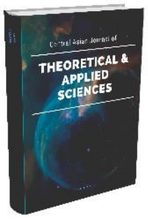

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The Experimental Study of Adsorption of Ni (II) from Aqueous Solution using Chelating Schiff's Base Derived from 2-Aminobenzoic Acid and Benzoin

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Abstract: *The adsorption of nickel from aqueous solution using chelating Schiff's base derived from 2-aminobenzoic acid and benzoin was studied. The prepared Schiff base resin was characterized by means of Fourier Transform Infrared Spectroscopy (FTIR) and Atomic Absorption Spectroscopy (AAS) was used to determine its concentration. The bands at 3378 cm-1 and 1680 cm-1 of Schiff base shows the presence of O-H and the C=N group respectively while the shift in the Schiff base peaks at 3413 and 1681cm-1 indicates adsorption. The adsorption kinetics studies were investigated using 0.5g of Schiff base in 10 mg/L solutions of Nickel (ll) ions under previously obtained optimized conditions. The maximum adsorption of Nickel (ll) ions by Schiff's base derived from 2-aminobenzoic and benzoin was 97.7% within initial concentration of 10mg/L and the removal rate of 97.7% was also within 90 minutes. The kinetic studies showed that the removal of Nickel (ll) ions correlated well with the pseudo second-order kinetic model indicating chemical adsorption and the adsorption capacity of Schiff base was 4.89mg/g for Nickel (ll) ions and it possess monolayer and as well found to be fitted into Langmuir Isotherm.*

Keywords: *Adsorption, Ni (II) ion, chelating Schiff bases, 2-aminobenzoic acid and benzoin*

INTRODUCTION

Toxic heavy metal contamination of industrial wastewater is an important environmental problem. Many industries such as electroplating, pigments, metallurgical processes, mining and leather industries release various concentrations of heavy metals. Metal ions such as cadmium, chromium, copper, lead, zinc, manganese, nickel and iron are commonly detected in both natural and industrial effluents (El-Sayed, 2011). In spite of strict regulations restricting their careless disposal, these metal cations may still emerge in a variety of wastewaters stemming from catalysts, electrical apparatus, painting and coating, extractive metallurgy, antibacterial, insecticides and fungicides, photography, pyrotechnics, smelting, metal electroplating, fertilizer, mining, pigments, stabilizers, alloy industries, electrical wiring, plumbing, heating, roofing and construction piping, water purification, gasoline additives, cable covering, ammunition and battery industries and sewage sludge (Kocaoba,, 2005).

In the past few years, special attention has been given to the environmental contamination with heavy metal ions because of their high toxicity and non-biodegradability. The commonly used procedures for removing metal ions from effluents include filtration (Bessbousse, 2005), chemical precipitation (Bessbousse, 2005), chemical coagulation, flocculation, ion exchange, reverse osmosis, membrane technologies and solvent extraction. However, these methods are limited by high operational cost and/or may also be inefficient in the removal of some toxic metal ions, mainly at trace level concentration (Yurdakoc,, 2005). The use of adsorbents of biological and natural origin has emerged in the last decade as one of the most promising alternatives to conventional heavy metal management strategies. One of the promising methods is the use of chelating resins. Chelating resins are easily regenerated from metal ions and they differ from activated carbon and ion exchange resins in their high selectivity in sorption processes (Donia, 2008). Many articles that cover a vast number of different chelating resins were reported. Recently, it was reported on the use of magnetic resins in removal of some metals from aqueous solutions (Donia, 2005). These methods are also cheap and often highly scalable. Attention has recently been focused on natural Schiff's bases and its derivatives as bio-adsorbents. A large number of Schiff bases have been studied for their interesting and important properties, e.g., their ability to reversibly bind oxygen (Donia, 2008), catalytic activity in hydrogenation of olefins and transfer of an amino group, photochromic properties, and adsorbing ability towards some toxic metals. The Schiff's base complexes were also tested for antibacterial activity against common pathogenic organisms and showed mild to moderate activity (Donia, 2008).

Therefore, this work focuses on the adsorption of nickel from aqueous solution using chelating Schiff's base derived from 2-aminobenzoic acid and benzoin.

MATERIALS AND METHODS

Reagents

The starting materials such as 2-aminobenzoic acid and benzoin were used without any further purification. Nickel (ll) chloride, distilled water and anhydrous sodium acetate, rectified spirit, 96% absolute ethanol.

Apparatus

Vacuum desiccator, 250cm^3 Beakers, Conical flasks, Test tubes, 50ml measuring cylinder, 2ml syringe, Round bottom flask, Steam bath, retort stand, Refluxing condenser, Filter paper, funnel. Fourier Transform Infrared Spectroscopy (FTIR) Cary 630(Agilent Technology), Atomic Absorption Spectroscopy (AAS), Model: BUCK SCIENTIFIC VGP 210, and Incubator Shaker.

Synthesis of Schiff's Base

Into an ethanolic solution of prepared benzoin (0.01mole) and 2- amino benzoic acid (0.01mole) in 500cm^3 round bottom flask, 3.0g anhydrous sodium acetate was added. The mixture was refluxed for one hour on the steam bath. To precipitate the grayish white product, the content was poured into an ice - cold water for precipitation which was separated and recrystallized from rectified spirit, filtered, washed with deionized water, and dried in a vacuum desiccator (Mahaptra *et al.*, 1977).

Preparation of Standard Solution for Calibration Curve:

A stock solutions was first prepared by dissolving 0.25g of nickel (ll) chloride in small amount of distilled water in 250ml volumetric flask and make up to the mark and concentrations 5, 10, 15, 20, 25 and 30mg/L was prepared by dilution of each stock solution by using dilution formula

$C_1V_1 = C_2V_2$ Godwin O. Ojokuku (2001).

Where, C_1 = concentration of prepared stock solution prepared, V_1 = initial volume of stock solution needed to prepare standard solution, C_2 = final concentration required and V_2 = final volume. Thus, 50cm^3 of each standard solution prepared was taken to AAS to run the absorbance for calibration curve.

Contact Time

Both the amount of Schiff base used (0.1g) and 10mg/L of nickel (ll) chloride solution was kept constant throughout. The contact time intervals were 30, 60, 90, 120, 150, and 180min. Into 50cm^3 of 10mg/L of nickel(ll)chloride solution contained in 50ml rubber container 0.1g of Schiff base was added and the whole six samples were shaken at room temperature using incubator shaker. After shaking the samples, each was filtrated one after the other and the filtrate was analyzed using AAS to determine the final concentration.

Adsorbent Dosage

In adsorbent dosage, only mass of Schiff base was varied from 0.5g, 1.0g, 1.5g, 2.0g, and 2.5g. Both concentrations of 10mg/L of nickel (ll) chloride and time (90mins) remain constant. Into various mass of Schiff's base placed in 100cm^3 rubber container, 50cm^3 solution of nickel(ll) chloride each was added and the whole five samples was shaken for 90mins. The mixture was then removed from incubator shaker and filtered. The absorbance of the filtrate was checked using AAS machine.

Batch Adsorption Experiment

Batch method were conducted by placing amount of 0.5g of the prepared dry Schiff base in a series of stopper conical flasks containing 10mg/L of Nickel (ll) ion solution. The batch adsorption studies were carried out at different time intervals 15, 30, 45, 60, 75 and 90 minutes (Rehab *et al*., 2013). This was carried out for kinetic and isotherm studies.

RESULTS AND DISCUSSIONS

RESULTS

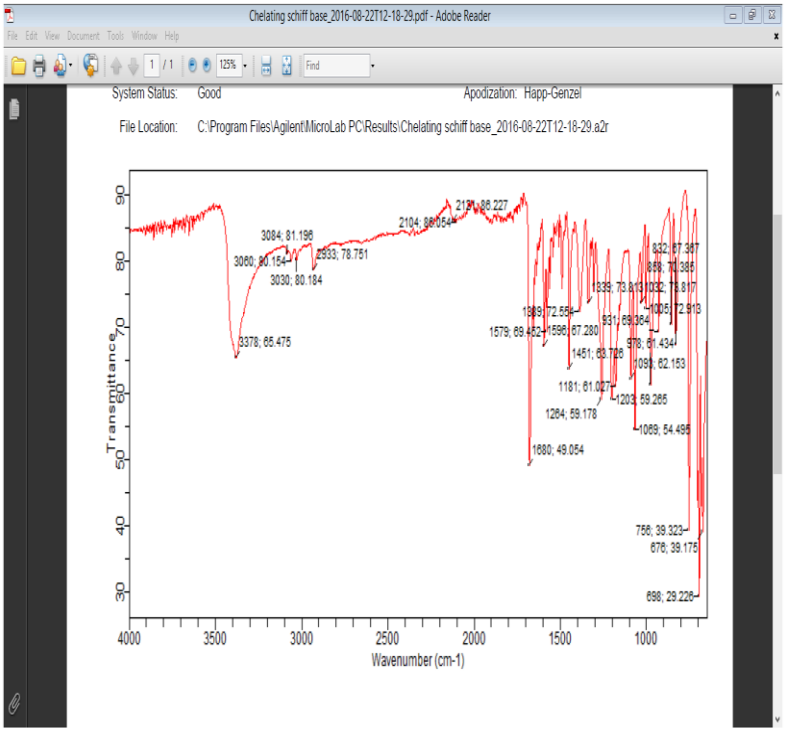

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Figure 1: FTIR of Schiff base

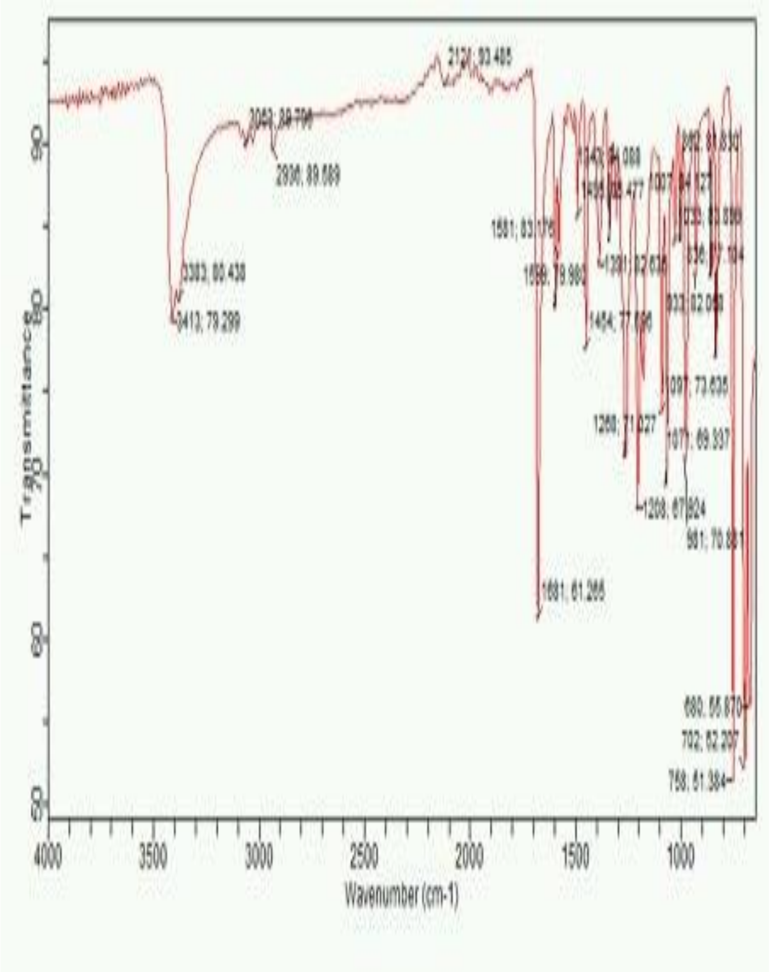


Figure 2: FTIR of Schiff base after Adsorption

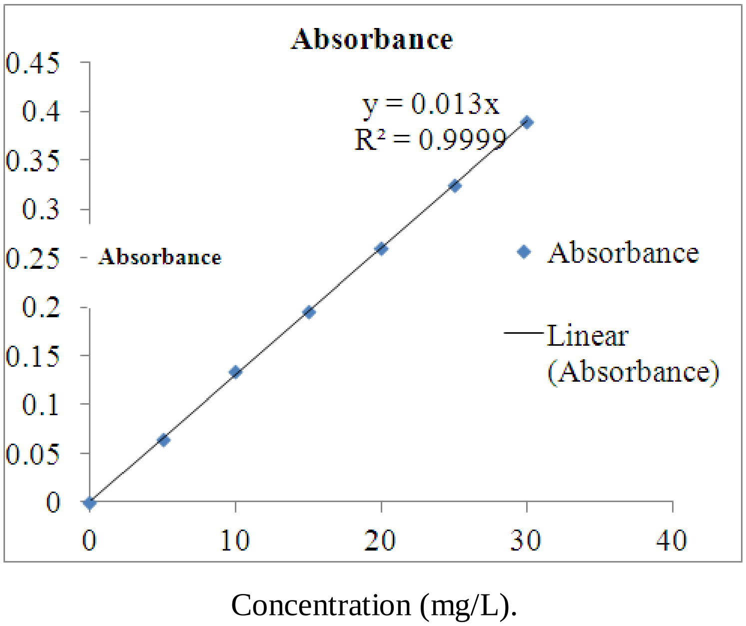


Figure 3: Calibration Curve of Nickel (ll) chloride.

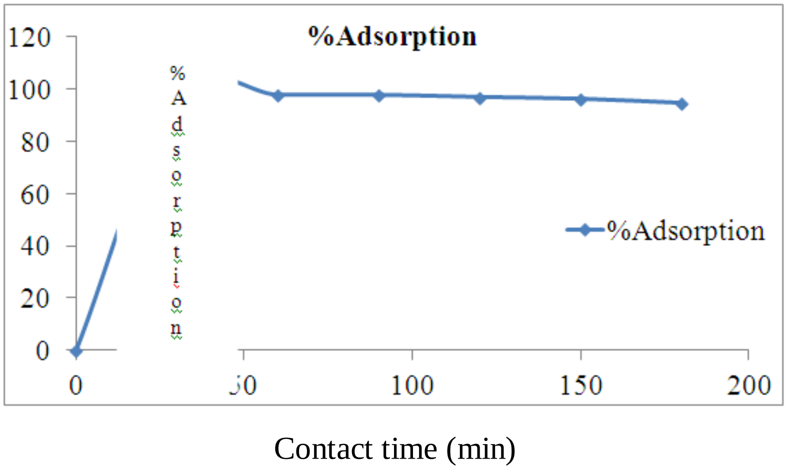
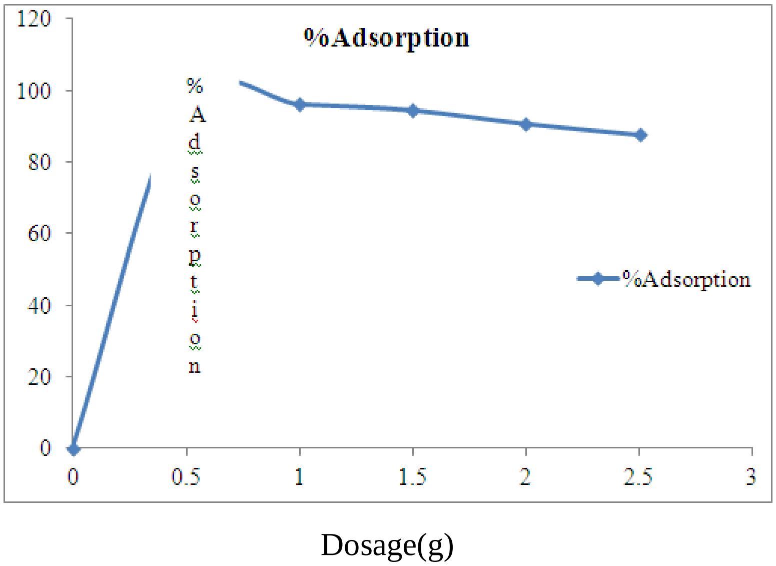


Figure 4: Graph of Adsorbent Dosage versus Contact Time



Fgure 5: Graph of Adsorption versus Adsorbent Dosage

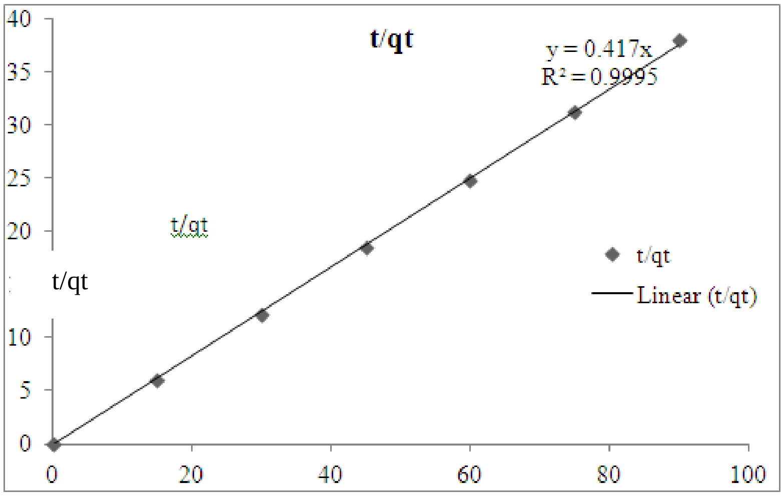


Figure 6: Graph of t/qt Versus t

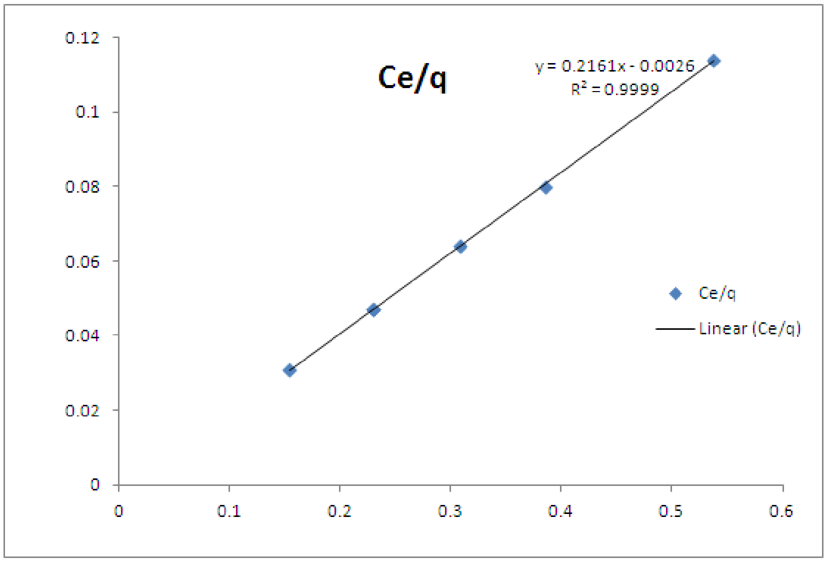


Figure 7: Graph of Ce/qe Versus Ce

DISCUSSION

Characterization of Schiff Base

The observed bands at 3378 cm^{-1} and 1680 cm^{-1} as shown in Fig. 1(i.e. FTIR of Schiff base) shows the presence of O-H and the C=N group, respectively. The presence of C=N group indicates the synthesis of Schiff base. This is in line with Duraiswamy *et al.*, 2007

Fig. 2, shows the FTIR spectrum of the Schiff base after adsorption. The peaks at 3413 and 1681cm^{-1} indicates shift in bands after adsorption.

Calibration Curve

From Fig. 3, calibration done at different concentration of nickel (ll) standard solutions, the graph is plotted for absorbance on against concentration and the calibration curves have correlation values of 0.9999 and slope 0.013.The calibration data for nickel (ll) solution. It is used calculating final concentration.

Effect of Contact Time

Fig.4 shows the effect of contact time on the amount of nickel (ll) ion metal ion adsorbs by the Schiff base. The percentage removal of nickel (ll) ion as the adsorption started increases fist but after 90 minutes the percentage start to decreased.

Effect of Adsorbent Dosage

From Table 3, the optimum Schiff base weight was 0.5g and maximum percentage removal of metal ion was 97.7%. This is to show that as the weight of Schiff base used in this work increase the percentage of the metal ion adsorbed decrease.

Adsorption kinetics

The adsorption kinetics studies were investigated using 0.5g of Schiff base in 10 mg/L solutions of nickel (ll) ions under previously obtained optimized conditions. The Pseudo second order models were investigated using this equation: $t / q_t = 1/(K_2 q_e^2) + t/ q_e$

Where,

qe(mg/g) = adsorbed nickel ion on the adsorbent at equilibrium,

qt (mg/g) is the adsorbed nickel ion on the adsorbent at time t, and

K_2 = the rate constant of pseudo second order adsorption in g mg^{-1} min^{-1}. Hence, the study follows pseudo second order model and was found to fitted with Langmuir isotherm. These correspond with the findings of Dambies *et al*.,2001 and Namasivayaam *et al*., 2006.

CONCLUSION

The maximum adsorption of Nickel (ll) ions by Schiff's base derived from 2-aminobenzoic and benzoin was 97.7% within initial concentration of 10mg/L and the removal rate of 97.7% was also within 90 minutes. The kinetic studies showed that the removal of Nickel(ll) ions follow pseudo second order and the adsorption capacity of Schiff base was 4.89mg/g for Nickel(ll) ions and it possess monolayer. Also, it was found to be fitted into Langmuir Isotherm.

References

1. Ashraf M. A., Mahmood K., Wajid A.(2011): Synthesis, Characterization and Biological Activity of Schiff Bases. IPCBEE, Vol. 10, pp 1–7.
2. Bansal R. C, Goyal M.(2005): Activated Carbon Adsorption. Taylor and Francis Publication. Francis, 497p ISBN 0-8247-5344-5.
3. Boujelben, N., J. Bouzid and Z. Elouear (2009): "Adsorption of Nickel and Copper onto Natural Iron Oxide-Coated Sand from Aqueous Solutions: Study in Single and Binary Systems,"*Journal of Hazardous Materials*, Vol. 163, No. 1, pp. 376-382151
4. Chuan-Wei Oo*, Hasnah Osman, Sharon Fatinathan, Maizatul Akmar Md. Zin (2013): The Uptake of Copper(II) Ions by Chelating Schiff Base Derived from 4 Aminoantipyrine and 2 Methoxybenzaldehyde, *International Journal of Nonferrous Metallurgy*, Vol. 2, page 1-9.
5. Dambies L, Vincent T, Domard A, Guibal E (2001): Magnetic nanoparticle of chitosan gel beads by ionotropic molybdate gelation. *Biomacromolecules* 2(4):1198-1205.
6. Donia, A., A.A Atiam and K.Z Elwakeel (2005): Selective separation of mercury(ll) using synthetic resin containing amine and mercaptan as chelating groups. *React. Funct. Polym*.,Vol 65, pp. 267-275.
7. Duraiswamy, S., Michael, R.E, Matthias, Z., and Karuppanan, N.(2007): Hydrolytic cleavage of Schiff base by [$RuCl_2$ (DMSO)4] . *Polydedron*, 26, 4314-4320.
8. El-Sayed, G.O., H. A. Dessouki and S. S. Ibrahiem (2011): The Malaysian Journal of Analytical Sciences, Vol 15 No 1 ,pp. 8 – 21.
9. Godwin O. Ojokuku (2001): Practical Chemistry for Schools and Colleges, 3rd Edition, Published by Gbabeks Publishers Limited, G.P.O Box 37252, Ibadan, Nigeria. Page 108.
10. Kocaoba, S., and T.Akyuz (2005): "Effects of conditioning of sepiolite priorvto cobalt and nickel removal," *Desalination*, Vol.181, No. 1–3, pp.313–318.
11. Kumar S., Dhar D. N., Saxena P. N.(2009). Applications of metal complexes of Schiff bases a review. *J. Sci. Ind. Res*., 68, 181–187.
12. Lee, C. I., Yang, W. F., and Hsieh, C. I., (2004): "Removal of Copper(II) by Manganese-Coated Sand in a Liquid Fluidized Bed Reactor," *Journal of Hazardous Materials*, Vol. 114, No. 1-3, pp. 45-51.
13. Mashhadizadeh, M. H., Pesteh, M., Talakesh, M., Sheeikhshoaie, I., Ardakani, M.M., and Karim, M.A.,(2008): "Solid Phase Extraction of Copper(II) by Sorption on Octadecyl Silica Membrane Disk

Modified with a New Schiff Base and Determination with Atomic Absorption Spectrometry," *Spectrochimica Acta Part B*, Vol. 63, No. 8, pp. 885-888.

14. Miyake , Y.,(1997): Adsorption of PCE from soil vapour extraction on activated carbon fiber. *J. Resour. Environ*., 33:896-899.
15. Namasivayaam C, Sangeetha D(2006): Removal of Molybdate from water by Adsorption onto $ZnCl_2$ Activated coir pith Carbon. *Bioresour Technol* 97:1194-1200
16. Palma, G., J. Freer and J. Baeza (2003): "Removal of Metal Ions by Modified Pinus radiate Bark and tannins from Water Solutions," *Water Research*, Vol. 37, No. 20, pp. 4974 - 4980.
17. Reham Hassan, Hassan Arida , Manal Montasser, and Nehad Abdel Latif (2013): Synthesis of new Schiff Base from Natural Products for Remediation of Water Pollution with Heavy Metals in Industrial Areas, *Journal of Chemistry* Volume 2013, *Research Articlen* ID240568,10pages.
18. Susan, E. A., J. O. Trudy, R. M. Bricka and D. D. Adrian, (1999): "A Review of Potentially Low-Cost adsorbents for Heavy Metals," *Water Research,* Vol. 33, No. 11, pp. 2469- 2479.
19. Tsai, W.,(2002): A review of environmental hazard and adsorption recovery of cleaning solvent hydrochlorofluoro carbons(HCFCs). *J loss prevent proc ind* ., 15(2):147-157.