Effect of Ageing on the Extraction of Vanadium (V) From Mixture of Vanadium (V) and Molybdenum (VI) In Hydrochloric Acid Solution with Organ Phosphorus Extract Ants

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Abstract

The Industrial procedure of solvent extraction does not need half of the total of energy used in pryrometallurgy, which decreases the cost and improved extraction efficiency. It may also be possible that ageing affect extraction efficiency. The effect of ageing on the extraction of vanadium (V) from the mixtures of Vanadium (V) and Molybdenum (VI) of hydrochloric acid with bis-2-ethylhexyl phosphoric acid, tri-butyl phosphate, tri-octyl phosphine oxides in n-heptane as extractants were used to investigate the effect of ageing of vanadium (V) for nine days. The extractants in n-heptane was used to extracts vanadium (V) from aqueous solutions of Vanadium (V) and Molybdenum (VI) in the hydrochloric acid under different experimental conditions. The parameters that could influence the extraction efficiency of Vanadium (V) such as ageing, extractants concentration (30% volume per volume Tri-butyl phosphate), (1% weight per volume Tri-octyl phosphine oxide) and (20% volume per volume Bis-2-(ethyl hexyl) phosphoric acid) were used to check the effect of ageing of vanadium (V). The extracted Vanadium (V) was stripped with tetra-oxosulphate (VI) acid (H2SO4). Using modified Vogel's method, vanadium was analyzed using an established method. The effect of ageing of vanadium (V) was deduced from each of the extractants due to how longer they stay and knowing the effectiveness of each of the extractants on the metal Vanadium (V) day by day.

Keywords: Vanadium (V); Tri-butyl phosphate (TBP); Tri-octyl phosphine oxide (TOPO) and Bis-2-(ethyl hexyl); phosphoric acid (D-2-EHPA)

Introduction

Vanadium is a chemical element with the symbol V and atomic number 23. Vanadium belongs to the VB group of the periodic table. Its dominant valences are +4 and +5 [1,2]. Having different valences, vanadium can form various complexes; especially in aqueous solutions. A pertinent factor affecting variation of the vanadium valence is medium p^H. Oxidation state of vanadium determines its toxicity. Vanadium pentoxide is more harmful than the elemental form [3,4]. It is an essential metal and just like other transition metals and has many beneficial properties such as hardness, silvery grey, tensile strength, fatigue resistance, specific physiological functions, good corrosion resistance at low temperature and high melting point, electrically conductive, which determine that it is widely used in a lot of areas, such as steel and iron, aerospace, catalysts, power-generation, machine tools industry, automotive, agricultural, construction and nuclear reactor components [5-7]. It is sometimes describe as soft because it is ductile, malleable and not brittle. Other applications such as catalysts, biological applications and fuel cells have increased the importance of vanadium recently. It is considered an important alloying element in the steel industry and a material with superior performance in the aerospace and chemical industry [8,9]. Other applications in catalysis, ink, dye, paint, varnish, insecticide, photography, pharmaceutical and glass industry are of significance. Vanadium is scarcely distributed in the earth crust [10,11].

Vanadium is not found as a free form element in nature, but once isolated artificially, the formation of an oxide layer, somewhat stabilizes the free metal against further oxidation. Several separation processes have been proposed to recover vanadium, vanadium was traditionally extracted from stone coal roast-leach solution which is built on the principle of oxidizing the lower valence state of Vanadium (III) to higher valence states of Vanadium (IV) and Vanadium (V) at high temperature and then a vanadium product is gotten by direct precipitation and refining of the leach solution but Negative aspects of the roast –leach technologies are that the roasting efficiency is about 45 to 55% and the overall vanadium recovery is below 60% [12]. The first large scale industrial use of vanadium was in the steel alloy chassis of the Ford Model T, inspired by French race cars. Vanadium steel allowed reduced weight while increasing tensile strength. The process of recovering vanadium from a certain stone coal was carried out by direct acid leaching process and blank roasting acid leaching process. The vanadium leaching efficiency in direct acid leaching process was 92.39% while in blank roasting acid leaching process was 85.43% under the comparative leaching condition of 15%(volume per volume) H_2SO_4, 1 mL/g, 4 h, 95 ± 1°C and 5% (weight per weight) CaF_2.

Calcium Fluoride (CaF_2) reacted with sulphuric acid to generate hydrofluoric acid.

Solvent extraction technique is a portion of analytical chemistry and has been recognized as an excellent separation method because of its ease, simplicity, speed, and wide scope. Utilizing apparatus no more complicated than a separating funnel, requiring just several minutes at the most to perform, applicable both to trace and macro-levels of metals, extraction procedures offers much to the analytical chemist.

Molybdenum is a chemical element the symbol Mo and atomic number of 42. It is a white platinum-like metal with a melting point of 2610°C (4730°F). In it pure state, it is tough and ductile, and it is characterized by moderate hardness, high thermal conductivity, high resistance to corrosion, and a low expansion coefficient. Small quantities of molybdenum significantly improve the abrasion resistance, anticorrosive properties, and high-temperature strength and toughness of the matrix material. The name is gotten from Neo-Latin Molybdenum from ancient Greek. The element was discovered in 1781 by Carl Wilhelim Scheele, he produced molybdic oxide by attacking pulverized molybdenite (MoS_2) with concentrated nitric acid and then evaporating the residue to dryness. The growing importance and economic value of Molybdenum leads to an increasing interest in the development of efficient processes aiming its recovery from secondary resources. Molybdenum finds numerous applications (alloy additions, catalyst, polymer compounding, corrosion inhibitors, lubricants, etc.), but its recycling is related mostly to spent catalysts and a steel scraps' reprocessing. Irrespective of the molybdenum origin, its recovery usually employs various metallurgical processes, often involving leaching operations generating leach solutions for a further processing. Among different reagents proposed for leaching Mo-bearing materials, sulphuric acid appears to be the most common due to its availability and a low price. The treatment of leach solutions is typically performed by means of conventional separation techniques i.e. precipitation, ion exchange, adsorption and solvent extraction. Among these processes, solvent extraction is the most commonly used method, particularly in extractive metallurgy for separation, recovery, and purification of target metals.

Molybdenum occurs in various oxidation states, however an oxidative leaching with tetraoxo-sulphate (VI) acid (H_2SO_4) leads to the formation of the oxidation state +6, it depends on metal concentration, pH of solutions and their ionic strength. The profile of the abundance of each Molybdenum (VI) species contrasted with the pH indicated that Molybdenum exists in cationic, neutral and anionic forms. The three forms differentiated acid–base behavior of Molybdenum (VI) suggests the three kinds of liquid extractants (cationic, anionic and solvating) can be used to extract this metal. A vast majority of researches published so far relate to the extraction of Molybdenum (VI) ions mainly with the use of commercial extractants, i.e. Aliquat 336, Alamine 304, Alamine 336, TOA, (2-ethylhexyl) phosphoric acid (DEHPA), Tri-Butyl Phosphate (TBP) and LIX series reagents. Unfortunately, these extractants are not effective in the removing of the metal from sulfate media.

Molybdenum is commonly recovered from leach liquors by means of the solvent extraction process. The extraction medium currently used in the hydrometallurgical industry consists of bis (2-ethylhexyl) phosphoric acid (D2EHPA) as the extractants and kerosene as the diluents at low pH values [13,14]. However, kerosene is volatile, flammable and toxic; characteristics that involve many environmental and health issues. Recently, ionic liquids have been proposed as a potential replacement of those volatile organic diluents due to their excellent properties such as hydrophobic property, non-flammability and negligible vapor pressure. This latter advantage could allow the recycling of the ionic liquid many times without decreasing the extraction performance of the process.

The only commercially viable mineral in the production of molybdenum is its bisulfide (MoS_2), it is found in molybdenite. Molybenum is recovered as a co-product or by-product. The largest producers of molybdenum are China, United States, Chile, Peru, Mexico, and Canada.

Bis-2-(ethylhexyl) phosphoric acid (D2EHPA)

Bis-2-(ethylhexyl) phosphate is commonly known as D2EHPA, it has a molecular formula of $C_{16}H_{35}O_4P$. It is a colorless liquid and low vapor pressure which is used as solvent in liquid-liquid extractions. It is produced from phosphorus oxychloride and 2-ethylhexanol. It is sold by weight; it is nontoxic to bacteria and does not induce gene initiation in bacteria. The density is 0.965 g/mL at 25 and molecular weight of 322 g/mol. Laboratory tests demonstrate that bis-2-(ethylhexyl) phosphoric acid is biodegradable.

Tri-butyl phosphate (tbp)

Tri-butyl phosphate is commonly known as TBP, is an organophosphorus compound with chemical formula of $(CH_3CH_2CH_2CH_2O)$ 3PO. It is manufactured by reaction of phosphoryl chloride with n-butanol.

$POCl_3 + 3C_4H_9OH \ PO(OC_4H_9)_3 + 3HCl$

It is a solvent and plasticizer for cellulose esters such as nitrocellulose acetate. It forms stable hydrophobic complexes with some metals; these complexes are soluble in organic solvents as well as supercritical CO_2. It is majorly used in industry as a component of aircraft hydraulic fluid, brake fluid, and as a solvent for extraction and purification of rare-earth metals from their ores. It is also used as solvent in inks, gums, adhesives, and anti-forming agent and so on.

Tri-octyl phosphine oxides (topo)

This compound is as an extraction or stabilizing agent. It is an air-stable white solid at room temperature. It has a chemical formula of OP $(C_8H_{17})_3$. It is usually prepared by oxidation of tri-octylphosphine, which is in turn produced by alkylation of phosphorus tri-chloride. Tri-octyl phosphine oxide is used in the extraction of metals especially uranium. The high polarity which results from the dipolar phosphorus-oxygen bond, allows this compound to bind to metal ions.

Materials and Method

Preparation of 500 cm^3 of 8 Molar Hydrochloric acid (HCl)

Hydrochloric acid (339.0 cm^3) was taken in a measuring cylinder accurately from the stock, small of water was poured into the volumetric flask of 500 cm^3, the acid measured was poured into it and water was added to make up to the mark in the volumetric flask.

Preparation of 500 cm^3 of 6 Molar Hydrochloric acid (HCl)

A volume (254.2 cm^3) of Hydrochloric acid was taken in a measuring cylinder accurately from the stock, small of water was poured into the volumetric flask of 500 cm^3, the acid measured was poured into it and water was added to make up to the mark in the volumetric flask.

Preparation of 250 cm^3 of 0.01 Molar Sodium Vanadate (NaVO$_3$)/0.01 Molar Sodium Molybdate (NaMoO4)/0.1 Molar Potassium Chloride (KCl)

For 0.01 Molar Sodium Vanadate (NaVO$_3$)/0.01 Molar Sodium Molybdate (NaMoO$_4$)/0.1 Molar KCl in 6 Molar Hydrochloric acid (HCl)

Sodium vanadate (NaVO3) of 0.3048 g, 0.6049 g of sodium molybdate (NaMoO4) and 1.8625 g of potassium chloride were weighed and it was prepared with 6 Molar hydrochloric acid in 250 cm^3 standard lask.

For 0.01 Molar NaVO$_3$/0.01 Molar NaMoO4/0.1 Molar KCl in 8 Molar Hydrochloric acid (HCl)

Sodium vanadate (NaVO$_3$) of 0.3048 g, 0.6049 g of sodium molybdate (NaMoO$_4$) and 1.8625 g of potassium chloride were weighed and it was prepared with 8 Molar hydrochloric acid in 250 cm^3 standard flask. The stock solution was extracted over a period of nine days.

Preparation of 30% v/v Tri-butyl phosphate (TBP) in n-heptane

The 30% v/v tri-butyl phosphate in n-heptane was prepared by dilution method using (M1V1=M2V2). 100 cm^3 of Tri-butyl phosphate and 233.3 cm^3 of n-heptane was measured using measuring cylinder; it was mix together in an empty reagent bottle by swirling it very well.

Preparation of 1% w/v Tri-octyl phosphine oxides (TOPO) in n-heptane

Tri-octyl phosphine oxide (3 g) was weighed, and then dissolved in 300 cm^3 n-heptane (it was made up to 300 cm^3).

Preparation of 20% v/v Bis-2-(ethyl hexyl) phosphoric acid (D2EHPA) in n-heptane

The 20% v/v bis-2-(ethyl hexyl) phosphoric acid in n-heptane was prepared by dilution method using (M1V1=M2V2). 100 cm^3 of D2EHPA and 400 cm^3 of n-heptane was measured using measuring cylinder; it was mix together in an empty reagent bottle by swirling it very well.

Preparation of 500 cm^3 of 2 Molar Tetra-oxosulphate (VI) acid (H$_2$SO4)

The 2 Molar tetra-oxosulphate (VI) acids were prepared by the method of dilution. 55.5 ml of H$_2$SO$_4$ was measured using measuring cylinder and was diluted with 444.5 cm^3 of distilled water in 500cm^3 of standard lask.

Preparat on of 0 .5 M olar Na$_2$wO$_4$.2H$_2$O i n 2 50 cm^3 of solution

A mass (41.2 g) of sodium tungstate was accurately weighed into a beaker using a weighing balance, while in the beaker; water was added to the salt in order for dissolution to take place. The solution was then poured into a 250 cm^3 standard lask, rinsed into it until it is made up to the mark.

Preparat on of 1 :2 P hosphoric A cid (H$_3$PO$_4$) i n 2 50 cm^3 standard flask

Ration 1:2

1+2=3

Ratio volume of phosphoric acid=1/3×500=166.7 cm^3

Phosphoric acid (166.7 cm^3) was taken accurately into a measuring cylinder and poured into a 500 cm3 containing a little amount of water and made up to the mark with water.

Preparat on of 0.25 Molar Tetra-oxosulphate (VI) acids (H$_2$SO$_4$) in 500 cm^3 of solut on

H$_2$SO$_4$ (7 cm^3) was taken in a measuring cylinder accurately from the stock, small of water was poured into the volumetric flask of 500 cm^3, the acid measured was poured into it and water was added to make up to the mark in the volumetric flask.

Effect o f ageing i n t he extraction of va nadium (v) from the mixture of vanadium (v) and molybdenum (vi)

Extractants: 30% volume per volume Tri-Butyl Phosphate/n-heptane

Contact time: 5 minutes

Speed: 100 rev/min

Procedure:

10 ml 0.01 Molar of sodium vanadate (NaVO3)/0.01 Molar of sodium molybdate (NaMoO4)/0.1 Molar of Potassium Chloride (KCl)/6 Molar Hydrochloric acid (HCl) was obtained from the stock earlier prepared, and poured into a separatory funnel attached to a retort stand, 10 ml of the extractants 30%v/v Tri-Butyl Phosphate in n-heptane was also poured into the separatory and covered with the lid. The separatory funnel containing the mixture was then removed from the retort stand, placed in a hollow container, and padded with foam to enable it stand on the orbital shaker on which it will be placed. The shaker was set to revolve at 100 rpm for five minutes before it was then switched on.

After shaking for five minutes, the separatory funnel was removed and re-attached to the retort stand; cork removed, and allowed to stand for about two minutes. This allowed the mixture to settle, and separate into two distinct phases: the organic and the aqueous phase. The aqueous phase (usually the

lower part of the mixture) was run into a measuring cylinder from the tap, volume recorded and then emptied into a 25 cm^3 sample bottle.

The interfacial layer was removed from the organic phase left in separatory funnel by running two-three drops into an empty beaker. The organic layer was poured from the top of the separatory funnel into a beaker, emptied into a measuring cylinder so that the volume can be recorded, and then poured again into the separatory funnel. Tetra-oxosulphate (VI) acid (H$_2$SO$_4$) (stripping agent for vanadium) was then poured into the separatory (volume corresponding to the volume of the organic phase already in the separatory funnel), corked, and the process of shaking, settling, running of the aqueous phase into a measuring cylinder, the volume was recorded and the final organic phase is then discarded. The process above was repeated for Tri-octyl phosphine oxide (TOPO), bis-2-(ethyl hexyl) phosphate (D2EHPA) and 10 ml 0.01 Molar of sodium vanadate (NaVO$_3$)/0.01 Molar of sodium molybdate (NaMoO$_4$)/0.1 Molar of potassium chloride/8 Molar of Hydrochloric acid. The extraction was repeated for each extractants over a period of nine days.

Determination of vanadium

Vanadium in the sample (raffinate and stripped solutions) was determined by the modified Vogel's method [14]. 0.1 cm^3 of a sample was taken using a pipette into a 25 cm^3 measuring cylinder, a ter which 2.5 cm^3 of 1:2 H$_3$PO$_4$, 10 cm^3 of 0.25 Molar of H$_2$SO$_4$, and 0.5Molar Na2WO4 solutions were added and the solution was made up to 20 cm^3 with distilled water. The solution was heated to boil with a Pyrex beaker and allowed to cool. After cooling, the solution was then made up to 25 cm^3 with distilled water and thereafter poured into a dry and clean sample bottle for analysis. The absorbance of the sample was read at 400 nm using laboratory technical visible spectrophotometer [15,16]. The concentration of Vanadium (V) in the solution was determined by comparing with the absorbance of a prepared standard. The above procedure was repeated for all samples.

Electronic spectra

The electronic uv-visible spectra bands of the stock, and organic phase for all the extractants, tri-n-butyl phosphate in n-heptane, tri-octyl phosphine oxide in n-heptane and bis-2-(ethylhexyl) phosphate were recorded on the spectrophotometer (shimadu uv-1800, Japan) in the range of 200-900 nm at Central Laboratory Federal University of Technology Akure (FUTA) [17,18].

Result and Discussion

Effects ageing in the extraction of V(V) from 6 Molar Hydrochloric acid (HCl) solution with Tri-butyl phosphate (TBP), Tri-octyl phosphine oxide (TOPO), Bis-2-(ethylhexyl) phosphoric acid D2 EHPA.

The effect of ageing on the percentage vanadium (V) extraction from 6 Molar hydrochloric acid with 30% volume per volume TBP, 1% weight per volume TOPO, and 20% volume per volume D2EHPA is presented in Table and Figure of effect of extractants (TBP, TOPO, and D2EHPA) with days for 6 Molar Hydrochloric acid solution. Extraction was studied for different days ranging from day 1 to day 9 with TBP, TOPO, and D2EHPA. The percentage V (V) extraction (E%) varied from 93.0 to 97.1%for TBP, 97.1% for TOPO, and 93.0 to 97.1% for D2EHPA. With TOPO the percentage of vanadium (V) extraction was constant in all the days, for TBP, the percentage of vanadium (V) extraction decreases/constant with increase in the days, and for D2EHPA the percentage of vanadium (V) extraction decreases/constant with increase in the days [19].

Effects ageing in the extraction of V(V) from 8 Molar Hydrochloric acid (HCl) solution with Tri-butyl phosphate (TBP), Tri-octyl phosphine oxide (TOPO), Bis-2-(ethylhexyl) phosphoric acid (D2EHPA) (Tables 1-6).

The effect of ageing on the percentage vanadium (V) extraction from 6 M hydrochloric acid with 30% volume per volume TBP, 1% weight per volume TOPO, and 20% volume per volume D2EHPA is presented in Table and Figure of effect of extractants (TBP, TOPO, and D2EHPA) with days for 8 Molar Hydrochloric acid solution. Extraction was studied for different days ranging from day 1 to day 9 with TBP, TOPO, and D2EHPA. The percentage V(V) extraction (E%) varied from 82.8 to 97.1%for TBP, 60.0 to 76.7% for TOPO, and 52.4 to 97.1% for D2EHPA. With TOPO the percentage of vanadium (V) extraction was constant/decrease/increase with increase in the days, for TBP, the percentage of vanadium (V) extraction increase/constant with increase in the days, and for D2EHPA the percentage of vanadium (V) extraction decreases/increase/decrease with increase in the days [20] (Figure 1,2).

Table 1: Effect of extract ants (TBP, TOPO, and D2EHPA) with days for 6 Molar HCl.

DAYS					EXTRACTANTS							
	TBP				TOPO				D2EHPA			
	[V(V)]aq	[V(V)]org	D	E%	[V(V)]aq	[V(V)]org	D	E%	[V(V)]aq	[V(V)]org	D	E%
1	0.0003	0.0097	32.3	97.1	0.0003	0.0097	32.3	97.1	0.0003	0.0097	32.3	97.1

3	0.0007	0.0093	13.3	93.0	0.0003	0.0097	32.3	97.1	0.0007	0.0093	13.3	93.0
5	0.0003	0.0097	32.3	97.1	0.0003	0.0097	32.3	97.1	0.0040	0.0060	1.5	60.0
7	0.0003	0.0097	32.3	97.1	0.0003	0.0097	32.3	97.1	0.0003	0.0097	32.3	97.1
9	0.0003	0.0097	32.3	97.1	0.0047	0.0053	1.1	52.4	0.0003	0.0097	32.3	97.1

Table 2: Effect of extract ants (TBP, TOPO, and D2EHPA) with days for 8 Molar HCl.

DAYS					EXTRACTANTS							
	TBP				**TOPO**				**D2EHPA**			
	[V(V)]aq	[V(V)]org	D	E%	[V(V)]aq	[V(V)]org	D	E%	[V(V)]aq	[V(V)]org	D	E%
1	0.0017	0.0083	4.9	82.8	0.0003	0.0097	32.3	97.1	0.0003	0.0097	32.3	97.1
3	0.0010	0.0090	9.0	90.0	0.0003	0.0097	32.3	97.1	0.0047	0.0053	1.1	52.4
5	0.0007	0.0093	13.3	93.0	0.0003	0.0097	32.3	97.1	0.0010	0.0090	9.0	90.0
7	0.0003	0.0097	32.3	97.1	0.0040	0.0060	1.5	60	0.0017	0.0083	4.9	82.8
9	0.0003	0.0097	32.3	97.1	0.0023	0.0077	3.3	76.7	0.0027	0.0073	2.7	73.0

Figure 1: A plot of E% against day for the extraction of vanadium (V) from 6 Molar Hydrochloric acid with Tri butyl phosphate (TBP), Tri octyl phosphine oxide (TOPO), Bis-2-(ethylhexyl) phosphoric acid (D2EHPA).

Figure 2: A plot of E% against day for the extraction of vanadium (V) from 8 Molar Hydrochloric acid with Tri butyl phosphate (TBP), Tri octyl phosphine oxide (TOPO), Bis-2-(ethylhexyl) phosphoric acid (D2EHPA).
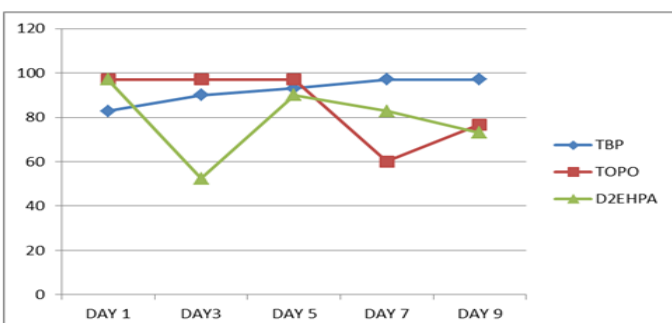
Electronic Absorption Spectra data of TBP, TOPO, D2EHPA, V(V) Stock, Aqueous Phases, Organic phases of Vanadium (V) Extracted From Hydrochloric acid (HCl) Solutions.

The electronic spectra bands of tri-butyl phosphate, tri-octyl phosphine oxides, and bis-2-(ethylhexyl) phosphoric acid, aqueous stock of Vanadium (V) solutions of 6 Molar/8 Molar hydrochloric acid, organic phase of tri-butyl phosphate (TBP), tri-octyl phosphine oxides (TOPO) and bis-2-(ethylhexyl) phosphoric acid (D2EHPA) Vanadium (V) are presented in the tables below.

The presence of charge transfer band in both the aqueous phase and organic phase shows that Vanadium (V) was extracted.

Table 3: Aqueous phase for 6 Molar Hydrochloric acid.

Days	Frequency (Cm-1)	Assignment
5	43,478 (230 nm)	Charge transfer
	40,186 (245 nm)	
9	47,170 (212 nm)	Charge transfer
	44,843 (223 nm)	

Table 4: Aqueous phase for 8 Molar Hydrochloric acid (HCl).

Days	Frequency (Cm-1)	Assignment
5	45,871 (218 nm)	Charge transfer
	27,027 (370 nm)	
9	46,512 (215 nm)	Charge transfer
	12,300 (813 nm)	

Table 5: Organic phase for 8 Molar Hydrochloric acid (HCl).

BAND (cm-1)			
DAY	TBP	TOPO	D2EHPA
9	14,409 (694 nm)#>	43,573 (229.5 nm)	40,984 (244 nm)
	12,477 (801.5 nm)		29,455 (339.5 nm)

Calibration Curve for Vanadium (V) in 8 Molar Hydrochloric acid

Table 6: Calibration Curve for Vanadium (V) in 8 Molar Hydrochloric acid.

Concentration (M)	Absorbance (Nm)
0.001	0.003
0.005	0.015
0.01	0.03

Figure 6 of calibration curve for Vanadium (V) in 8 Molar Hydrochloric acid

Conclusions

Having investigated the strength of tri-butyl phosphate, tri-octyl phosphine oxides, Bis-2-(ethyl hexyl) phosphoric acid in n-heptane for the effect of ageing of extraction of Vanadium (V) from hydrochloric acid solutions. The following conclusions are drawn:

- Extraction percentage in tri-butyl phosphate from 6 Molar hydrochloric acid decreases and then constant, tri-octyl phosphine oxides from 6 Molar hydrochloric acid was constant and decreases, Bis-2-(ethyl hexyl) phosphoric acid from 6 Molar hydrochloric acid decreases and then constant with ageing.

- Extraction percentage in tri-butyl phosphate from 8 Molar Hydrochloric acid increases, tri-octyl phosphine oxides from 8 Molar hydrochloric acid was constant, and then fluctuate, Bis-2-(ethyl hexyl) phosphoric acid from 8 Molar hydrochloric acid decreases and then fluctuate with ageing.

- For extraction percentage from 6 Molar hydrochloric acid, a tri-octyl phosphine oxide is more efficient for the extraction of Vanadium (V) than the two other extractants as ageing progresses.

- For extraction percentage from 8 Molar hydrochloric acid, a tri-octyl phosphine oxide is more efficient for the extraction of Vanadium (V) than the two other extractants as ageing progresses.

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