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Adsorption of Heavy Metal Pb (II) from Synthetic Waste Water by Polypyrrole composites

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Abstract
The aim of the research work is a new application of Polypyrrole and its composites with bentonite for removing of heavy metal ions. The conducting polypyrrole composites were prepared by oxidation in presence of $FeCl_3$. It was found that the polypyrrole composites can be used as an effective adsorbent in the removal of Pb (II) from wastewater under specific conditions. The effect of various parameters such as pH of solution, dosages of adsorbent contect time and initial concentration of metal ion solution were investigated. Also the product were characterized by Fourier transform infrared spectrometer (FTIR) and analyzed by atomic absorption spectrophotometer (AAS) device.

Keywords: *Adsorption, Wastewater, Lead, Polypyrrole composites, AAS, FTIR.*

1. Introduction

Heavy metals are major pollutants in the environment because of their toxicity and threat to creatures and human being at high concentrations [1], Metals that are released into the environment tend to persist indefinitely, accumulating in living tissues throughout the food chain [2]. Mostly, heavy metals (Arsenic, lead, chromium, cadmium, nickel etc.) are present in low concentration in wastewater and are difficult to remove from water [3]. The removal of toxic heavy metals such as cadmium, copper, lead, nickel, mercury and zinc from aqueous environment has received considerable attention in recent years due to their toxicity and carcinogenicity which may cause damage to various systems of the human body. They also can be readily absorbed by marine animals and directly enter the human food chains, thus presenting a high health risk to consumers [4].

There are more than 20 heavy metals, but four are of particular concern to human health: Lead (Pb), Cadmium (Cd), mercury (Hg), and inorganic Arsenic (As) [5, 6]. Lead is a type of high environmental risk heavy metal [7apsh]. Environmental Protection Agency (EPA) 0.06 mg/L in air not to exceed 1.5 μ/m^3 averaged over 3 months. EPA limit in drinking water to 15 $\mu g/L$. OSHA 0.05 $\mu g/L$ in work room air is 50 μ/m^3 for an 8-hour workday If a worker has a blood Lead level of 40 μ/m^3, OSHA requires that worker to be removed from the workroom [7]. Lead poisoning is one of the commonest occupational diseases, although in recent years there has been a decline in both the number of reported cases and the severity of the symptoms presented, hence Lead poisoning has shifted from an industrial hazard to an environmental one. Lead affects the red blood cells (anemia and other effects on the hemopoietic system are the commonest effects) and causes damage to organs including the liver, kidneys, heart, and male gonads, as well as causes effects to the immune system [8]. These effects are more common after exposure to high levels of Lead. It can cause abortion and damage the male reproductive system. It is gonad toxic, causes a reduction in pregnancies in successfully mated mice, and is embryo toxic. Effects on the kidneys, gastrointestinal tract, joints and reproductive system, and acute or chronic damage to the nervous system, anemia, headache, fatigue, weight loss, cognitive dysfunction and decreased coordination, memory loss, nerve conductions. The central nervous system is most sensitive to the effects of lead [9].

There are numerous methods currently employed to remove and recover the metals from our environment and many physico-chemical methods have been proposed for their removal from wastewater [10]. Adsorption is one of the techniques to remove heavy metals contaminants from wastewater. Different adsorbents such as seaweeds [11], crab shell [12], dried aerobic activated sludge [13], loofa sponge-immobilized biomass of chlorella sorokiniana [14], activated carbon prepared from almond husk [15], spent animal bones [16] and waste factory tea [17] have been used to remove nickel ions from aqueous water, but low adsorption capacities or efficiencies limit their applications. Therefore, investigating new adsorbents with higher adsorption capacities and efficiencies has been the aims of many researchers. Conductive electroactive polymers such as polypyrrole and polyaniline can be used for the removal of heavy metals from water and waste waters [18-20]. For Efficient and quick removal of the heavy metal contaminants polycomposite materials bentonite, activated carbon, conductive electro-active polypyrrole were used by different researchers.

2. Experimental

2.1 Instruments used in Experiment

Atomic Absorption Spectrophotometer (Shimadzu 6300), Fourier transform infrared (FTIR) spectrometer (BRUKER), Magnetic mixer model MK20, vacuum oven, Digital weighing meter (Adair Dutt AD Series), Double distillation column, P^H Meter and P^H strips were used for this experimentation.

2.2 Reagents and standard solutions

Materials used in this work were Pyrrole (d = 0.97 g/mL) 98 % reagent grade from Aldrich, Ferric chloride ($FeCl_3$) from SD fine Chemicals M.W. 162.21, Bentonite and Sodium Arsenate (Na_2AsO_4) M.W. 180.033 from Loba Chemicals, Sodium Hydroxide (NaOH), Sulfuric acid (H_2SO_4) and Distill water used which is making by double distillation column.

Standard solution of Lead

1.618 grams of $Pb(NO_3)_2$ was added in the 1000 ml of distilled water in 1000 ml volumetric flask. It was dissolved by shaking and the volume was made up to the mark. Lead concentration of this solution was 1000 mg/l.

2.3 Synthesis of Polypyrrole Composites

The reaction was carried out in an aqueous media as water at room temperature for 5 hours. In a typical experiment 1 mL of pyrrole monomer was added to a stirred aqueous solution (100 mL) containing 5.4 g of FeCl3 as oxidant when the solution became homogen. After 5 hours, the polymer was collected by filtration, and in order to separate the oligomers and impurities, the product was washed several times in succession with deionized water. It was then dried in a vacuum oven at 40°C for 12 h [21]. The mixture of polypyrrole and bentonite where mix in same percentage ratio to make polypyrrole composites [22].

3. Result and Discussion

3.1 Characterization of polypyrrole

A Brukar FTIR Instrument is used for the characterization of the polypyrrole adsorbent. As can be seen, the FTIR spectrum changed when the composites were obtained in various conditions. As can be seen in Fig. the peak related to pyrrole unit at 1588 cm-1. The peaks are at 1176 cm-1 (C-N stretching vibration), 1038 cm-1 (C-H in-plane deformation), 918 cm-1 (N-H in-plane deformation), 638 cm-1 (C-H out-of-plane deformation) and 568 cm-1 (C-H out-of-plane ring deformation). The chemical method can be a general and useful procedure to prepare conductive polymer and its composites. PPy is attractive as an electrically conducting polymer because of its relative ease of synthesis. In order to exploit this material in some potential commercial applications, it will be necessary to synthesize it at low cost. The electrical conductivities of various composites produced under different reaction conditions were measured on pressed pellets of the composite powders [23].

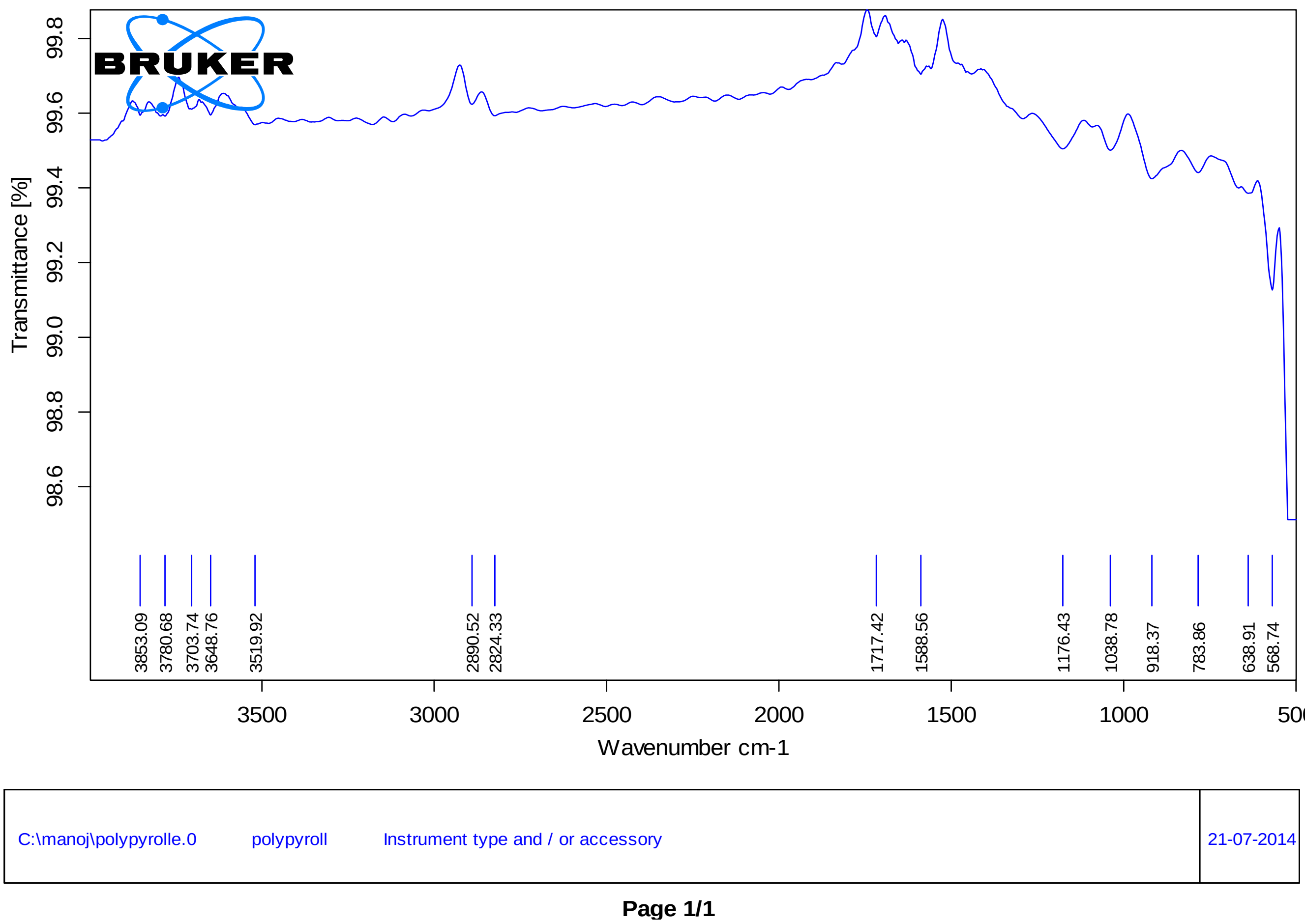

Fig 1: FTIR Characterization of Polypyrrole composites

3.2 Batch mode adsorption studies: The adsorption of heavy metals on adsorbent ware studied by batch technique. The general method used for this study is described as below:

A known weight of adsorbent (e.g. 0.6 g adsorbent) was equilibrated with 100 ml of the heavy metal namely Pb(II) solution of known concentration (5, 10, 20 and 50 ppm) in 4 stoppered borosil glass flask at a room temperature (27 ^{0}C) for a known period (10–50 Min.) of time. After equilibration, 10 ml sample collected from each flask, in time interval of 10, 20, 30, 40 and 50 minutes, the suspension of the adsorbent was separated from solution by filtration using Whatman No. 1 filter paper. The concentration of heavy metal ions remaining in solution was measured by AAS spectrophotometer.

The effect of several parameters, such as pH, concentrations, contact time and adsorbent dose on the adsorption were studied. The pH of the adsorptive solutions was adjusted using sulfuric acid, sodium hydroxide and buffer solutions when required. The results of these studies were used to obtain the optimum conditions for maximum heavy metals removal from aqueous solution. The percent heavy metal removal was calculated using Eq.

Metal ion removal (%) = $[(C_o - C_e) / C_o] \times 100$ …………… (1)

Where C_o: initial metal ion concentration of test solution, mg/l; Ce: final equilibrium concentration of test solution mg/l.

4. Effect of Various Parameters:-

4.1. Effect of contact time Fig. 2 shows the variation in the percentage removal of heavy metals with contact time using 0.6 g/100ml Pb of Ppy composites adsorbent at 5 pH Pb for varying initial metal ions concentration ranging from 05 ppm to 50 ppm. It is observed that maximum removal of Pb(II) ions are nearly 84% in 40 min contact times. It is observed that in all cases the percentage removal is comparatively lower for 10 min. contact time, with increasing removal efficiencies at higher contact time up to 40 min and then gradually constant and decreases after 50 minutes.

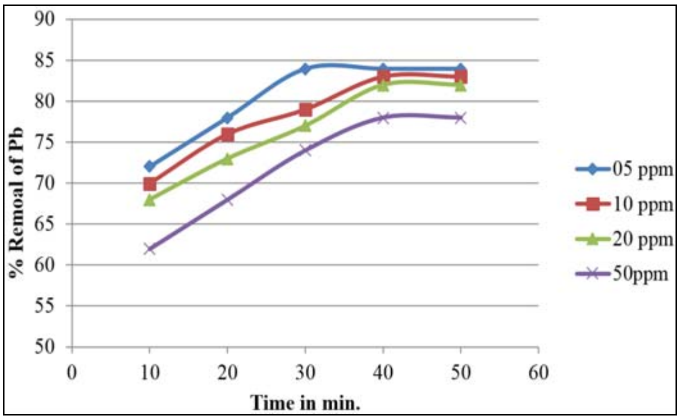

Fig 2: Effect of contact time on Lead ions by Polypyrrole composite

4.2 Effect of adsorbent dosage

The results for adsorptive removal of heavy metals with respect to adsorbent dose are shown in Fig.3 over the range 0.2 to 1gram/100ml, at pH 5 and 40 minutes contact time. The percentage removal of heavy metals is seen to increase with adsorbent dose. It is observed that there is a sharp increase in percentage removal with adsorbent dose for Pb (II) ions. The maximum removal of Pb is 84% at 0.6 gram dose amount of Ppy composites adsorbent.

It is apparent that the percent removal of heavy metals increases rapidly with increase in the dose of the adsorbents due to the greater availability of the exchangeable sites or surface area. Moreover, the percentage of metal ion adsorption on adsorbent is determined by the adsorption capacity of the adsorbent for various metal ions.

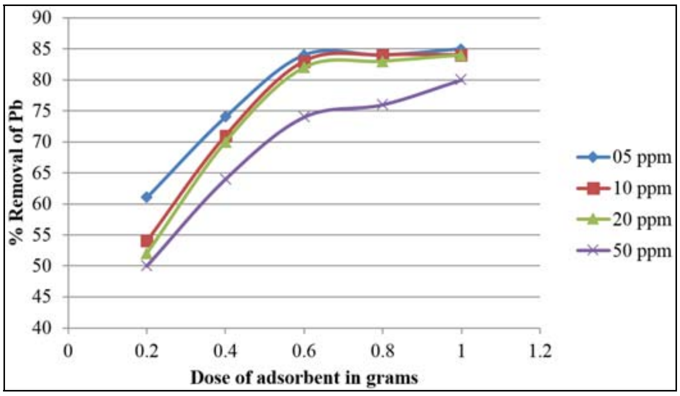

Fig 3: Effect of amount of adsorbent dose on Lead ion by Ppy composites.

4.3 Effect of pH: - pH variation is one of the most important parameters controlling uptake of heavy metals from wastewater and aqueous solutions. Fig. 4 shows the effect of pH on heavy metals removal efficiencies on Ppy composites adsorbent. These studies were conducted at an initial metal ions concentration of 5, 10, 20, and 50ppm in 100ml solution, and constant adsorbent dose 0.6g /100ml of Pb solution and agitation period is 40 min. for all heavy metal ions at varying the pH in each solution. The percentage adsorption increases with pH to attain a maximum at 6pH and thereafter it decreases with further increase in pH. The maximum removals of Pb (II) at 5 pH were found to be nearly 84%.

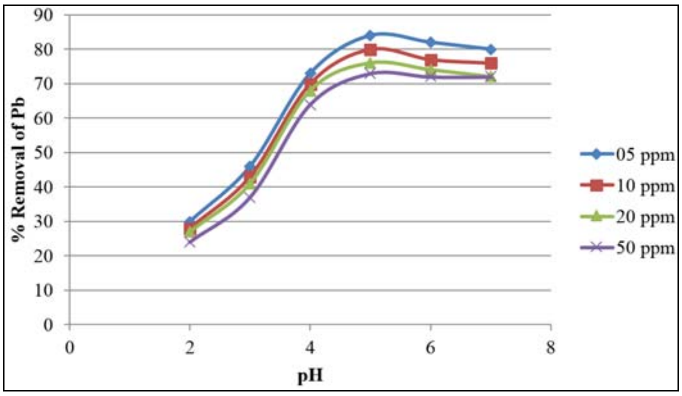

Fig 4: Effect of pH on % removal of Lead ion by Polypyrrole adsorbent.

4.4 Effect of concentration: The effect of concentration at 0.6g/100min adsorbent dose, 5 pH and 40 min contect time. The effect of initial concentration on the percentage removal of heavy metals Pb(II) by Polypyrrole Composites is shown in Fig 5. It can be seen from the figure that the percentage removal decreases with the increase in initial heavy metal concentration, the percentage removal is highly effective on the 5 ppm initial concentration after which percentage removal decreases gradually to below 70%. At higher initial concentrations Pb(II) metals are gradually decreases their percentage removal. At lower initial metal ion concentrations, sufficient adsorption sites are available for adsorption of the heavy metals ions. Therefore, the fractional adsorption is independent of initial metal ion concentration. However, at higher concentrations the numbers of heavy metal ions are relatively higher compared to availability of adsorption sites. The maximum removal of Lead is 84% at 05 ppm concentration. Hence, the percent removal of heavy metals depends on the initial metal ions concentration and decreases with increase in initial metal ions concentration.

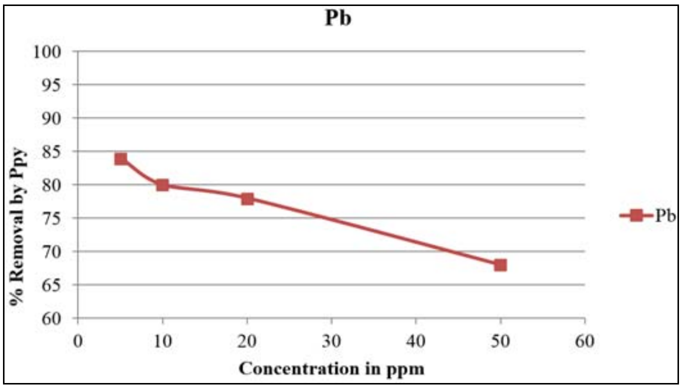

Fig 5: Effect of concentration on % removal of metal ions by Ppy composites adsorbent.

5. Conclusion

Polypyrrole conducting polymer can be easily synthesized via chemical polymerization. In this study, the effect of various agents on removal of Lead from water using Ppy composites was investigated. The study indicated the suitability of the adsorbents used for removal of Lead form aqueous solution. The polypyrrole composite has shown considerable potential for the removal of Lead from aqueous solution. From this research following conclusions are drawn:-

- The results indicate that Ppy composites adsorbent is suitable for removal of heavy metal from wastewater.
- Adsorptive capacity and metal removal efficiency of adsorbent namely Ppy composites increased with contact time and reached maximum near at 40 min which is very small time.
- Adsorptive capacity and metal removal efficiency of adsorbent Polypyrrole composites decrease with increased initial concentration of metals and the exhibited optimum in 05 ppm.
- Adsorption of Lead is maximum at 5 pH. Alkaline pH range was found as the favorable condition for maximum Lead removal.
- Because of the availability of higher number of Ppy ions per unit volume of Lead solution, the amount of Lead ions uptake per gram of adsorbent increased by increasing the adsorbent dose and exhibited optimum with 0.6 g.

Polypyrrole and its composites characterizations as it have good electro-active capacity for removal of the several heavy metals rather than Pb.

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7. Nomenclature

Ppy	= Polypyrrole
PVA	= Poly vinyle Alcohol
Pb	= Lead
AAS	= Atomic Adsorption Spectrophotometer
FTIR	= Fourier transform infrared spectrophotometer
C_o	= initial metal ion concentration of test solution, mg/l
C_e	= final equilibrium concentration of test solution mg/l

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