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# Determination of Trace Amount of Cu (II) Using UV-Vis. Spectrophotometric Method

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**Abstract:** Trace amount of Copper(II) has determined by spectrophotometric technique using 1-(2-pyridylazo)-2-naphthal (PAN), as a new spectrophotometric reagent which is insoluble in water. PAN reacts in highly acidic solution at pH 2.40 to 2.50 with Cu(II) to give a pink chelate which has an absorption maximum ( $\lambda_{max}$ ) at 550nm. The reaction is instantaneous and absorbance remains stable for over 48hrs. The average molar absorption coefficient ( $\epsilon$ ) was found to be  $2.05 \times 10^4 \text{ L mol}^{-1} \text{ cm}^{-1}$  and Sandell sensitivity is  $3.23 \times 10^{-4} \mu\text{g cm}^{-2}$ . Linear calibration graphs were obtained for  $0.1\text{--}4.0 \mu\text{g L}^{-1}$  of Cu(II) and RSD (%) is 1.16. The stoichiometric composition of the chelate is 1:2 (Cu: PAN). Large excess of over 50 cations, anions, and some common complexing agents (e.g. oxalate, phosphate, tartarate, thio-urea) do not interfere in the determination. The method was successfully used in the determination of Cu(II) in Several Standard Reference Materials as well as in some environmental and industrial waste water. The method has high precision and accuracy.

**Keyword:** UV-VIS. Spectrophotometry, Absorption spectrum ( $\lambda_{max}$  fixation), 1-(2-pyridylazo)-2-naphthal (PAN), Calibration using Beer's law, Environmental and waste water samples.

### 1. Introduction:

Different types of ligand were used with about 30 toxic metal ions to obtain colour chelate through the novel reaction techniques. Finally Trace amount of toxic element Cu(II) was determined by spectrophotometric method using PAN as a new spectrophotometric reagent in acidic water. Copper in trace amounts is important industrially<sup>[1]</sup>, as a toxicant<sup>[2]</sup> and biological non-essential<sup>[2]</sup>, as an environmental pollutant<sup>[3]</sup> and as an occupational hazard<sup>[4]</sup>. It is a toxic metal, has been responsible for a number of diseases<sup>[5]</sup>. The symptoms of copper poisoning are instantaneous hypertension, shortening of life-span; Kidney damage, bronchitis, retardation of growth, cirrhosis, Wilson's, Alzheimer's diseases, gross abnormalities of the vital organs

and the risk of skin cancer<sup>[6]</sup>. It also caused generalized cancers in laboratory animals and has been linked epidemiologically with certain human cancers<sup>[6]</sup>. The most serious situations being the disease called cirrhosis, Wilson's, Alzheimer's diseases and skin cancer which causes gradual weakening of the bone structure, diminution of stature and ultimately the total collapse of the entire skeletal system<sup>[7]</sup>. Its extreme toxicity towards marine and fresh water organisms is also well known<sup>[7]</sup>. Copper is a potential health hazard due to its presence in drinking water, food cooked in copper utensil<sup>[7]</sup>. The permissible limit of copper in drinking water is  $2.0 \text{ mg L}^{-1}$  according to EPA<sup>[8]</sup>. Increasing copper pollution of the environment resulting from the growth of copper based industries and

the use of fossil fuels makes the development of method for the trace and ultra-trace analysis of this toxic metal essential. Spectrophotometry is essentially a trace analysis technique and is one of the most powerful tools in chemical analysis. PAN has been reported as a spectrophotometric reagent for Co, Ni, Zn, Mn, Ca<sup>[9]</sup> but has not previously been used for spectrophotometric determination of Cu(II) in acidic aqueous media. This paper reports its use in a very sensitive, highly specific spectrophotometric method for the trace determination of Cu(II). The method possesses distinct advantages over existing methods<sup>[10-18]</sup> with respect to sensitivity, selectivity, range of determination, simplicity, speed, pH range, thermal stability, accuracy, precision and ease of operation. The method is based on the reaction of non-absorbent PAN in highly acidic solution with copper to produce a highly absorbent deep pink chelate product, followed by direct measurement of the absorbance in aqueous solution. With suitable masking, the reaction can be made highly selective

## 2. Experimental:

### 2.1 Apparatus:

A shimadzu (Kyoto, Japan) (Model-1601PC) double beam UV-VIS. recording spectrophotometer and Jenway (England, U.K.) (Model-3010) pH meter were used for the measurement of absorbance and pH, respectively. A Shimadzu (Model-AA 6200) atomic absorption spectrophotometer equipped with a micro computer-controlled nitrous oxide-acetylene flame was used for comparison of the results.

### 2.2 Reagents and Solutions:

All the chemicals used, were of analytical-reagent grade of the highest purity available. Doubly distilled de-ionized water, which is non-absorbent under ultraviolet radiation, was used throughout. Glass vessels were cleaned by soaking in acidified solutions of KMnO<sub>4</sub> or K<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub> followed by washing with nitric acid (1+1) and rinsed several times with high-purity de-ionized water. Stock solutions and environmental water samples (1000mL each) were kept in

polypropylene bottles containing 1mL of concentrated HNO<sub>3</sub>. More rigorous contamination control was used when the copper levels in the specimens were low.

### 2.3 PAN Solution (4.01x 10<sup>-4</sup> M):

Prepared by dissolving the requisite amount of PAN (BDH chemicals) in a known volume of highly acidified (HCl) de-ionized water. More dilute solutions of the reagent were prepared as required. PAN is insoluble in water and soluble in organic solvent, but we have used acid and water to soluble PAN.

### 2.4 Cu(II) Standard Solutions:

A 100mL of stock solution of divalent copper was prepared by dissolving 0.03929mg of AR crystallize copper sulfate (Cu SO<sub>4</sub>; 5H<sub>2</sub>O) (Merck) in doubly distilled de-ionized water. Aliquots of this solution were standardized by EDTA titration using Sulfon black-T as indicator. More dilute standard solutions were prepared by appropriate dilution of aliquots from the stock solution with de-ionized water and when required.

### 2.5 EDTA Solution:

100mL stock solution of EDTA (0.01% w/v) was prepared by dissolving 10mg of A.C.S. grade (≥99%) of disodium dihydrogen ethylenediamine tetraacetate dihydrate in (100mL) de-ionized water.

### 2.6 Potassium Permanganate Solution:

A 1% potassium permanganate Solution (Merck) was prepared by dissolving in de-ionized water. Aliquots of this solution were standardized with oxalic acid. Sodium azide solution (2.5% w/v) (purity >99%) was also used.

### 2.7 Tartarate Solution:

A 100mL stock solution of tartarate (0.01% w/v) was prepared by dissolving 10mg of A.C.S grade (99%) potassium sodium tartarate tetrahydrate in (100mL) de-ionized water.

### 2.8 Aqueous Ammonia Solution:

A 100mL solution of aqueous ammonia was prepared by diluting 10mL concentrated  $\text{NH}_4\text{OH}$  (28–30%, A.C.S grade) to 100mL with deionized water. The solution was stored in polypropylene bottle.

### 2.9 Other Solutions:

Solutions of a large number of inorganic ions and complexing agents were prepared from their analar grade or equivalent grade water soluble salts (or the oxides and carbonates in hydrochloric acid); those of niobium, titanium, zirconium and hafnium were specially prepared from their corresponding oxides (Specpure, Johnson Matthey) according to the recommended procedures of Mukharjee<sup>[19]</sup>. In the case of insoluble substances, special dissolution methods were adopted<sup>[20]</sup>.

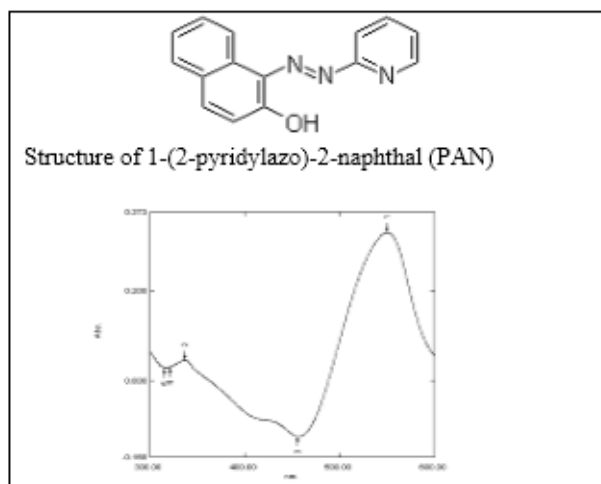
### 2.10 Procedure:

To 0.1–1.0mL of a neutral aqueous (pH=4) solution containing 1–10 $\mu\text{g}$  of copper in a 10mL calibrated flask was mixed with 1:5-1:10 fold molar excess of PAN reagent solution preferably  $4.01 \times 10^{-4}\text{M}$  followed by the addition of 0.5M hydrochloric acid (HCl) and  $\text{NH}_4\text{OH}$  to control pH of solution at around 2.50. The mixture was diluted to the mark with de-ionized water. The absorbance was measured at  $\lambda_{\text{max}}=550\text{nm}$  against a corresponding reagent blank. The copper content in an unknown sample was determined using concurrently prepared calibration graph.

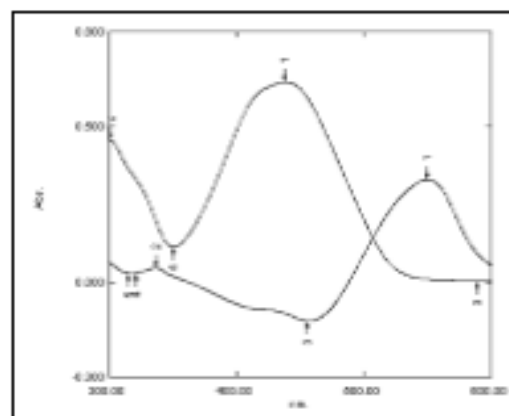
## 3. Results and discussion:

### 3.1 Absorption spectrum:

The absorption spectrum of the Cu (II)-PAN solution system in 1(M) HCl medium was recorded using the UV-Vis. Spectrophotometer. The absorption spectrum of the Cu(II)-PAN are a symmetric curve with the maximum absorbance co-efficient is shown in (Fig-1) and Absorption spectrum of PAN and Cu(II)-PAN against the reagent blank at pH=2.50 in aqueous solution is shown in Fig.-1.a. In all instances measurements were made at 550nm against a reagent blank. The reaction mechanism of the present method is as reported earlier<sup>[21]</sup>.



**Fig.1:** Absorption spectrum of Cu (II)-PAN against the reagent blank (at pH=2.50,  $\lambda_{\text{Max}}=550\text{ nm}$ ) in aqueous solution.

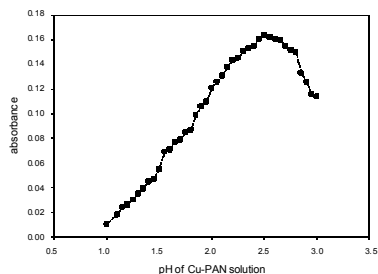


**(Fig.1.a):** Absorption spectrum of PAN and Cu (II)-PAN against the reagent blank at pH=2.50 in aqueous solution.

### 3.2 Effect of Acid and pH:

To see the effect of different pH we have taken 0.5ppm Cu(II) solution. Of the various acids (nitric, sulfuric, hydrochloric and phosphoric) studied hydrochloric acid was found to be the best acid for the system. The absorbance was maximum when the pH of the solution is 2.5 at room temperature ( $25 \pm 5$ )<sup>0</sup>C. We have controlled the pH of the solution using hydrochloric acid and ammonium hydroxide as a base and double distilled water. Outside this range of acidity, the absorbance decreased (Fig.-2). At  $\lambda_{\text{Max}}=550\text{nm}$  the absorbance values of Cu(II)-PAN complex are as follows. At higher concentration of PAN

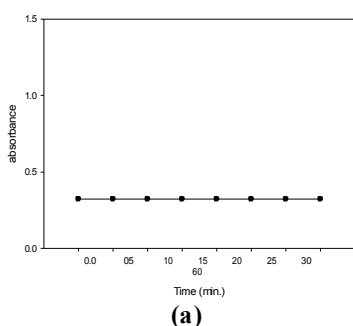
solution starts to form ppt. at pH 2.00. So we have used the lower concentrated solution ( $4.0 \times 10^{-4} \text{M}$ ) of PAN.



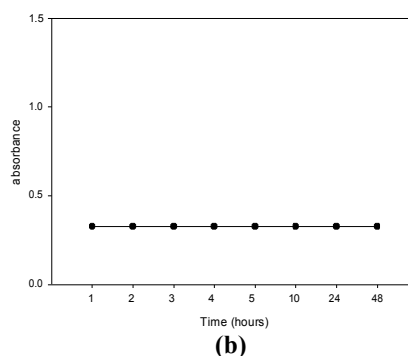
**Fig.-2:** Effect of pH on the absorbance of Cu(II)-PAN (1:10) complex.

### 3.3 Effect of Time:

The reaction is instantaneous. Constant maximum absorbance was obtained just after diluting to volume and remained strictly unaltered for 48 hours (Fig.-3 a, b). At pH over 3.00 Cu(II)-PAN complexes and PAN itself start to form ppt in solution. When the solution forms ppt it goes out of the measurement of spectrophotometric analysis. We have fixed the pH at 2.50; (or 2.00 to 2.50) in this pH the complex will not form ppt for the long time. We have observed sample of complex for 48 hours and constant maximum absorbance was obtained just after diluting to volume and remained strictly unaltered from beginning to end.



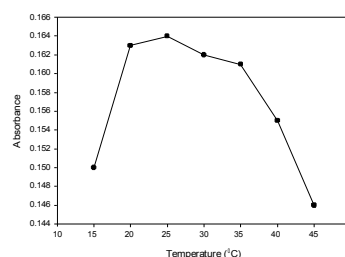
**Fig.-3.a:** Effect of the time on the absorbance of Cu(II)-PAN (1:10) system.



**Fig.-3. b:** Effect of the time on the absorbance of Cu(II)-PAN (1:10) system.

### 3.4 Effect of Temperature:

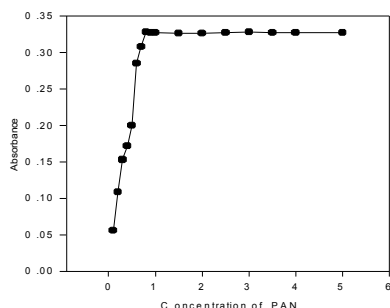
The Cu(II)-PAN system obtained maximum and constant absorbance at room temperature ( $25 \pm 5$ ) $^{\circ}\text{C}$ . Outside this range of temperature, the absorbance decrease gradually (Fig.-4).



**Fig-4:** Effect of temperature on absorbance of Cu(II)-PAN solution.

### 3.5 Effect of Reagent Concentration:

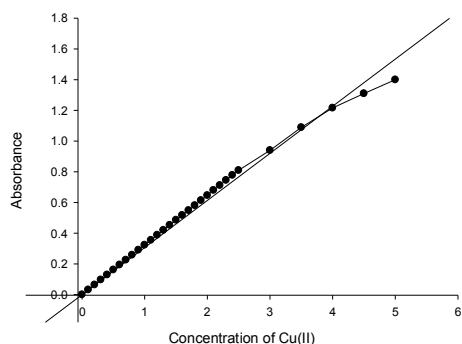
Different molar excesses of PAN were added to fixed metal ion concentration and absorbances were measured according to the standard procedure. It was observed that at the 1ppm Cu(II) metal the reagent molar ratios of 1:2-1:20 produce a constant absorbance of the Cu(II)-PAN complex (Fig.-5). For all subsequent measurements different amount (mL) of  $4.01 \times 10^{-4} \text{M}$ , PAN reagent was added.



**Fig.-5:** Effect of reagent (PAN) molar concentration ratio on the absorbance of Cu(II)-PAN system.

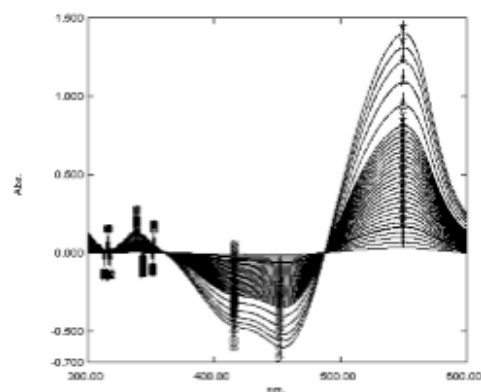
### 3.6 Calibration Graph (Beer's law):

The well-known equation ( $A=\epsilon cl$ ) for spectrophotometric analysis in very dilute solution was derived from Beer's law. The effect of metal concentration was studied over  $0.1\text{--}5.0\mu\text{gL}^{-1}$ . The absorbance was linear for  $0.1\text{--}4.0\mu\text{gL}^{-1}$  of Cu(II) at  $\lambda_{\text{max}}=550\text{nm}$ . The molar absorption co-efficient, ( $\epsilon$ )<sup>[22]</sup> was found to be  $2.052\times 10^4\text{ L mol}^{-1}\text{cm}^{-1}$ . Of the calibration graph which that showing the limit of linearity range is given in (Fig-6) and overlay of spectrum layout is shown in (Fig-6.a).



\* [Coefficients:  $b[0]=0$ ,  $b[1]=0.3235095023$ ]

**(Fig.-6):** Calibration graph of absorbance of Cu(II)-PAN complex against the different concentration of Cu 0.1 to 5.0 ppm.



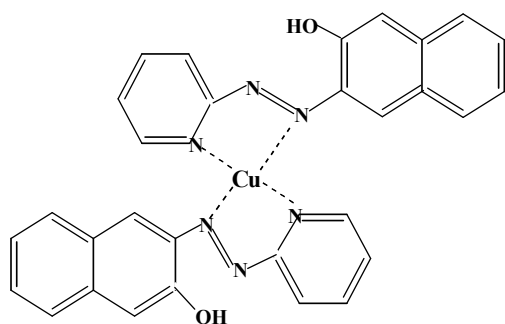
**(Fig-6.a):** The overlay of absorption spectrum of Cu(II)-PAN for  $0.1\text{--}5.0\mu\text{g mL}^{-1}$  of Copper at  $\text{pH}= 2.50$ ,  $\lambda_{\text{max}}=550\text{nm}$ .

### 3.7 Effect of foreign ions:

The effect of over 50 ions and complexing agents on the determination of only  $1\mu\text{g mL}^{-1}$  of Cu(II) was studied. The criterion for interference<sup>[23]</sup> was an absorbance value varying by more than  $\pm 5\%$  from the expected value for copper alone. The most serious interferences were from Ni(II), Co(II) and Fe(III) ions. Interference from these ions is probably due to complex formation with PAN. The greater tolerance limits for these ions can be achieved by using several masking agents. In order to eliminate the interference if Ni and Co are present in the sample they are eliminated by extraction from the sample using 15ml of  $10\times 10^{-3}\text{mole/L}$  DMG solution in 1,2-dichloroethane. If the aqueous phase contains mercury and iron, 1gm of KI was added masking agent for Hg and 10gm of KF dissolved in 4mole/L  $\text{HNO}_3$  solution was used to preclude the interference of iron<sup>[24]</sup>. Interference from these metal ions Ni(II), Co(II) and Fe(III) have been effectively removed by a short single step ion-exchange separation process, using an Amberlite XAD-8 resin (100-200 mesh) ion exchanger<sup>[25]</sup>.

### 3.8 Composition of the absorbent Complex:

Job's method<sup>[26]</sup> of continuous variation and the molar-ratio method<sup>[27]</sup> were applied to ascertain the stoichiometric composition of the complex. A Cu(II)-PAN (1:2) complex was indicated by both methods.



Structure of the Cu(II)-PAN complex (proposed)

### 3.9 Precision and accuracy:

The precision of the present method was evaluated by determining different concentrations of Cu(II) (each analyzed at least five times). The

relative standard deviation ( $n=5$ ) was 0–1.16% for 0.1–4.0  $\mu\text{gL}^{-1}$  of Cu(II) in 10mL, indicating that this method is highly precise and reproducible (Table-1). The detection limit is 0.1–4.0  $\mu\text{gL}^{-1}$ . Added copper was accurately recovered from the other metals. The reliability of our Cu(II)-PAN procedure was tested by recovery studies. The average percentage recovery obtained for addition of Cu(II) to some environmental water and industrial waste water samples was quantitative as shown in (Table-2). The results of water samples analysis by the spectrophotometric method were in excellent agreement with those obtained by AAS. Hence the precision and accuracy of the method were found to be excellent.

### 3.10 Selected analytical parameters obtained with the optimization experiments:

Parameter	Studied range	Selected Value
Wavelength, $\lambda_{\text{max}}$ (nm)	200 - 800	550
pH	1.0 – 3.5	2.40 – 2.50
Time/h	0 - 72	24
Temperature, $^{\circ}\text{C}$	1 - 50	25 $\pm$ 5
Reagent (fold molar excess, M: R)	1 : 2 – 1: 20	1 : 5 – 1: 10
Linear range, $\mu\text{gL}^{-1}$	0.01 - 20	0.1 – 5.0
Detection limit, $\mu\text{gL}^{-1}$	0.1 - 20	0.1 – 4.0
Reproducibility (% RSD)	0 - 5	0 – 1.16

### 4. Applications:

The present method was successfully applied to the determination of Cu(II) in various industrial waste water samples of various compositions (Table-2) and also in number of real samples, e.g. several Certified Reference Materials (CRM). The method was also extended to the determination of copper in a number of environmental samples. In view of the unknown composition of environmental water samples, the same equivalent portions of each such sample was analyzed for Cu(II) content, recoveries in both the ‘spiked’ (added to the samples before the mineralization or dissolution) and the ‘unspiked’ samples are in good agreement (Table-2). The results of industrial waste water analysis by spectrophotometric method were found to be in excellent agreement with those obtained by AAS. The precision and accuracy of the method were excellent.

#### 4.1 Determination of Cu(II) in Environmental and Industrial Water:

Each filtered (with whatman No.-40) environmental water sample (1000mL) was evaporated nearly to dryness with a mixture of 5mL of concentrated  $\text{H}_2\text{SO}_4$  and 10mL of concentrated  $\text{HNO}_3$  in a fume cupboard following a method recommended by Greenberg et al.<sup>[28]</sup>, and was then cooled to room temperature. The residue was then heated with 10mL of de-ionized water in order to dissolve the salts. The solution was then cooled and neutralized with dilute  $\text{NH}_4\text{OH}$  in the presence of 1–2mL of 0.01 % (w/v) tartarate solution. The resulting solution was then filtered and quantitatively transferred into a 25mL calibrated flask and made up to the mark with de-ionized water. An aliquot (1–2mL) of this pre-concentrated water sample was pipette into a 10mL Calibrated flask and the Cu(II) content was

Determined as described under procedure using KF as a masking agent. The analysis of environmental water samples from various sources for Cu (II) are shown in (Table-3). Most spectrophotometric method for the determination of Cu (II) in natural and sea water require pre-concentration of Cu (II)<sup>[29]</sup>. The concentration of Cu (II) in natural and sea water is a few  $\mu\text{gL}^{-1}$ .

The suggested safe level of copper in drinking water for humans varies depending on the source, but tends to be pegged at 2.0mg/L<sup>[28]</sup>. The results of water samples analysis by spectrophotometric method were found to be in excellent agreement with those obtained by AAS, results are shown in table-2.

**Table-1:** Standard deviation and relative Standard deviation of Cu (II) - PAN system:

Sample No.	Cu(II) taken $\mu\text{gL}^{-1}$	Cu(II) Found $X_1 \mu\text{gL}^{-1}$	Mean $\bar{X}$ $\mu\text{gL}^{-1}$	$X_1 - \bar{X}$	$(X_1 - \bar{X})^2$	Standard deviation ( $\pm S$ )	Relative standard deviation ( $S_r$ )%
1	100.0	98.5	100.14	1.64	2.67	$\pm 1.16$	1.16
2	100.0	99		1.14	1.29		
3	100.0	101		0.86	0.75		
4	100.0	100.5		0.36	0.13		
5	100.0	99.5		0.64	0.41		
6	100.0	101.5		1.36	1.85		
7	100.0	101		0.86	0.74		
8	100.0	99.5		0.64	0.41		
9	100.0	98.5		1.64	2.69		
10	100.0	101.5		1.36	1.85		
11	100.0	101		0.86	0.74		
N = 11		$\sum X_1 = 1101.5$		$\sum X_1 - \bar{X} = 11.364$	$\sum (X_1 - \bar{X})^2 = 13.53$		

$$\text{Mean } \bar{X} = \frac{\sum X_1}{N} = \frac{1101.5}{11} = 100.14$$

$$\text{Standard deviation, } S = \sqrt{\frac{\sum (X_1 - \bar{X})^2}{N-1}} = \sqrt{\frac{13.53}{11-1}} = \sqrt{1.353} = \pm 1.16$$

$$\text{Relative Standard deviation } (S_r) \% = \frac{S}{\bar{X}} \times 100 = \frac{1.16 \times 100}{100.14} = 1.16$$

**Table-2:** Determination of Copper in some environmental water and industrial waste water samples (\*Average of five replicate determinations.):

Sample		Copper/ $\mu\text{g L}^{-1}$		Recovery $\pm S$ (%)	$S_r^b$ (%)
		Added	Found <sup>a</sup>		
Tap water		0	2.5	$\pm 0.2$	0.25
		100	102.0	$99 \pm 0.6$	0.58
Waste Water of UFFL		0	1.5	$100.2 \pm 0.4$	0.39
		100	101.0		
Waste Water of PUFFL		0	1.0	$100.4 \pm 0.6$	0.59
		100	102.0		
Waste Water of CUFL		0	1.0	$100.2 \pm 0.8$	0.79
		100	101.5		
Waste Water of JFCL		0	1.5	$100.0 \pm 0.3$	0.29
		100	102.0		
Waste Water of AFCL		0	1.5	$100.0 \pm 0.4$	0.39
		100	102.0		
Waste Water of TSP		0	2.5	$100.2 \pm 0.3$	0.29
		100	103.5		
River water	Buriganga (upper)	0	5.0	$100.9 \pm 0.4$	0.24
		100	107.0		
River water	Buriganga (lower)	0	5.5	$99.4 \pm 0.3$	0.37
		100	105.5		
Sea water	Bay of Bengal (upper)	0	12.0	$99 \pm 0.2$	0.29
		100	120.0		
Sea water	Bay of Bengal (lower)	0	13.5	$100.1 \pm 0.3$	0.21
		100	114.8		
Drain water	Berger Paints, Dhaka	0	15.0	$99 \pm 0.5$	0.43
		100	113.0		
Drain water	Asian Paints, Dhaka	0	12.0	$100.9 \pm 0.3$	0.26
		100	114.0		

**Table-3:** Determination of Copper in some environmental water and industrial waste water samples (a, average of five replicate determinations, b, the measure precision is the relative standard deviation  $S_r$ ):

Serial No	Sample	Copper/ $\mu\text{g L}^{-1}$		Sample source
		AAS	Proposed method	
01	Waste Water	0.9	$1.5 \pm 0.5$	UFFL, Ghorashal, Narshingdi.
02	Waste Water	1.6	$1.0 \pm 0.6$	PUFFL Ghorashal, Narshingdi.
03	Waste Water	1.7	$1.0 \pm 0.8$	CUFL, Chittagong.
04	Waste Water	2.0	$1.5 \pm 0.4$	JFCL, Jamalpur.
05	Waste Water	1.8	$1.5 \pm 0.3$	AFCL, Ashogong.
06	Waste Water	2.9	$2.5 \pm 0.3$	TSP, Chittagong.
07	River water	5.4	$5.0 \pm 0.4$	Buriganga
08	Sea water	12.3	$12.0 \pm 0.3$	Bay of Bengal
09	Drain Water	15.6	$15.0 \pm 0.6$	Berger Paints, Dhaka
10	Drain Water	12.4	$12.0 \pm 0.3$	Asian Paints, Dhaka

#### 4.2 Determination of Cu (II) in alloys and Steels:

0.1g amount of an alloy or steel sample

Was accurately weighed into a 50mL flask following a method recommended by Parker<sup>[30]</sup>.



To it, 10mL of 20% (V/V) sulfuric acid was added, carefully covering with a watch-glass until the brisk reaction subsided. The solution was heated and simmered gently after addition of 5mL of concentrated HNO<sub>3</sub> until all carbides were decomposed. Then 2mL of 1:1 (V/V) H<sub>2</sub>SO<sub>4</sub> was added and the solution was evaporated carefully to dense white fumes to drive off the oxides of nitrogen and then cooled to room temperature (25± 5)<sup>0</sup>C. After suitable dilution with de-ionized water, the contents of the flask were warmed to dissolve the soluble salts. The solution was then cooled and neutralized with dilute NH<sub>4</sub>OH in the presence of 1–2mL of 0.01% (W/V) tartrate

Solution. The resulting solution was filtered, if necessary, through a whatman No. 40 filter paper into a 50mL calibrated flask. The residue was washed with a small volume of hot water and the volume was made up with de-ionized water. A suitable aliquot (0.1–1.0mL) of the above solution was taken into a 10mL calibrated flask and the Cu(II) content was determined as described under procedure using fluoride as a masking agent. The results are shown in (Table-4). Added copper was recovered accurately from the other metals.

**Table-4:** Determination of copper in alloys and Steels samples (a. Value given represents the average of triplicate determination, b. The measure of precision is the standard deviation (S).):

Sample No.	Certified Reference Material (Composition, %)	Cu spiked		Recovery ± S <sup>b</sup> (%)
		Added (µgL <sup>-1</sup> )	Found <sup>a</sup> (µgL <sup>-1</sup> )	
1.	BAS032a, Al-Bronze Alloy Cu=85.9, Zn=0.94 Mn=0.27 Fe=2.67, Ni=1.16, Al = 8.8	0.10	86.01	100 ± 0.2
		0.50	85.95	99 ± 0.5
2.	BAS-646, High speed steel, Te=0.90, Cr = 4.55, Mo=4.95, V= 1.99	0.10	0.102	100 ± 0.2
		0.50	0.50	100 ± 0.0

## 5. Conclusions:

In this Thesis a new simple, sensitive, selective and inexpensive technique with Cu(II)-PAN complex was developed for the determination of Cu(II) in environmental and industrial waste water samples for continuous monitoring. Although many sophisticated techniques such as pulse polarography, HPLC, AAS, ICP-AES, and ICP-MS, are available for the determination of Cu(II) at trace level in numerous complex materials, factors such as the low cost of the instrument, easy handling, lack of requirement for consumables etc. have caused spectrophotometry to remain a popular techniques particularly in laboratories of developing countries with limited budget. The sensitivity in terms of relative standard deviation of the present method are very reliable for the determination of Cu(II) in real samples down to µgL<sup>-1</sup> levels in aqueous medium at room temperature (25± 5)<sup>0</sup>C.

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