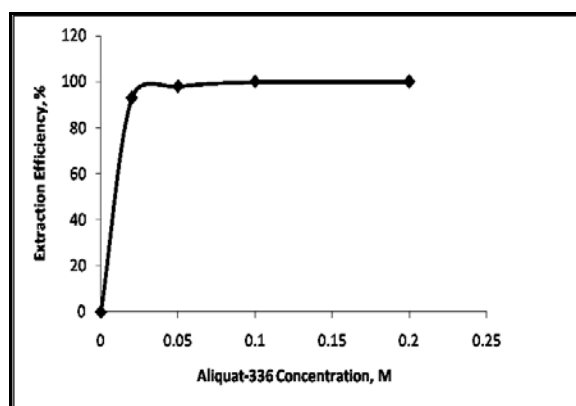
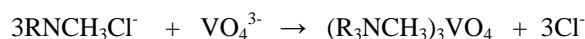
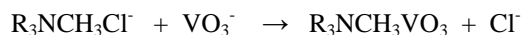


Fig. (9): Effect of Aliquat-336 concentration on V extraction by Aliquat-336 from U-barren El-Sahu leach liquor. (O:A ratio 1:1, contact time 5 min, pH 2.5)



These reactions indicate that 0.68g V/L would require either 5.3 or 15.9 g Aliquat-336 according to the first or the second above mentioned equation respectively. Since the working 0.05 M Aliquat-336 corresponds to 20.2 g/l, it is clearly evident that the latter is quite sufficient for almost complete V extraction as shown in **Fig. (9)**. On the other hand, the 0.02 M Aliquat-336 (8.08 g/l) which has resulted in 93% V extraction would not be adequate to attain this extraction efficiency if VO_4^{3-} is the only extracted anionic species.

3.2.3.4. Effect of O/A Ratio and Construction of McCabe-Thiele Diagram

To construct the McCabe-Thiele extraction diagram of V by Aliquat-336 from El-Sahu U-barren leach liquor for calculating the required number of theoretical stages in a mixer-settler system, a number of extraction experiments using O/A ratios (4/1 to 1/4) were carried out. From the obtained results (**Table (5)** and **Fig. (10)**), it is clearly evident that while complete extraction of V occurs at the O/A ratios of 4/1 and 3/1, however, the organic phase assays only 170 and 237 ppm respectively. Decreasing the O/A ratios to 2/1 and 1/1 has resulted in a slight decrease of the extracted V to 99 and 98% respectively. Further decreasing the O/A ratio down to 1/4, it was found that the organic phase assays 2.32 g/l V equivalent to about 85% extraction efficiency and a decrease in the distribution co-efficient down to only 23. In the meantime, the 0.05 M Aliquat-336 assaying 20.29 g/l can stoichiometrically extract 2.6 g V of VO_3^- is the extracted species, however, if the latter is VO_4^{3-} , the required Aliquat-336 concentration should be 60.6g/l.

Table (5): Effect of O:A phase ratio on vanadium extraction by Aliquat-336 from U-barren El-Sahu leach liquor

O/A ratio	Vanadium, (mg l ⁻¹)		D _a ^o	Extraction efficiency, (%)
	Aq. phase	Org. phase		
4:1	0.0	170	α	100
3:1	0.0	237	α	100
2:1	5	338	68	99.3
1:1	11	669	61	98.4
1:2	36	1288	36	94.7
1:3	76	1812	24	88.8
1:4	100	2320	23	85.3

(pH 2.5, contact time 5 min, 0.05 M Aliquat-336)

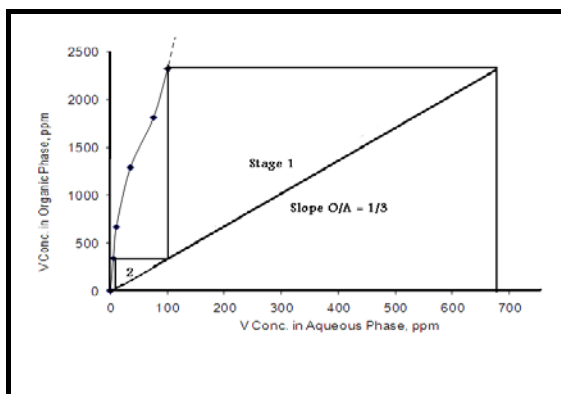


Fig.(10): McCabe-Thiele extraction diagram for V recovery from El Shaun U-barren leach liquor. (pH 2.5, contact time 5 min, 0.05 M Aliquat-336).

The McCabe-Thiele extraction diagram for V has then been constructed using the obtained equilibrium data shown in **Table (4)** for plotting the equilibrium isotherm (**Fig. 10**). An operating line of a slope (O/A) attaining about 1/3 was then fitted to the equilibrium isotherm and from which 2 extraction stages would be required.

4. Conclusions

Successful U/V separation has been achieved upon their combined acid leach liquor of El-Sahu carnotite-bearing kaolin of SW Sinai through successive application of the DEHPA and Aliquat-336 after proper oxidation of the latter to ensure that V would completely exist in its anionic pentavalent state. The optimum conditions of both solvent extraction circuits have been studied. The latter involved a pH of 2.5 of the leach liquor, an 0.05 M DEHPA and a contact time of 5 min for complete U extraction while for the subsequent V extraction, an 0.05 M Aliquat-336 at the same pH and contact time for U. Construction of the two corresponding McCabe-Thiele diagrams has indicated that complete U extraction could be obtained in 2 stages when using an O/A flow rate of 1/4 whereas V extraction could also be obtained in 2 stages, however, by using an O/A flow rate of 1/3.

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