International Journal of Research in Advanced Engineering and Technology
ISSN: 2455-0876, Impact Factor: RJIF 5.44
www.engineeringresearchjournal.com
Volume 2; Issue 1; January 2016; Page No. 45-48

Recovery of heavy metal from electronic waste

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Abstract

The rapid industrialization has raise the demand for heavy metals, but the reserves of high-grade ores are diminishing. E-waste term refers to electrical and electronic products which has multiple components some are toxic and hazardous that can cause serious health and environmental issues if not handled properly. Multiple components such as discarded computers, televisions, VCRs, stereos, copiers, fax machines, electric lamps, cell phones, audio equipment and batteries if improperly disposed can leach lead and other substances into soil and groundwater. Many of these products can be reused, refurnished, or recycled. E-waste contains precious materials such as gold, silver, copper, glass and plastics and also contains harmful materials like arsenic, mercury, cadmium and lead, which is affected to environment and human life. This paper include the titration and DTPA methods for the recovery of heavy metal such as Copper, Iron, Aluminum from E-waste. The estimation test were performed by AAS spectrometer using DTPA method states that 1.761ppm Copper and 117.4ppm Iron were present. The estimation test performed by titration method for Aluminum yields 80% presence of Aluminum 15% Iron and 5% other metals

Keywords: DTPA method, E-waste, heavy metal, AAS

Introduction

The current pattern of industrial activity allows the natural flow of materials and introduces novel toxic chemicals into the environment (Faisal and Hasnanin, 2004) [27] Heavy metals include cadmium, lead, chromium, copper and nickel, which contaminate the soils, ground water, sediments and surface waters are extremely toxic to biological and ecological systems. The heavy metals are released due to the discharge of effluent into the environment by a large number of processes such as electroplating, leather tanning, wood preservation, pulp processing, steel manufacturing, etc., and the concentration levels of these heavy metals varies widely in the environment. Heavy metals pose a critical concern to human health and environmental issues due to their high occurrence as a contaminant, low solubility in biota and the classification of several heavy metals as carcinogenic and mutagenic (Alloway, 1995; Diels *et al*., 2002) [28, 29].

DTPA, a chelating agent, combines with free metal ions in solution and form soluble complexes due to the reduced ionic activity in solution desorption takes place, bringing in some more ions from solid phase. DTPA offers the most favourable combination of stability constants for the simultaneous complexing of Zn, Cu, Fe and Mn. since Fe and Zn deficiency is frequently experienced in calcareous soils, the method is designed to excessive dissolution of $CaCO_3$ with the release of occluded micronutrients which are normally not available to plants. this is achieved by the inclusion of soluble Ca^{++} and buffering the reagent at pH 7.3 with TEA (which burns cleanly during flame atomization). When the extractant is added to soil, additional Ca^{++} and Mg^{++}enter the solution. this is largely because the protonated TEA exchanges with these ions from the exchange sites and this leads to the increased ionic concentration of Ca^{++} in the solution which in turn helps in suppressing the dissolution of CaCO3 DTPA extractant has the ability to chelate Zn, Cu, Fe and Mn in competition with Ca^{++} and Mg^{++} and unlike most other chelating agents is applies a moderate stress to solubilize soil Fe at a pH where $CaCO_3$ is not dissolved. Suitability of this method has been proved through excellent relationships between the test values and plant utilisable nutrients under pot and field studies conducted the world over.

Atomic absorption spectrometer, consisting of a light source emitting the line spectrum of an element (hollow-cathode lamp or electrode less discharge lamp), a device for vaporizing the sample (usually a flame), a means of isolating an absorption line (monochromator or filter and adjustable slit), and a photoelectric detector with its associated electronic amplifying and measuring equipment.

Materials and method

E-waste (PCBs) collected from local electronic shop of Ujjain, Madhya Pradesh, India and taken 1.130 kg PCBs for to do perform experimental work. First cleaned and manually dismantled the PCBs by using piler and screw driver, after dismantled the total weight of PCBs is 1.00 kg.

Sample preparation method

The E-waste PCB taken were first crushed with the use of piler and screw driver nearby 1inch in shape. About 0.5 g of the PCB were taken and dissolved in the solution of diluted HCL solution. The sample were prepared by dissolving 0.5gm of PCB in four different volumes of diluted HCL solution as 1ml, 10ml, 15ml and 20ml respectively. All the four sample were kept for 2 days for the dissolution. After that the solution is filtered by the use of filter paper and the filtrate PCB is kept for drying in presence of sunlight for 2 days and is weighed by the use of weighing machine. It has been observed that sample D has the largest amount of PCB dissolved as compared to all the three sample. This sample were prepared for the estimation of Iron present in PCBs of electronic waste. Procedure used for the estimation of

Iron were the DTPA method performed by the AAS spectrometer instrument.

For the estimation of Aluminum amount present in PCBs of electronic waste all the four sample were prepared by dissolving 0.5 g of PCB with different amount of solvent as Nitric Acid as 1ml, 10ml, 15ml and 20ml respectively. All the four sample were kept for 2 days for the dissolution. After that the solution is filtered by the use of filter paper and the filtrate e waste is kept for drying for 2 days and is weighed by the use of weighing machine. It has been observed that sample L has almost full amount of PCB dissolved as compared to all the three sample. Sample K and J also have large amount of PCB dissolved. Sample I has some traces left in the solution.

For the estimation of Copper amount present in PCBs of electronic waste sample were prepared by dissolving 0.5 g of PCB in different concentration of chemical solution. For sample E we have taken 0.5gm of PCB and 1ml of Ferric Chloride dissolved in 100ml of distilled water. For sample F 10 ml of Ferric Chloride is taken in 100 ml of distilled water. For sample G 15 ml of Ferric Chloride is taken in 100 ml of distilled water. For sample H 20 ml of Ferric Chloride were taken in 100 ml of distilled water. All the four sample were kept for 2 days for the dissolution. After that the solution is filtered by the use of filter. It has been observed that sample H has almost full amount of PCB dissolved as compared to all the three sample. Sample G and F also have large amount of PCB dissolved. Sample E has some traces left in the solution.

For the estimation of Copper DTPA method were performed by the use of AAS spectrometer instrument.

Titration procedure for Iron 10 g of the sample were taken and dissolved it in 50 mL of water and filter. To the filtrate about 10mL of concentrated HCL were added and heated to boiling. Iron is reduced by adding stannous chloride solution until the yellow colour disappears. Stannous chloride was added in limited amount not in excess. Solution is cooled and the addition of mercuric chloride solution is done rapidly, the solution is stirred in order to form a white precipitate of mercurous chloride slowly which indicates the presence of slight stannous chloride. The solution is kept for 5 minute. Addition of phosphoric acid was done and the solution is diluted to 200-250 mL with water. 5 drops of diphenylamine indicator were added to the solution and titrated with the standard potassium dichromate solution until the colour of the solution changed to a deep blue which does not fade on stirring.

Titration procedure for Aluminium: 10g of the sample were taken in 500 mL of volumetric flask and 150 mL of distilled water were added and dissolved by shaking. 20 mL of this solution were taken in a250 mL conical flask and 2 mL of nitric acid in the ratio of 1:12. The solution is boiled for 1 minute then cooled. Addition of 20 mL of M/20 EDTA solution by pipette. pH were adjusted to 3 with the nitric acid using pH meter the solution is boiled for 2 minute. After cooling 10 mL of sodium acetate buffer solution were added and addition of 2-5 drops xylenol orange solution was done. The solution is titrated with M/50 zinc solution making the end point where the colour turns pale yellow to red.

Water soluble aluminum compounds as Al_2O_3 = [127.45*M (d-a)]/S-1.4297A

M= molarity of standard zinc solution, d = titre of standard zinc solution used in blank determination in mL, a = titre of standard zinc solution used for sample solution in mL, S = sample taken for test, A= percent by mass of iron as determined by the titration process performed for determination of water soluble Iron compounds.

M = m*65.37 Here, m = mass of zinc metal taken for the preparation of solution in g

A = (5.58*V*N)/M Where, V = volume of standard potassium dichromate solution required for the titration in mL, N = normality of standard potassium dichromate solution, M = mass of the sample.

Results and Discussion

It has been observed that on increasing the amount of Hydrogen Chloride, Ferric Chloride and Nitric Acid in solution its absorbance towards metal concentration also increases. Amount of solvent increases results in increasing the metal concentration which supports the fact of dissolving metals in solution so its absorbance also increases.

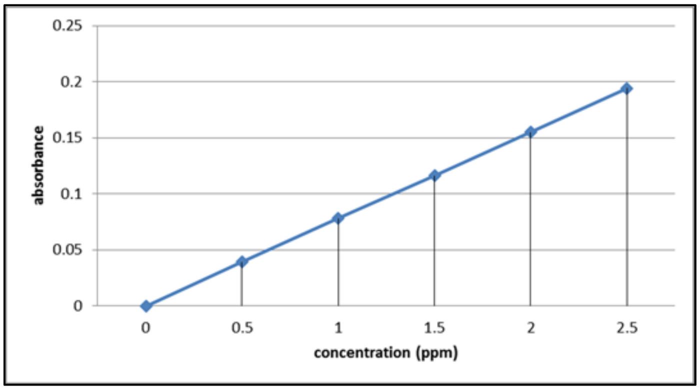

Fig 1: Graph showing copper metal ion concentration v/s absorbance of standard solution of DTPA by Atomic Absorption Spectrometer

It has been observed that standard solution has copper absorbance linearly. The graph showing that on increasing the concentration of solution its absorbance in solution also increases as amount of concentration of chemical in solution increases.

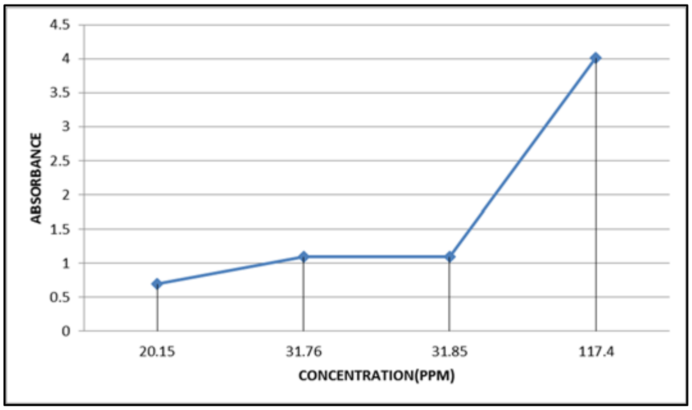

Fig 2: Graph showing the copper metal ion concentration v/s absorbance.

It has been observed that on increasing the amount of $FeCl_3$ in solution its absorbance towards metal concentration also increases. As on observation of graph at 1ml $FeCl_3$ the absorbance is negligible as the amount of $FeCl_3$ increases the absorbance is also increasing, at 20 ml $FeCl_3$ the absorbance is at highest level i.e. 4.012.

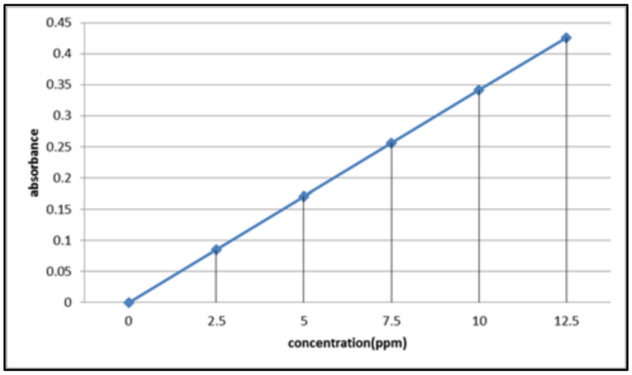

Fig 3: Graph showing Iron metal ion concentration v/s absorbance of standard solution of DTPA by Atomic Absorption Spectrometer

It has been observed that the standard solution for iron has absorbance linearly with respect to the concentration of solution for metal ion as concentration for the solution is less than its absorbance is also weak.

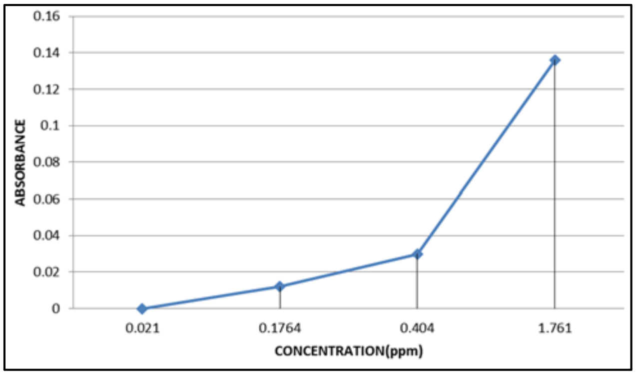

Fig 4: Graph showing Iron metal ion concentration v/s absorbance

It has been observed that the standard solution has absorbance depending on the concentration of solution. As the amount of HCl increases in solution its absorbance also increases. It has been observed that at 10ml HCl and 15ml HCl concentration in solution the absorbance is almost same slightly increasing. At 20ml HCl concentration it has shown a major change to its absorbance.

Conclusion

The study indicated that the higher quantity of acids enhances the process of copper, iron and aluminium detection. Experiment both at higher level and lower level doses of acids were performed and it has been observed that at lower level the dissolution of metal was low at higher it was high. it has been concluded that the absorbance has direct proportionality with the concentration of solution. It has been seen that the pH adjustment were compulsory for the detection of aluminium metal from its standard solution done by the titration process. The result concludes that Copper is 1.761ppm, and Iron is 117.4ppm estimated by AAS spectrometer and 80% Aluminum by titration method. The estimated metal can be converted to their respective salts.

Acknowledgment

This work is supported by the U.E.C, Ujjain, India and Soil Testing Laboratory, Ujjain, India.

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