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### RESEARCH ARTICLE

## AN EFFICIENT SOLVENT EXTRACTION METHOD FOR NIOBIUM AND TANTALUM BY LAURYL ALCOHOL IN KEROSENE.

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#### Abstract

The present study on physically upgrade ore sample from Abu Rusheid contents 22.2 in wt. % Nb and 2.5 in wt. % Ta. The sample is fused with a mixture of sodium dihydrogen phosphate monohydrate and of disodium hydrogen phosphate in platinum crucible and the metal was dissolved in water. Extraction of Ta (V) and Nb (V) from the solution was carried out by 0.1 M lauryl alcohol in kerosene. The factors of pH, contact time, temperature, settling time and A/O phase ratio were studied. Stripping of Nb (V) and Ta (V) was performed using 5M H<sub>2</sub>SO<sub>4</sub> for Nb(V) and distilled water for Ta(V) at O/A phase ratio 1:1 in two stages. The final recovery of Nb<sub>2</sub>O<sub>5</sub> and Ta<sub>2</sub>O<sub>5</sub> was 89% and 94% respectively. Stripped solution of Nb and Ta was precipitated by ammonia at pH 6.5-7.5 and pH 4.5-5.5 respectively and the product was confirmed by EDAX, XRD and FTIR analysis. Finally a technical flow sheet was constructed.

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#### Introduction:-

The niobium–tantalum ore in Abu Rusheid area was classified as refractory mineral of low-grade which was mainly composed of columbite. The Nb- Ta mineralization (columbite) at Abu Rusheid area has been known since the end of 1970s when a joint Soviet –Egyptian team, completed an evaluation based on the results of 1365 geochemical samples. Abu Rusheid was not explored until now but estimated as a big deposit accounting for ore reserves of 13 thousand tons of Ta<sub>2</sub>O<sub>5</sub> and 90 thousand tons of Nb<sub>2</sub>O<sub>5</sub> in contents amounting to 0.02 and of 0.14 % respectively (Sabet et al; 1976). Recently, Nuclear Materials Authority (NMA) launched a comprehensive exploration program in Wadi Al Gamal Basin since (2002) for Nuclear resources (REEs, Zr, Nb-Ta, Th, U, Ag ,... ) in the cataclastic rocks of Wadi Abu Rusheid area (Fig.1) (Ibrahim et al., 2002 and 2004).

According to United States Geological Survey (USGS), the global reserves of tantalum are larger than 100,000 tons, of which about 62% are found in Australia and about 36% in Brazil. The largest two tantalum deposits are both in Australia. Nowadays, about 15% to 20% of the total tantalum production is from waste recycling processes (Hintemann et al., 2018).

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The decomposition of tantalite- and niobium-bearing concentrates and obtainment of metal tantalite and niobium or their compounds is one of the most complex problems of rare metal technologies (Mehmet et al., 2018). The niobium– tantalum minerals associated with rare earth mainly exist in the form of multiple oxides, were readily leached under strong acidic conditions (Wang et al., 2012, Kumar et al., 2011). These minerals are often treated with many methods to extract the valuable metals, such as acid leaching, alkaline leaching, and roasting followed by hydrofluoric acid and electrolytic leaching (Zhang et al., 2011, Janacek et al., 2017). The separation and purification of these metals is mainly performed by extraction.

Two types of extraction flow sheets are used. The first type includes joint extraction of tantalum (V) and niobium (V) followed by their separation in the backwashing stage. The second type is based on successive selective recovery of tantalum (V) and niobium (V). To improve extractive separation of Ta (V) from Nb (V), an additional mineral acid (as a rule, sulfuric acid) is added into the solution. The  $H_2SO_4$  concentration in this solution should be relatively low, and the lower, the stronger the extractant basicity (Nikolayev et al., 2002).

All niobium minerals can be decomposed by hydrofluoric acid with complete dissolution, and this method is widely used for the dissolution of niobium–tantalum minerals (Zhou, et al., 2005 & 2011). However, concentrated hydrofluoric acid was easy to volatilize, which caused serious pollution problems (Zhou et al., 2004). Anatoly et al., (2004) applied liquid extraction of tantalum with 2 octanol. Where Maiorov, et al., (2010, 2013, 2015&2016) studied extraction recovery of Ta (V) and Nb (V) with octanol from HF acid solution containing large amount of Ta (V). Nikolover, et al., (2009) developed the flow sheet for the preparation of pure tantalum and niobium oxide. Kasikava, et al., (2009 & 2010) developed a process for converting Ta (V), Nb (V), Ti (V) sulphates and chlorides to their fluorides in order to improve separation of these elements. They extract Nb (V) from hydrochloride solution with tertiary amines in a protect diluents. A more trials for acid breakdown, leaching and extraction from some Egyptian ore material are given by El Huesani, (1996), El Hazeq, (2001), Amer, (2007), El Hazeq, et al., (2009, 2010).

### Geologic Setting

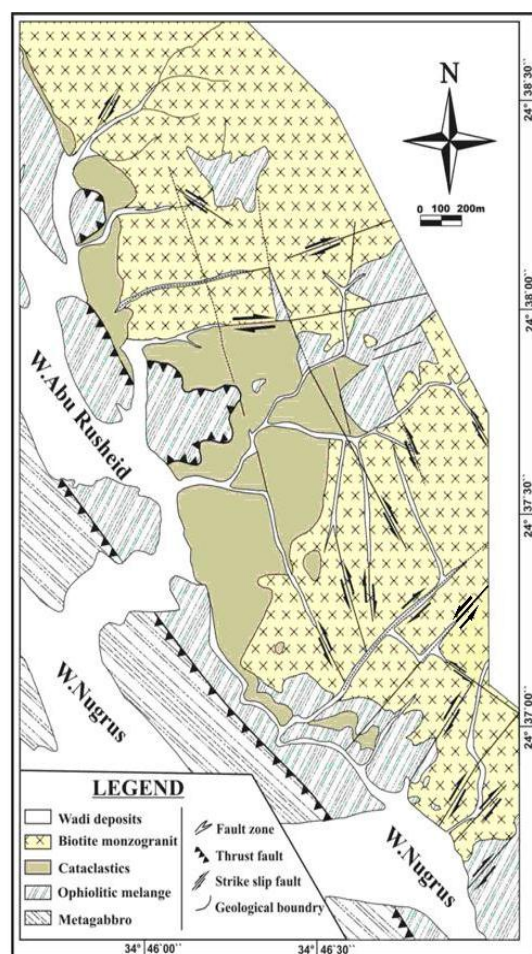
A geologic map of Abu Rusheid area was constructed (3 km<sup>2</sup>) on the base of a grid pattern 20 x 20 m (Figure .1) about 2 km<sup>2</sup> cataclastic rocks (host rock for Nb-Ta). The cataclastic rocks of Abu Rusheid area are highly sheared and characterized by banding (N-S) and cross-cut by perpendicular two shear zones generally (N-S and E- W). The cataclastic rocks are subdivided into: a) protomylonite, b) mylonite, c) ultramylonite and d) quartzite with gradational contacts. Columbite- tantalite occurs abundantly as disseminated minute grains either as single crystal or aggregates, visible by naked eyes (Ibrahim et al., 2002 & 2004).

Niobium content in Abu Rusheid area, ranges from 300 to 2000 ppm and forms high concentrated occurrences in the southern part of the study area (Fig.1) and covers an area of about 1,500,000 m<sup>2</sup> with average content 500 ppm. The estimated Nb was based on the evaluation over Wadi Abu Rusheid level (385m). The Nb- map (Fig.2) excludes all Nb-grade more than 0.1%. The Nb /Ta ratio is around 10. Abu Rusheid inferred resources are calculated on the basis of more than 100 ppm Ta and 500 ppm Nb as an average (Ibrahim et al., 2008 & 2018) as follows:

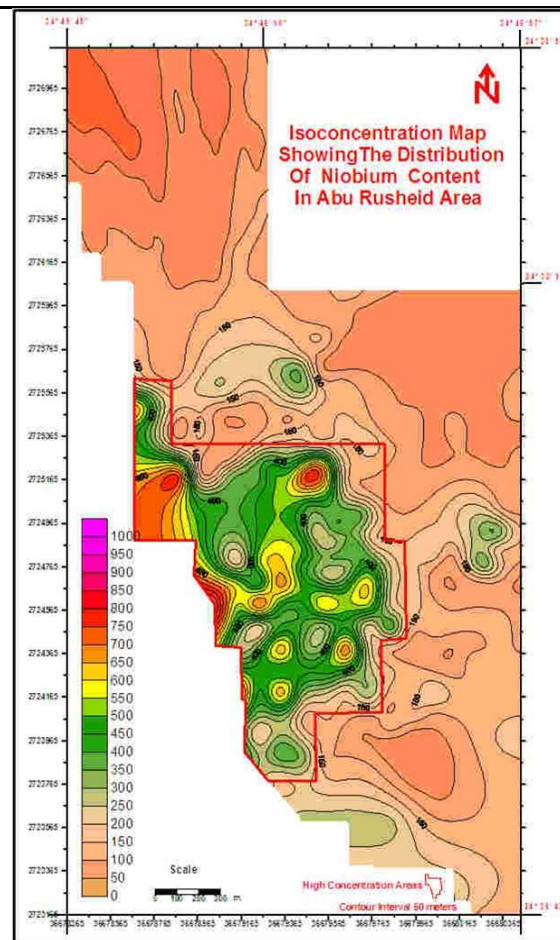
Trace Elements	Average Thickness (m)	Surface Area (m <sup>2</sup> )	Tonnage (m <sup>3</sup> )	Ore Grade (%)	Ore Metal (Tons)
Niobium (Nb)	75	1,500,000	220,000,000	0.05	86,170

The majority of mineral grains are considered Ferro-columbite with minor amounts of Ta and Mn. The corresponding chemical analyses are shown in Table (1). The results indicate the presence of excess of  $UO_2$  and  $P_2O_5$  in some samples. Other columbite grains seem to be contaminated with various mica types.  $Nb_2O_5$  contents range from 40.13 to 74.45 in wt. %, while  $Ta_2O_5$  varies from 2.64 to 6.70 in wt. %. Columbite is commonly in association with Fe–Ti oxides and U-Pb mineral (most probably kasolite). In view of the ore side, it is of scientific and practical interest to carry out a systematic investigation in

order to find out the appropriate condition for separating each of Ta (V) and Nb (V) using an efficient breakdown and leaching reagent beside a new solvent.



**Fig 1:-**Geologic map of Abu Rusheid area, (after Ibrahim et al., 2004).



**Fig 2:-**Isoconcentration map showing the distribution of niobium content in Abu Rusheid area, after Ibrahim et al., (2008).

**Table 1:-**Results of ESEM analyses for ferricolumbite, Abu Rusheid cataclastic rocks

	1	2	3	4	5	6	7
P <sub>2</sub> O <sub>5</sub>	3.72	0	0	0	0	0	0
CaO	0.24	0.2	0.33	0.33	0.25	1.65	1.46
TiO <sub>2</sub>	0.63	0	0.67	0.63	0.38	0.42	0
MnO	2.22	3.61	2.98	3.47	3.32	0.33	0
Fe <sub>2</sub> O <sub>3</sub>	15.13	13.8	13.61	22.78	14.77	3.58	3.46
TaO	3.62	4.74	4.76	5.87	6.70	3.09	2.64
Nb <sub>2</sub> O <sub>5</sub>	74.45	72.58	66.19	60.47	69.61	50.16	40.13
Al <sub>2</sub> O <sub>3</sub>	0	1.67	1.25	2.03	0	1.58	2.56
Y <sub>2</sub> O <sub>3</sub>	0	2.45	0	0	0	0	14.07
UO <sub>2</sub>	0	0.54	4.85	0	0.64	20.09	18.84
K <sub>2</sub> O	0	0.4	0.74	0	0	1.89	1.38
SiO <sub>2</sub>	0	0	4.27	4.42	4.18	4.33	4.54
ThO <sub>2</sub>	0	0	0	0	0.16	2.26	0
PbO	0	0	0	0	0	9.07	3.34

<b>Total</b>	<b>100</b>	<b>99.99</b>	<b>99.99</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>
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### Extraction

#### Ore Opening (Preparation of sample solution):

Four grams of sodium dihydrogen phosphate monohydrate and four grams of disodium hydrogen phosphate were mixed well in a dry platinum crucible, heated slowly first on wire gauze, and then strongly on the flame for the formation of condensed phosphate. An accurately weighed 0.5 g. sample portion was added to the cooled melt. The crucible with the content was heated on the flame for fusion with swirling. After 3 – 4 minutes, the crucible was covered with a platinum lid and kept on the burner for complete decomposition (about 5 minutes). The crucible was swirled intermittently, cooled and transferred in to a 250-ml beaker containing distilled water. The beaker was heated on a water bath for dissolution of the melt. The crucible was removed from the beaker, washed thoroughly, and the volume was made to 100 ml.

### Analytical procedures

To define the mineralogical composition of the working ore material, the bulk and separated picked grains were subjected to: 1)-X-Ray diffraction analysis using a Philips X-ray diffract meter, model PW 223/20. In this analysis, the copper tube was operated at 40 KV and mA.3. 2) -Environmental scanning electron microscope (ESEM), Philips X1.30 and 4) - ICP Standards and calibration curve. The measurement was performed using simultaneous inductively coupled plasma emission spectrometer (720 ICP-OES, Agilent Technologies). Samples were introduced via glass concentric nebulizer fitted to glass cyclonic spray chamber (single pass).

### Solvent extraction of Nb and Ta

Extraction of Nb and Ta was carried out using the organic solvent Lauryl alcohol. The solvent was diluted in kerosene to prepare different concentrations. In an each extraction experiment, the organic phase was conducted with the aqueous phase as in separating funnel where they were shaken together for the desired time. The two phases were then allowed to settle, separate and an aliquot sample of the aqueous phase was analyzed for its remaining metal content in order to calculate the distribution coefficient.

### Extraction Isotherm and construction of Mac Cabe Thiele diagram for the extraction process

10 gm of both organic (0.1 M Lauryl alcohol in kerosene and aqueous phase are contacted for 15 mins until equilibrium is attained. The phases are allowed to separate and aqueous phase is removed from the separating funnel and analysis. Fresh aqueous solution is then added to the funnel containing the remainder of the organic phase in an amount to give the same phase ratio as the originally used. The two phases are again contacted until equilibrium is obtained. This process is carried out until saturation of the solvent with Nb or Ta is obtained, pH should be adjusted to 0.25 for Nb and 2 for Ta. The obtained data were used to obtain the equilibrium curve. The next step in the construction of McCabe-Thiele diagram was to try a number of operating lines. The slope is equal to the ratio of organic/aqueous volumes. At each operating line, the theoretical number of stages could be stepped off upon the diagram.

### Equilibrium line and construction of Mc-Cabe Thiele diagram for the stripping:

In this study 10 gm loaded organic (0.1 M lauryl alcohol, in kerosene and 10 gm of 5 M H<sub>2</sub>SO<sub>4</sub> (stripping reagent for Nb) are contacted for 10 mins until equilibrium is attained. The phases are allowed to separate. A measured portion of the aqueous phase is taken for analysis. Fresh loaded 0.1 M lauryl alcohol is added to the separating funnel containing the remainder of the aqueous phase in amount to give the same phase ratio as original ore used. The same procedure is carried out. This process is carried out until solution of the aqueous phase with Nb is obtained. The same procedure is done for Ta except that the stripping agent is distilled water.

### Precipitation

Precipitation of each of Nb (V) and Ta (V) solution, each of the solution of Nb and Ta was precipitated by ammonia solution at pH 6-7.5 for Nb and 4.5-5.5 for Ta and calcined at 650 °C for 3 hrs. Finally a proposed technical flow sheet is given in Fig. (23).

## Results & Discussion:-

### Analysis of bulk sample:

Table 2:-shows average concentration of major oxides (wt. %) and trace elements (ppm) in mylonite sample, Abu Rusheid area

Oxides %	1
SiO <sub>2</sub>	71.12
TiO <sub>2</sub>	0.16
Al <sub>2</sub> O <sub>3</sub>	11.33
Fe <sub>2</sub> O <sub>3</sub>	9.55
MnO	0.50
MgO	0.16
CaO	0.39
Na <sub>2</sub> O	0.62
K <sub>2</sub> O	4.77
P <sub>2</sub> O <sub>5</sub>	0.005
Total	98.69
Cu	32
Pb	490
Zn	2100
Ni	1.5
U	1730
Th	3500
Sr	44
Ba	78
W	26
Zr	900
Sn	50
Y	860
Hf	52
Rb	2000
Ta	770
Nb	7600

### Chemical analysis:

Complete chemical analysis of the physically upgraded ore sample form Abu Rusheid mylonite is shown in Table (3) as defined by ICP.

Table 3:-Chemical analysis of the studied sample

Major constituent	Wt. (%)	Trace constituent	Wt. (%)
SiO <sub>2</sub>	29.5	Nb	22.2
TiO <sub>2</sub>	1.2	Ta	2.5
Al <sub>2</sub> O <sub>3</sub>	12.3		
Fe <sub>2</sub> O <sub>3</sub>	21.3		
CaO	1.1		
MgO	0.5		
MnO	2		
Na <sub>2</sub> O	1.02		
K <sub>2</sub> O	2.8		
P <sub>2</sub> O <sub>5</sub>	0.3		
L.O.I	0.4		
Total			99.5

### Characteristics

#### X-Ray diffraction pattern

Figure (3) shows XRD pattern of Nb ore sample from Abu Rusheid mylonite, while Ta not clear on the figure because of its less contents (less than 5 wt. % in the sample).

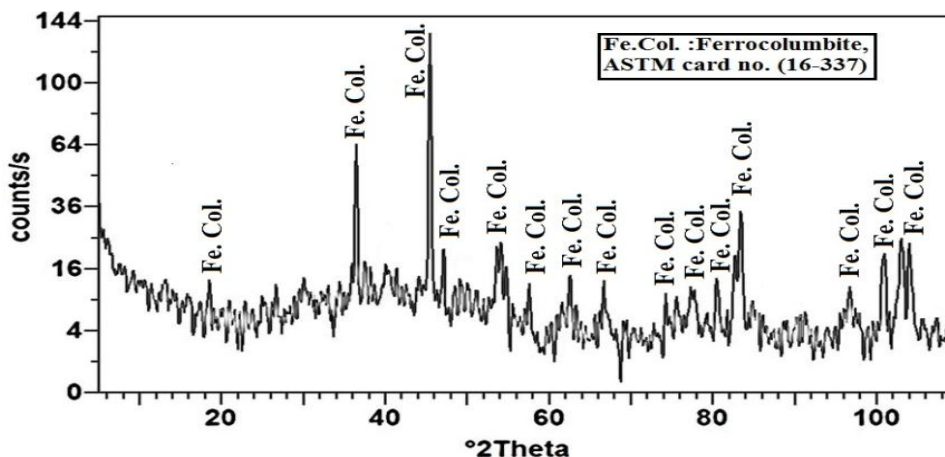
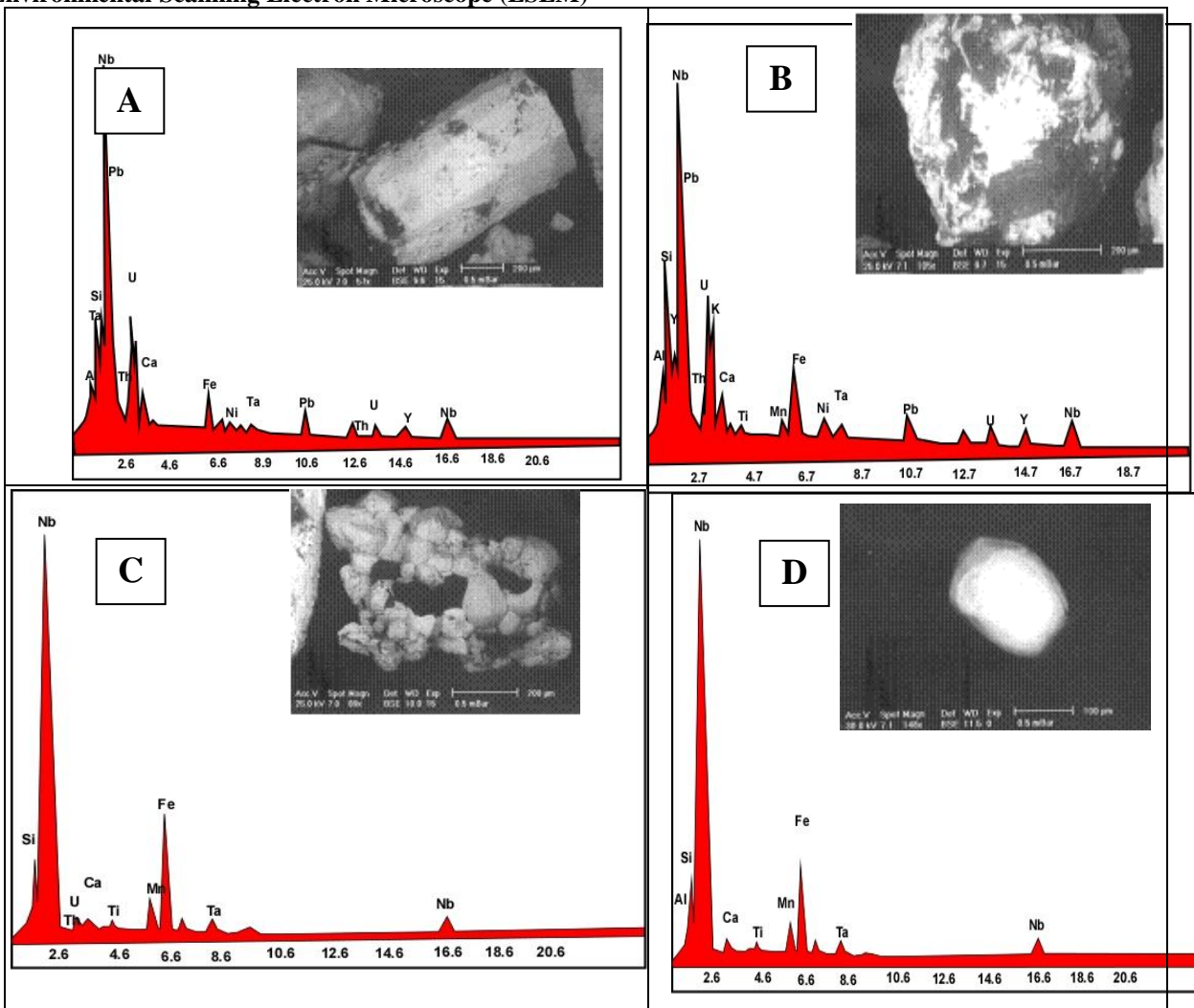


Fig 3:-X-Ray of Nb ore sample



**Environmental Scanning Electron Microscope (ESEM)**

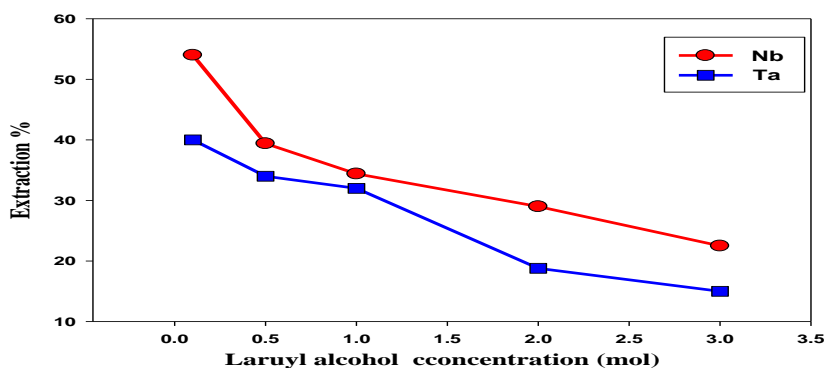
**Figure 4:-EDX showing different varieties of columbite from Abu Rusheid mylonite.**

**Recovery of Niobium and Tantalum**

Actually, the factors affecting solvent extraction process included solvent concentration, contact time, pH of the leach liquor and aqueous/ organic ratio (A/O). These factors were studied for both interesting metal values; Ta and Nb.

**Effect of lauryl alcohol concentration**

This effect was studied upon the Nb and Ta extraction efficiency where in the case of Nb extraction by conducting equal volumes of the feeds solution (free from Ta) with different solvent concentration ranging from 0.1M to 3M at a fixed contact time 15 mines at pH 0.25 and A/O phase ratio of 1:3. The result is plotted in fig. (5). From the results, it is clear that the extraction of niobium decrease gradually with increasing of alcohol concentration from 0.1M to 3 M, so, the best concentration of lauryl alcohol for Nb extraction is 0.1 M in kerosene. But in the case of the feeds solution (free from Nb) with different solvent concentration ranging from 0.1M to 3M at a fixed contact time 10 mines at pH 2 and A/O phase ratio of 1:3. The result is plotted in Fig. (5). From the results it is clear that the extraction of Ta decrease gradually with increasing of alcohol concentration from 0.1M to 3 M, so, the best concentration of lauryl alcohol for Ta extraction is 0.1 M in kerosene.



**Figure 5:-**Effect of Lauryl alcohol concentration up on extraction efficiency of Nb (V) and Ta(V)

#### Effect of different diluents on the extraction process

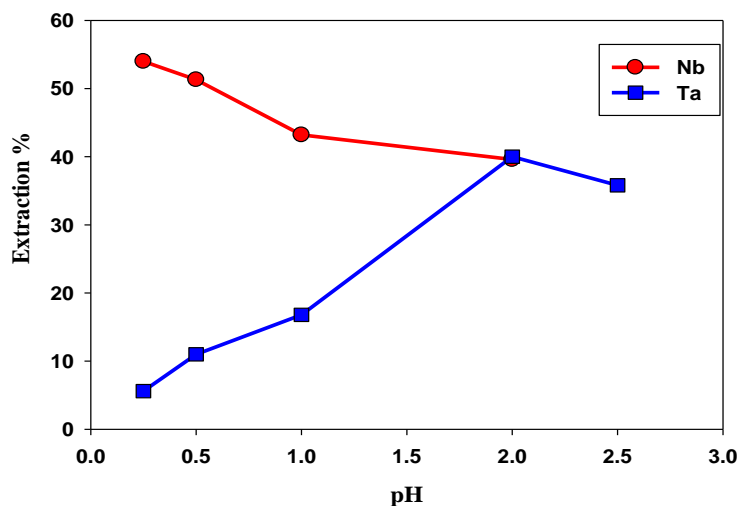
Table (4) reveals that kerosene is the best diluent for both Nb (V) and Ta (V) extraction.

**Table 4:-**Effect of diluents on the extraction of Nb (V) and Ta (V) by 0.1 M lauryl alcohol in kerosene

Diluent	Extraction % of Nb	Extraction % of Ta
Kerosene	60	54.3
CCl <sub>4</sub>	49.1	51.8
Xylene	49.1	46
Benzene	45.2	38.8
Chloroform	42.8	32
Toluene	40.4	28.9

#### Effect of pH of feed solution

To study the effect of pH of the feed solution upon Nb extraction efficiency, different pH values ranging from 0.1 to 2 of the feed solution were conducted while fixing the other extraction conditions 0.1M lauryl alcohol and A/O ratio 1:3, the corresponding Nb extraction efficiencies are show in Fig. (6), from the results obtained it is obvious that increasing the pH from 0.1 to 2.0, decreases the extraction of Nb from 54% to 39.6%. So it can be concluded that the best pH for Nb extraction at 0.25 and for Ta at 2.0.



**Fig 6:-**Effect of pH upon the extraction of Nb(V) and Ta(V)

#### d. Effect of contact time on the extraction process

To study the effect of contact time upon the extraction of Ta and Nb by 0.1M lauryl alcohol in kerosene, set-of experiment was performed at different contact time while fixing the other extraction factors at A/O phase ratio of 1:3, 0.1 M lauryl alcohol in kerosene and pH 0.25 for Nb and pH 2.0 for Ta. The data are plotted in Fig. (7). From the results obtained, it is clear that increasing the time from 5 to 15 min. increase Ta extraction efficiency to 54% and 60% for Nb. So it is concluded that the contact time for maximum extraction of Ta and Nb was 15 minutes.

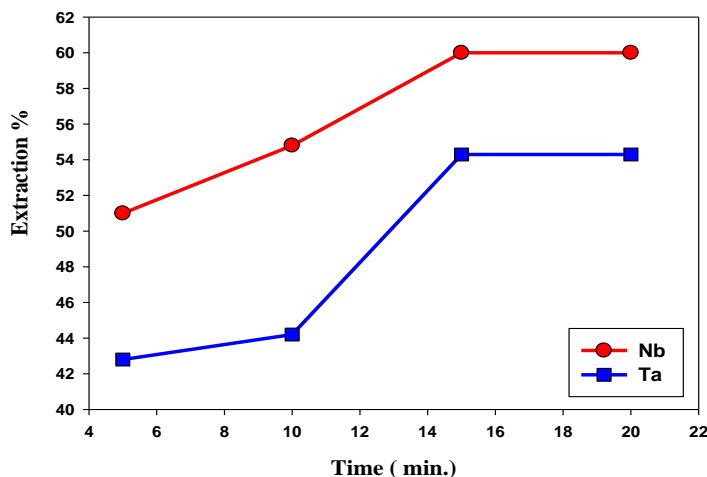


Figure 7:-Effect of contact time on the extraction of Nb (V) and Ta (V)

#### Effect of A/O phase ratio on the extraction of Nb and Ta

As it is clear from Figure (8) the best A/O phase ratio is 1:3 in both Ta and Nb percent extraction.

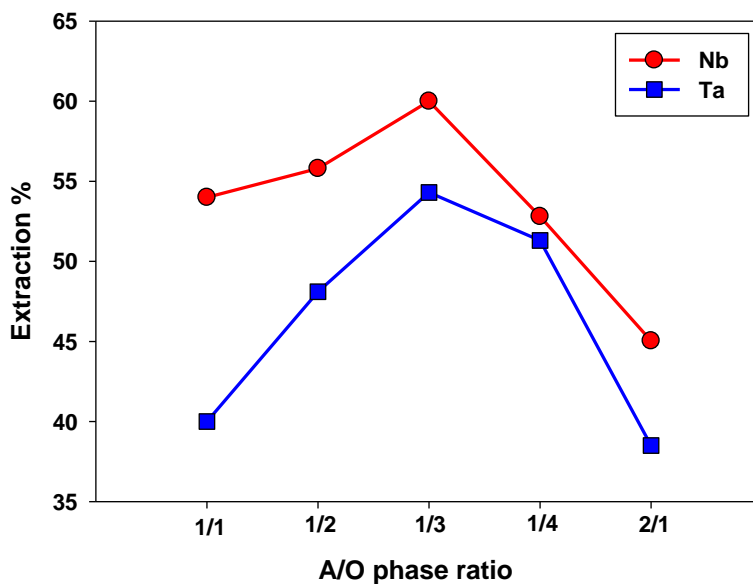
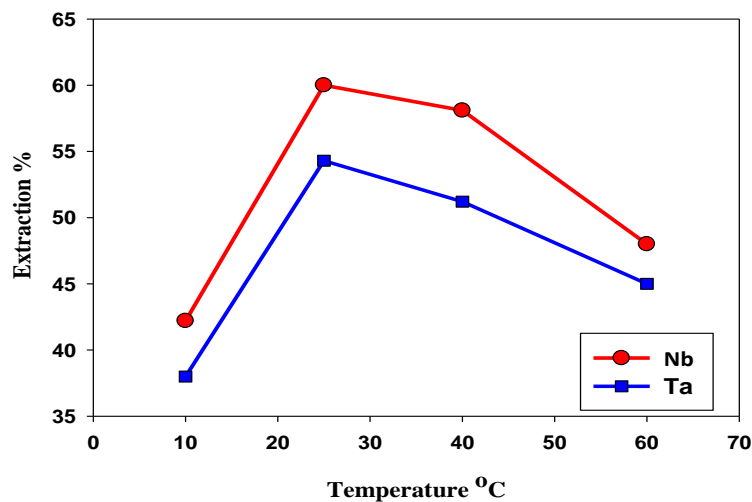


Figure 8:-Effect of A /O phase ratio on the extraction of Ta (V) and Nb(V)

#### Effect of temperature upon the extraction of Nb(V) and Ta(V)

The present factor is studied between 10°C and 60 °C. It is obvious that room temperature give the best extraction for Ta and Nb. This shows that reaction is exothermic.





**Figure 9:-**Effect of temperature upon the extraction of Nb (V) and Ta(V).

It is clear from fig. (9) that room temperature is the best temperature for the two metallic elements.

### Stripping

#### Effect of different stripping reagent on the stripping process

**Table 5:-**Effect of different stripping reagent on the stripping of Nb (V):

Stripping reagent	% Stripping Nb
0.5 M H <sub>2</sub> SO <sub>4</sub>	24.8
5 M H <sub>2</sub> SO <sub>4</sub>	68.1
7 M HF + 6 M H <sub>2</sub> SO <sub>4</sub>	57.4
10 M HF	35.8
10 M H <sub>2</sub> SO <sub>4</sub>	41.3

It is clear from Table (5) that 5 M H<sub>2</sub>SO<sub>4</sub> give is the highest stripping value for Nb.

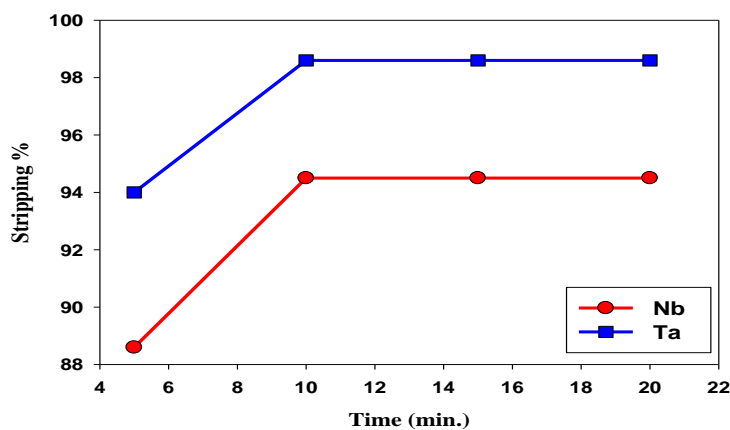
**Table 6:-**Effect of different stripping reagent on the stripping of Ta (V)

Stripping reagent	% Stripping Ta
Distilled water	75
0.5 M HF	20.8
0.5 M H <sub>2</sub> SO <sub>4</sub>	25.3
0.7 M H <sub>2</sub> SO <sub>4</sub> + 0.5 M HF	38.3

The best stripping reagent for stripping Ta is distilled water where 75 Ta stripping % is obtained (Table 6).

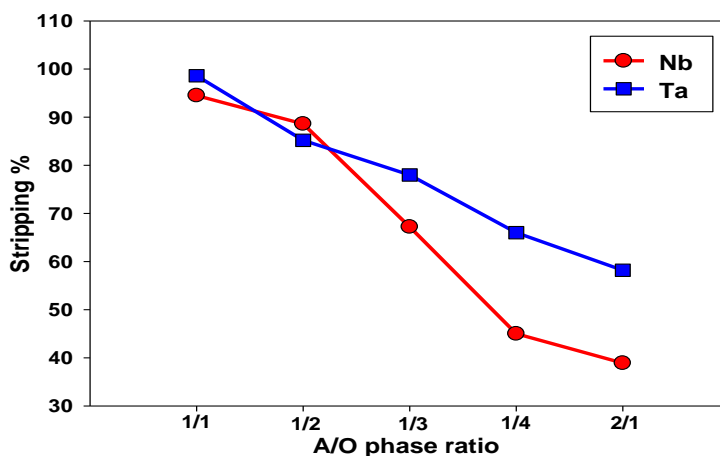
#### Effect of contact time on the stripping process of Nb(V) and Ta(V):

It is clear from Fig. (11) that at contact time of 10 mins, gives the highest stripping value for Ta (98.6%) and Nb (94.5%).



**Fig 10:-**Effect of contact time on the stripping of Nb (V) and Ta (V)

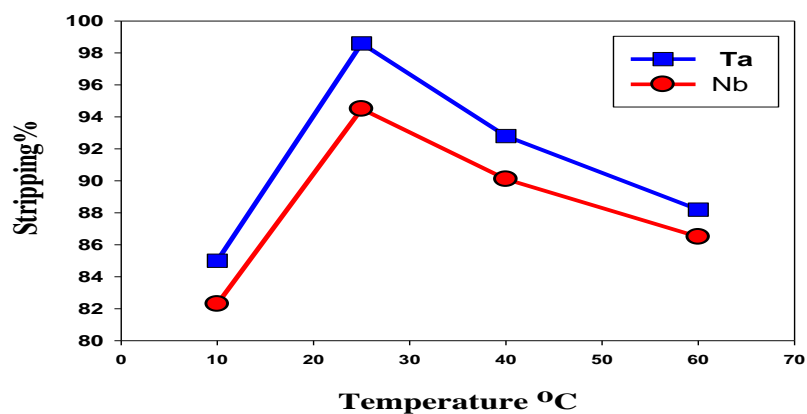
**Effect of aqueous / organic phase ratio on the stripping process of Nb (two stages) and Ta**



**Fig 11:-**Effect of A / O phase ratio on the stripping of Nb (V) (Two Stages) and Ta (V) (Two Stages).

It is clear from Fig. (11) that 1:1 is the best stripping A/O phase ratio for both Nb and Ta .

**Effect of temperature on the stripping process**



**Fig 12:-**Effect of Temperature on the stripping of Nb (V) and Ta (V).

From Fig. (12) it is clear that room temperature give the highest stripping % for Ta 98.6 and Nb 94.5% Activation energy.

#### Construction of McCabe – Thiele diagram for Nb Extraction

M McCabe – Thiele diagram is a compos diagram composed of two lines an equilibrium line and an operating line. It is shown from the diagram that two stage stripping is adequate for both Nb and Ta extraction and stripping.

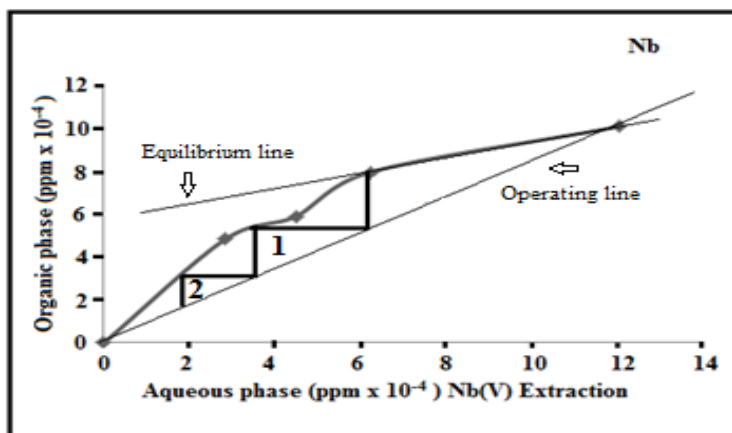


Fig 13:-McCabe – Thiele diagram for Nb extraction

It is clear from the obtained McCabe – Thiele diagram for Nb stripping the two stages. Stripping gives the highest Nb value at a phase ratio of 1:1 (Figs.13 &14).

#### Construction of McCabe – Thiele diagram for Nb Stripping

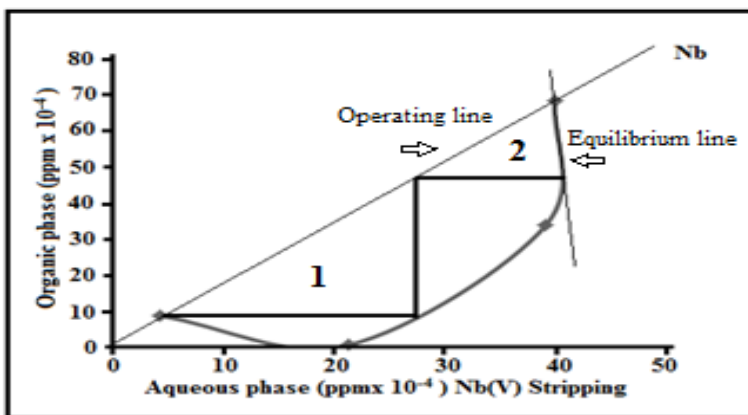


Figure 14:-McCabe – Thiele diagram for Nb stripping

#### Construction of McCabe – Thiele diagram for Ta Stripping: aqueous

McCabe – Thiele diagram is composed of two lines a) Equilibrium line and b) Operating line (Figs.15&16).

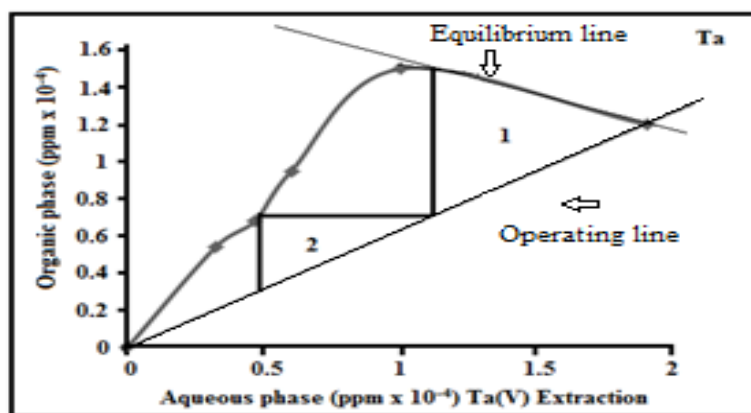


Fig 15:-McCabe- Thiele diagram for Ta extraction

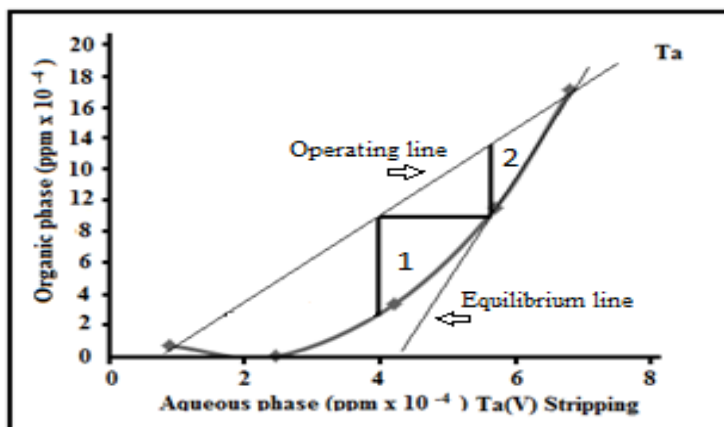


Fig 16:-McCabe- Thiele diagram for Ta stripping

**Precipitation of both Ta and Nb**

Precipitation of Ta is achieved by ammonia at pH 4.5-5.5 while that of Nb by ammonia at pH 6-7.5. Calculation of these precipitate at 650 °C for 3hr give  $Ta_2O_5$  and  $Nb_2O_5$  in a pure forms. Final product as shown in EDX for Nb (V) and Ta (V) (Figs. 17 & 18). Finally a technological flow sheet is proposed for each Nb and Ta (Fig.19).

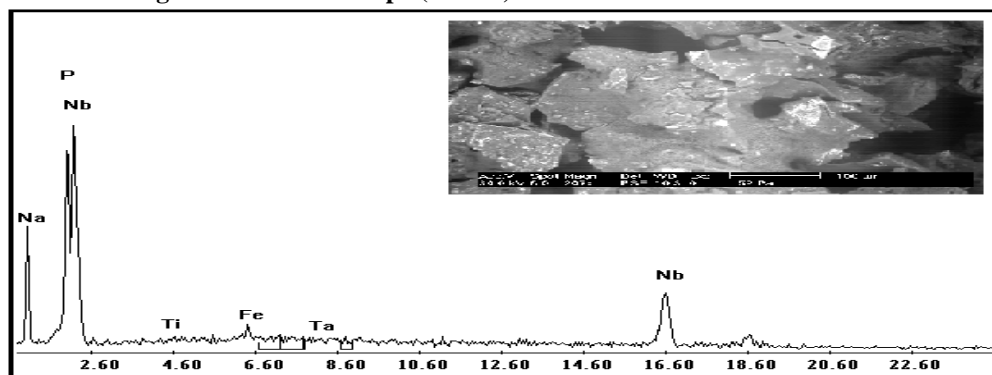
**Characterization of product:****Environmental Scanning Electron Microscope (ESEM):**

Figure 17:-EDX and backscattered images of Nb product

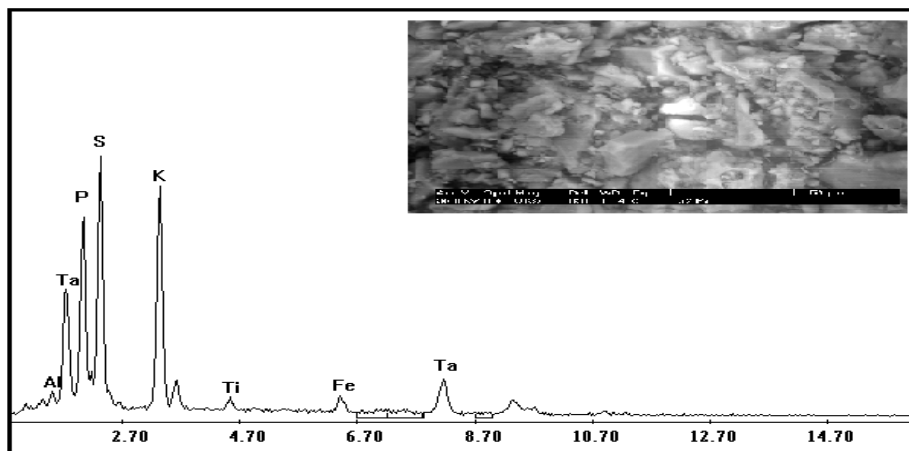


Figure 18:-EDX and backscattered images of Ta product

### Infrared spectroscopy (FTIR)

Figures (3, 4 & 5) show infrared transmission spectra of Tantalum, Niobium and a mixture of Nb and Ta (study sample) in the range  $4000-400\text{ cm}^{-1}$ .

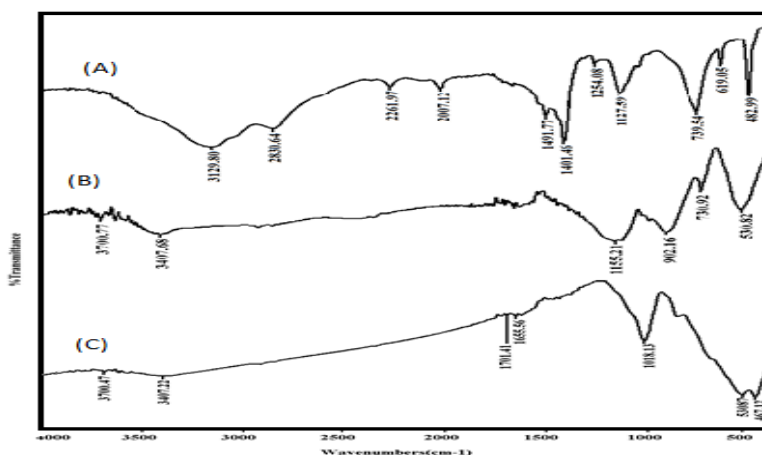


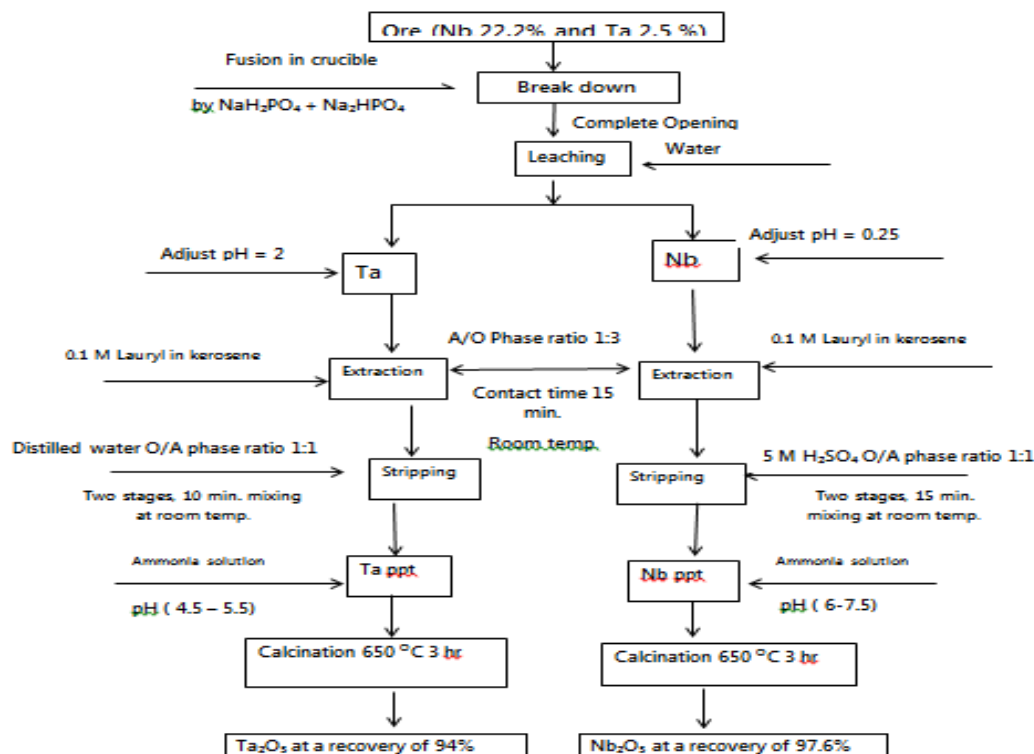
Fig 19:-FTIE of Nb and Ta ore and product

Where (A) = FTIE of Ta (V) precipitate.

(B) = FTIE of Nb (V) precipitate.

(C) = FTIE of Nb and Ta Ore

In Fig. (19) (C) The splitting of Nb-O stretching vibration peaks at  $590.52\text{ cm}^{-1}$  and the Ta -O stretching vibration peaks at  $467.12\text{ cm}^{-1}$  is an indication of Nb and Ta ore. This bands is shown only as one peak at  $428.99\text{ cm}^{-1}$  for Ta Fig. (19 A) and  $530.18\text{ cm}^{-1}$  as Nb Fig. (19 B).The bending mode of Nb-O and Ta-O stretching vibration bay outside the range of the infrared instrument.



**Fig 20:-**Proposed technical flow sheet for extraction of Ta (V) and Nb (V) from ore material

### Conclusion:-

The Nb- Ta mineralization (columbite) at Abu Rusheid area has been estimated as a big deposit accounting for ore reserves of 13, 000 tons of  $Ta_2O_5$  and 90, 000 tons of  $Nb_2O_5$  in contents amounting to 0.02 and of 0.14 % respectively (Sabet et al; 1976). Abu Rusheid inferred resources above Wadi Abu Rusheid level are calculated on the basis of ore grade 0.01% Ta and 0.05 % Nb as follows: 86.170 tons Nb and 8.6 tons Ta (Ibrahim et al., 2008 & 2018).

Ore characterization has first been prepared chemical analysis revealed the presence of valuable metal oxide involve 22.4 in wt.%  $Nb_2O_5$  as well as 2.4 in wt.%  $Ta_2O_5$  due to the refractory nature of the studied ore material, a breakdown by equal mixture of dihydrogene phosphate monohydrate and disodium hydrogen phosphor for complete decomposition filtered by water leaching.

Recovery of interesting metals (Nb and Ta) from bisulphate leach liquor involved several steps first extraction with 0.1M lauryl alcohol in kerosene as a new solvent at pH 0.25 for Nb and contact time 15 ml/ min. in a one stage followed by stripping in two stages with 5M  $H_2SO_4$  and Nb precipitation with ammonia at pH 6-7.5 followed by calcinations at 650 °C for 3hr. A pure  $Nb_2O_5$  is obtained at a recovery of 94.5%, whereas Ta is extracted at pH 2.0 with 0.1M lauryl alcohol in kerosene at a contact time of 15 ml /min. Stripping with water in two stages and precipitation with ammonia at pH 4.5-5.5, followed by calcinations at 650°C for 3 hrs. A pure  $Ta_2O_5$  is obtained at a recovery of 98.6% (Fig.18). Finally a technical flow sheet is given for processing of studied ore as show in Figure (20).

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