

# Solvent Extraction of Ni and Cu from Synthetic Solution Containing Ni, Cu, Fe and Zn by Using D2EHPA

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**Abstract** Solvent extraction is one of the effective methods for extracting copper and nickel from aqueous solution of pregnant liquid solution. This research is mainly based on direct solvent extraction method. The effect of extraction of D2EHPA on extraction of copper and nickel ions in synthetic solution has been investigated. In this study, by changing the levels of parameters such as speed and time of mixing, concentration of extractor, acidity (pH) and temperature were determined to extract copper and nickel from synthetic solution. It should be noted that, in this synthetic solution, the amount of copper was 770 ppm, nickel 3200 ppm, iron 800 ppm, and 200 ppm. The results of the experiments showed that the best and highest extraction of copper and nickel ions at 5 min, speed of 700 rpm, temperature= 45 ° C, extractor concentration= 30% and ratio A / O = 3 at pH = 6.

**Keywords:** solvent extraction, D2EHPA, pregnant liquid solution, copper and nickel extraction

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## 1. Introduction

Hydrometallurgical method is practiced in almost of the mines in which their reservoirs are of oxide ores in order to extract metal from the liquid solution. According to statistics in 2010, approximately 4.5 million tons of copper metal is yearly extracted from its ore by hydrometallurgical methods [1]. Solvent extraction is based on a variety of organic solvents. The extractants with different formula have been produced and utilized in order to extract elements such as copper, nickel, zinc and etc. from aqueous solution [2-7]. The purpose of the using solvent extraction method is to enrich the impregnated solution and reduce the impurities associated with valuable elements. According to the studies, extractants like D2EHPA and Cyanex 272 have been used to separate cobalt, manganese and zinc ions from aqueous solution [8,9]. On the other hand, the extractants LIX for extract copper [10] and Cyanex group [11] like Cyanex 301 and 302 and mixing of D2EHPA and TBP have been utilized to extract nickel ions. Nowadays, several studies have been carried out on the extraction of nickel from aqueous solution of pregnant leach solution. According to the studies, Different parameters such as type and concentration of extractor, speed and stirrer time, temperature and the A/O ratio have a important effect on the extraction of nickel from its aqueous solution [12-15]. So, optimizing the effective parameter shall be affect to the extraction different metals from its liquid solution. To date, several papers have been published the separation of nickel and cobalt, but few of

them have considered the extraction of nickel, copper, iron and zinc elements in one complex. Rout and et.al observed that mixing of two extractant such as D2EHPA and Cyanex 272 can increased the extraction of zinc and manganese. Moreover, they investigated that pure D2EHPA can extract Zn from liquid solution containing Zn and Mn selectively [9]. Chu Yong Cheng and et al extracted cobalt and nickel by D2EHPA and mixing of LIX1104 and Versatic 10. They observed that LIX1104 in 0.6 M concentration, pH= 6 and time= About 2.5 min can extract 95% of Ni from its liquid solution.

Time and speed of stirring are another important parameters for extracting the elements from aqueous solution. Increasing the stirring speed, increases the amount of turbidity of the aqueous and organic solution. So, the recovery rate is reduced [8].

The aim of the present study is selective solvent extraction and stripping of Ni from its liquid solution containing Ni-Cu and Ni-Cu-Fe-Zn ions. The variety of solvent extractants. D2EHPA is the important parameters such as concentration extractant, temperature, pH, mixing speed and time were also done. Extraction of Ni from the synthetic aqueous solution containing four Cu, Ni, Fe and Zn ions.

## 2. Materials and Methodology

### 2.1. Materials

D2EHPA is known to be an organophosphorus extractor and is known by the chemical formula di-2-ethylhexylphosphoricacid with 97% purity.

The  $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ ,  $\text{NiSO}_4 \cdot 6\text{H}_2\text{O}$ ,  $\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$  and  $\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$  to prepare the synthetic solutions containing Cu-Ni-Fe-Zn ions. The concentration of elements in the industrial solution is illustrated in Table 2. And it should be noted that, kerosene is used for dilute of organic phase.

**2.2. Methodology**

Ni and Cu were extracted using the solvent extraction method by different extractants D2EHPA in 5, 10, 15, 20, 25, 30% concentrations. The other parameters such as Speed and time stirrer, pH, TEMP and A/O ration were optimized to high extract of nickel.

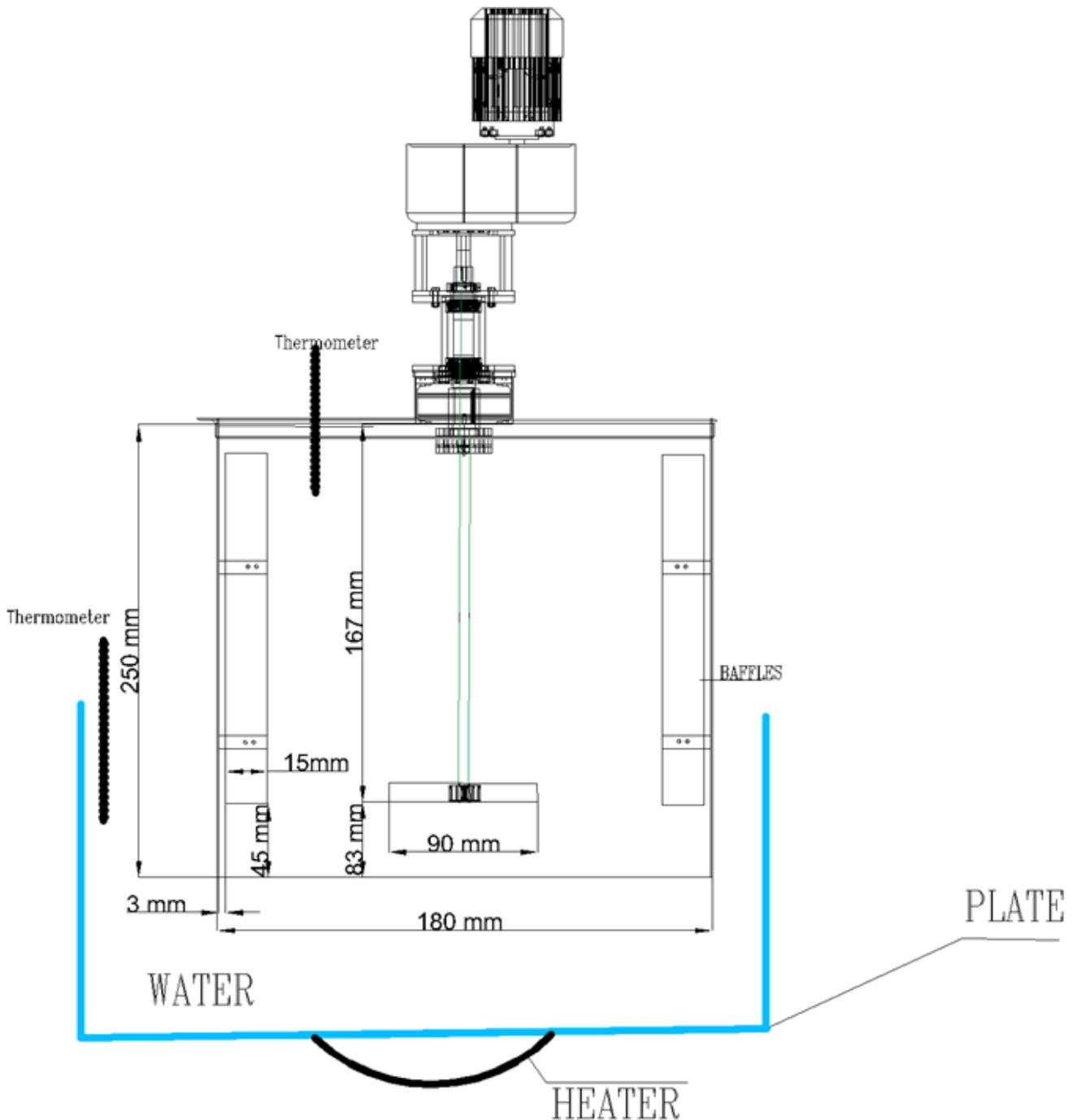
Table 1 is indicating of numerical parameters that used for extraction of Ni and Cu from its liquid solution.

**Table 1. Numerical parameters**

Type of organic	Parameters	D2EHPA
Organic CONC.		5-30 %
pH		2 – 6
Mixing speed		200 – 700 RPM
Mixing time		2 - 9 min
TEMP		25 - 45 °C
A/O		1:1 – 1:2 – 1:3 – 1:4

**Table 2. Elements concentration**

Elements	Ni	Cu	Fe	Zn	Co	Mg
Conc. (ppm)	3200	770	800	200	22	60



**Figure 1.** Detail design of mixer

### 2.3. Design of Tank and Agitator to Mixing

One of the important equipment in solvent extraction method is the agitator and tank of it. So, in this paper, the calculations of tank and agitator are included. It should be noted, all of calculation are follow the Denver sala and Industrial mixing hand books [18,19]. For these tests needed tank with 4-liter capacity. So, for better performance, 6-liter tank was designed. The type of impeller is pitched blade turbine and the material of shaft, impeller and baffles is stainless steel 316. Figure 1 is indicating of the detail design of it.

### 3. Result and Discussion

This extractant is categorized in the group of cationic organophosphorus extractant. Figure 2 is indicating the effect of organic (D2EHPA) concentration in different pHs for extracting Ni and Cu from its liquid solution.

According to Figure 2, increasing the pH can increase the extraction of nickel and copper in different organic concentrations. On the other hand, increasing pH from 2 to 6, the extraction of nickel and copper can increase till 30% and 20% Respectively. Also, increasing D2EHPA concentrate in pH=6 from 5% to 30% can extract nickel 38% and 52.5%. The extraction of copper and nickel 45% and 52% in pH=5 and 30% organic phase concentration respectively. So, in this level observed that pH=6 can extract copper and nickel better than the other pHs. Therefore, 6 was selected to continue the process and tests.

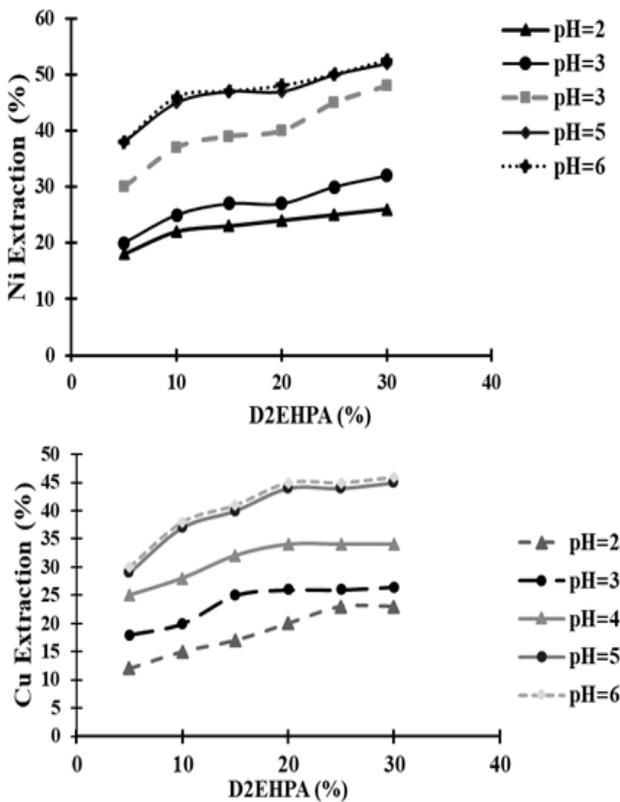


Figure 2. Extraction of Ni and Cu by different concentrations in pH=2-6 (RPM=500, TEMP= Ambient, Time= 5 min, A:O = 1:1)

Figure 3 is indicating of A:O ratio to extraction of Ni and Cu from its liquid solution.

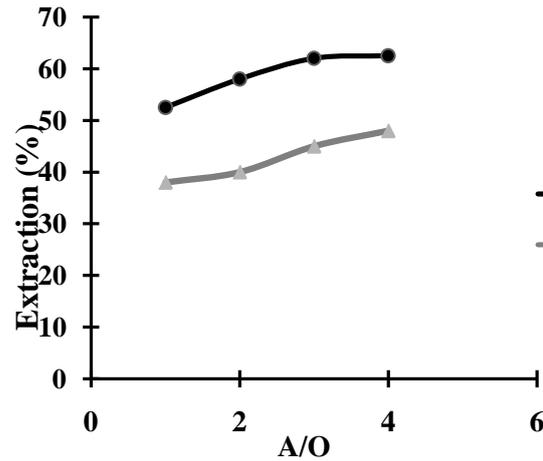


Figure 3. Extraction Cu and Ni from its liquid solution in pH=6, organic phase= 30%, RPM= 500, TEMP= Ambient and time= 5 min

As a Figure 3, A:O is important parameter that be used for extraction of Ni and Cu because by increasing of A:O the amount of nickel extraction was increase till 20%. According to Figure 3, the extraction of Ni in A:O= 1 and A:O = 4 are 52.5 and 62 respectively. The little difference between the A/O=4 and A/O=3, so it is economic to aspect the A/O=3 for other tests. The other important parameter is temperature of reaction. So, Figure 4 is indicating effect of different temperatures on extraction of Ni and Cu. In this figure showing that the 40°C is best temperature to extraction of Ni and Cu.

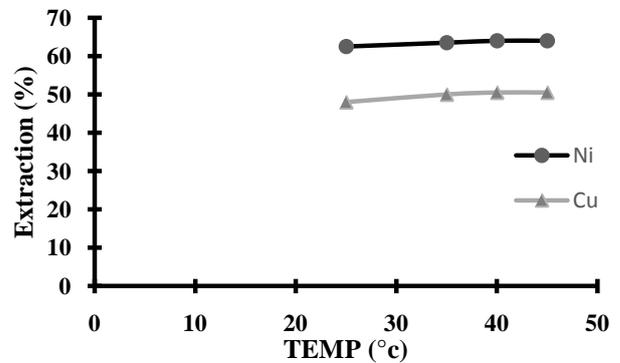


Figure 4. Effect of different TEMP on extraction of Ni and Cu (RPM= 500, CONC. :30%, Time:5 min and pH= 6)

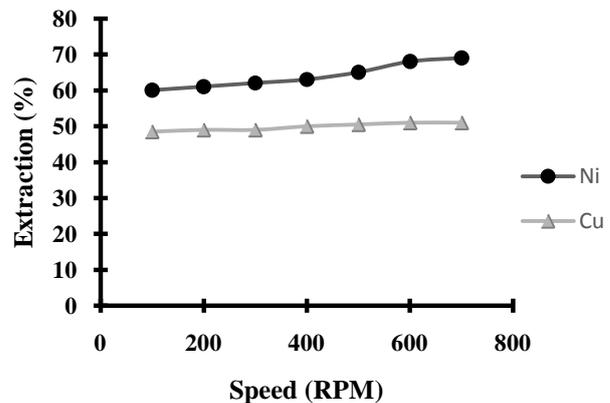
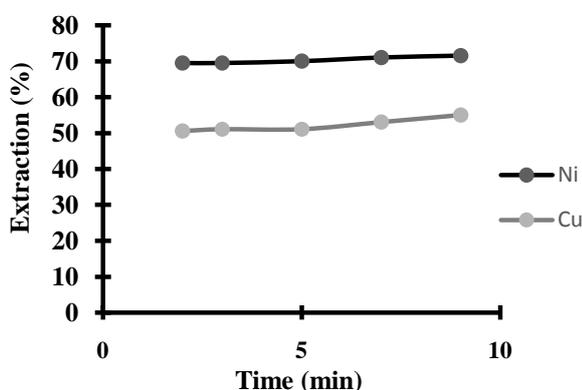


Figure 5. Effect of different mixing speed on extraction of Ni and Cu (TEMP= 45°C, CONC. :30%, Time:5 min and pH= 6)

The increment of the temperature has increased the extraction of Cu and Ni ions from solution (Figure 4). The extraction of Ni ions was increased 1.5% through raising the temperature from 25°C to 45°C. However, this increase led to enhance more Cu extraction to 2%. Regarding to Ni extraction, it was specified to set the temperature at 45°C for the extraction of Ni ions from the aqueous solution.

The effect of mixing speed on the extraction of Cu and Ni ions is presented in Figure 5. It postulated that increasing the mixing speed from 500 to 700 rpm has enhanced the extraction of Ni ions. Likewise, the speed increment from 500 to 700 rpm in the extractant concentration of 30% is led to increase Ni extraction from 67 to 70%. The results indicate that the increase of mixing speed at any concentration from the organic solution is directed into enhancing Ni extraction.



**Figure 6.** Effect of different Times on extraction of Ni and Cu (TEMP= 45°C, CONC. :30%, Speed= 700 RPM and pH= 6)

According to Figure 6, increasing stirring time just effect on copper extraction. On the other hand, Ni extraction Did not increase much (About 0.4 %). So, for less energy, the stirrer time is selected for 5 minutes.

**Table 3. Some previous studies related to the present work**

Methods and their materials		Elements	Results of extraction	Results of stripping	Ref.
Extractants	Stripping (With)				
Versatic 10, D2EHPA, cyanex 272 and Ion exchange	H <sub>2</sub> SO <sub>4</sub>	Cu-Ni-Zn-Co	Above 96% Cu	Above 85% Cu	[12]
Versatic 10 and TEHA	HCl	Fe-Zn	About 99.9% Fe and 80% Zn	Above 90% Zinc	[20]
Acorga M5640 and TRPO	-----	Cu-Ni	99.96% Cu and 6.6% Ni	-----	[21]

## 4. Conclusion

The main results of this research work are summarized as follows:

In this paper using different parameter such as organic concentration, Speed and stirring time, TEMP, pH, and A/O. Solvent extraction of Cu and Ni from synthetic and industrial solutions containing Ni-Cu ions were comprehensively investigated. The results show that extraction process with D2EHPA in different concentrations and parameters, Cu and Ni can be separated effectively from synthetic

solutions containing four main elements of Cu-Ni-Zn-Fe. D2EHPA can be extracted about 72 % Ni and 55% Cu ions in TEMP= 45°C, CONC. :30%, Speed= 700 RPM, time= 7 min, O/A=3 and pH= 6 from synthetic solution.

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