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Removal of Lead (II) from Aqueous Solution using Polypyrrole Adsorbent

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Abstract
In the present study efficient and quick removal of the Lead contaminants by using polypyrrole adsorbents were investigated. Lead causes many health problems to human beings. Effects of various parameters were studied like pH, contact time, adsorbent dose and initial concentration of lead by using polypyrrole (Ppy) adsorbent. Maximum 91 % lead removal was achieved by using Ppy adsorbent, and their capability to removal of Lead (II) from aqueous solution was studied. Polypyrrole was prepared by chemical oxidative polymerization of pyrrole using $FeCl_3$. The removal of Pb was investigated using polypyrrole (Ppy).

Keywords: Lead, Aqueous solution, Polypyrrole Adsorbent, Ppy composite Adsorption, Parameters

1. Introduction
Lead is one of the heavy metals that are often found in industrial wastewater and its discharge into the environment poses a serious threat due to its toxicity to aquatic and terrestrial lives. It is a group IV element on the periodic table which is remarkably highly resistant to corrosion in most acid and naturally occur as element buried in the earth crust in insoluble and biologically inoffensive forms (Ogunleye *et al*., 2014) [6].

Among the different heavy metals, lead is one of the common and most toxic pollutants into the natural waters from various industrial activities such as metal plating, oil refining (Yarkandi, 2014) [9] and manufacturing of storage batteries (Patterson J.W. 1985) [7], television tube, printing, paints, pigments, photographic materials, gasoline additives, matches and explosives brought about lead bearing wastewater (Patterson J.W. 1985) [7]. Lead contamination of the environment is primarily due to anthropogenic activities, making it the most ubiquitous toxic metal in the environment (Badmus *et al*., 2007) [1]. Exposure to Lead is widely recognized as a major risk factor for several human diseases once it goes beyond the World Health Organisation (WHO) maximum permissible limit (3-10$\mu g \cdot L^{-1}$) in drinking water (Needleman H.L. *et al*., 1999) [5]. It forms complexes with Oxo-groups in enzymes to affect virtually all steps in the process of haemoglobin synthesis and porphyrin metabolism. Other problems associated with toxic levels of lead exposure are encephalopathy, seizures and mental retardation, anemia and nephropathy. Hence, lead must be removed as much as possible from industrial effluents to prevent environmental hazard from its discharge (Ogunleye *et al*., 2014) [6].

Adsorption of metal ions by several functionalized polymers based on amines derivatives such as ethylenediamine, polyacrylamides, poly-4-vinylpyridine, polyethyleneimine and aniline formaldehyde condensate has been reported. Polypyrrole was used in the removal of fluoride ions from aqueous solution by conducting Polypyrrole. Conductive polymers such as polyaniline, polypyrrole, and polythiophene, have attracted so much research interest in wide range applications such as rechargeable batteries, electromagnetic interference (EMI) shielding, antistatic coatings, gas sensors, optical devices and removal of heavy metals (Reyad 2015) [8]. In this study various adsorbents such as bentonite, and conductive electroactive polypyrrole composites prepared chemically using various surface active agents was employed to the removal of lead from water (Eisazadeh, 2008) [2].

2. Materials and Methods
The preparation of adsorbent, glass ware, reagents and standard solution used to investigate the removal efficiency of lead, during experiment were given below.

2.2 Reagents and standard solutions
Materials used in this work were Pyrrole 98 % reagent grade from Aldrich, Ferric chloride ($FeCl_3$) from SD fine Chemicals (M.W. 162.21 g/mol, Density 2.9 g/cm³, Boiling point 315 °C and Melting point 306 °C). 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 distillation column.

2.3 Standard solution of Lead
1.618 grams of Lead (II) nitrate (It commonly occurs as a colourless crystal or white powder and, unlike most other Lead (II) salts, is soluble in water.) $Pb(NO_3)_2$ (M.W. 331.2098 g/mol, Melting point 270 °C and Density 4.53 g/cm³) 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.

2.4 Synthesis of Polypyrrole Composites Preparation
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 $FeCl_3$ 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 (Eisazadeh H., 2008) [3]. The mixture of polypyrrole and bentonite where mix in same percentage ratio to make polypyrrole composites (Eisazadeh H., 2007) [2].

3. Batch mode adsorption studies
The adsorption of heavy metals on adsorbent were studied by batch technique, A known weight of adsorbent (e.g. 0.6 g adsorbent) was equilibrate 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 percentage heavy metal removal was calculated using following Eq.

Percentage removal (%) = $[(Co - Ce)/Co] \times 100$ …… (1)

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

4. Results and Discussion
The percentage removal of lead was determined by using polypyrrole adsorbent. Effects of various parameters on the percentage removal efficiency of lead were analyzed.

4.1 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. 1 the peak related to pyrrole unit at 2384 cm-1. The peaks are at 1987 cm-1 (C-N stretching vibration), 1342 cm-1 (C-H in-plane deformation), 959 cm-1 (N-H in-plane deformation), 857 cm-1 (C-H out-of-plane deformation) and 736 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 (Eisazadeh H., 2012) [4].

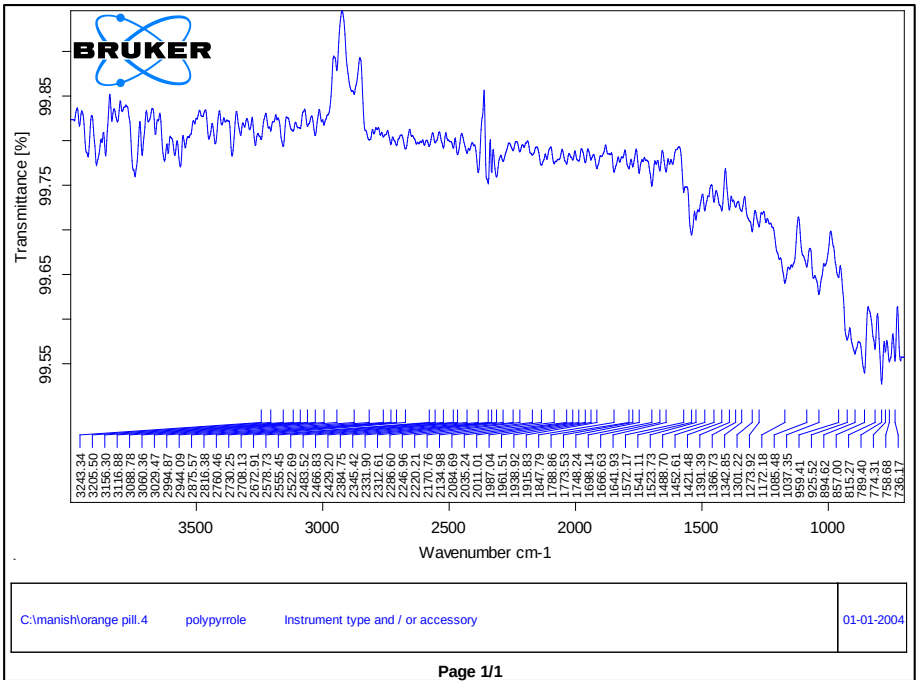

Fig 1: FTIR Characterization of Polypyrrole composites

5. Effect of Various Parameters

5.1 Effect of contact time

Fig. no 2 shows the of variation in the percentage removal of heavy metals with contact time at optimum condition, for initial lead ion concentration ranging from 05 ppm to 50 ppm. It is observed that maximum removal of Pb (II) ions are nearly 91% in 30 min contact time. It is observed that in all cases the percentage removal increase up to 30 min and then gradually decreases after 50 minutes, and then reaches constant value. as the results indicate, removal of lead using the PPy occurs quickly and it is not a highly time-dependent process. It was found that about 91% removal of lead occurs within 30 min. This confirms a high and rapid adsorption of lead by PPy adsorbent.

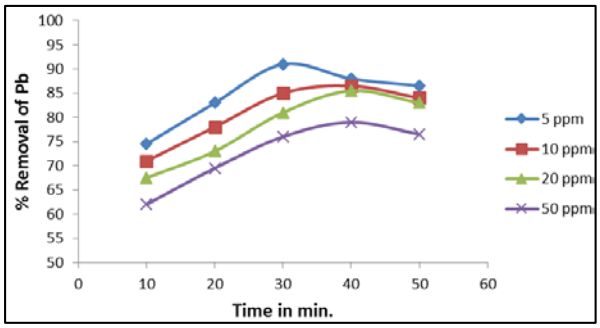

Fig 2: Effect of contact time on percentage removal of Lead (II) ion by Polypyrrole adsorbent (Parameter- 0.6g adsorbent dose, 5pH)

5.2 Effect of pH

The pH of the solution affects the charge on the surface of the adsorbents, so the change in pH also affects the adsorption process and the ion concentration may react with the functional groups on the active sites on the adsorption surface. These pH values affect the surface charge of adsorbent during adsorption. In order to evaluate the influence of this parameter on the adsorption, the experiments were carried out at different initial pH ranging from 2 to 7. The experiment was performed by Ppy composite, The pH variation is one of the most important parameters controlling uptake of heavy metals from aqueous solutions. Fig. 3 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, constant adsorbent dose 0.6g /100ml of Pb solution and agitation period is 40 min. The percentage adsorption increases with pH to attain a maximum at 6 pH and thereafter it decreases with further increase in pH. Lead ions at varying the pH in each solution. The maximum removals of Pb (II) at 5 pH were found to be nearly 91%.

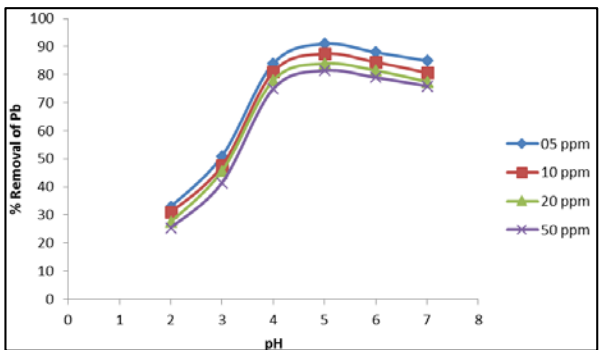

Fig 3: Effect of pH on percentage removal of Lead ion by polypyrrole adsorbent (Parameter – 0.6g adsorbent dose, 30 min contact time)

5.3 Effect of adsorbent dose

The results for adsorptive removal of lead with respect to adsorbent dose over the range 0.2 to 1 gram/100ml, at pH 5 and 30 minutes contact time are shown in Fig. 4. The percentage removal of lead 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 91% at 0.6 gram dose 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 lead ion adsorption on adsorbent is determined by the adsorption capacity of the adsorbent for various lead ions. The amount of lead ions uptake per gram of adsorbent increased by increasing the amount of adsorbent dose, this is due to the availability of higher number of polypyrrole ions per unit volume of solution. The absorbent surfaces become saturated with the Pb and the residual Pb concentration in the solution was high.

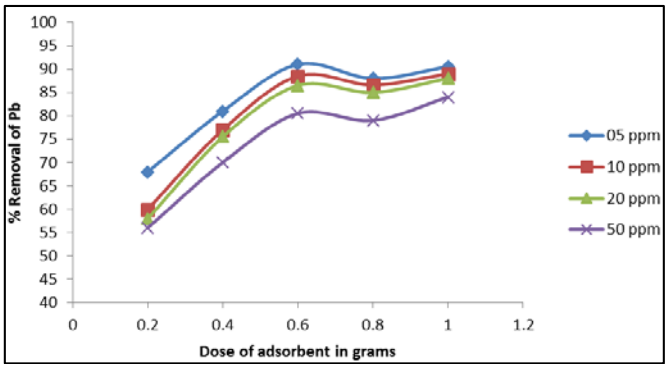

Fig 4: Effect of adsorbent (amount) dose on percentage removal of lead ion by Ppy composites adsorbent (Parameter – 5 pH, 30 min, contact time)

5.4 Effect of initial concentration

Figure no 5 shows the effect of concentration on the percentage removal of lead by using Ppy adsorbent at 0.6g/100 ml of adsorbent dose. Maximum 91% removal occurs at 5 ppm initial concentration of lead. It indicates that the percentage removal decreases with increase in the concentration of lead in aqueous solution due to reduced active sites on the adsorption surface.

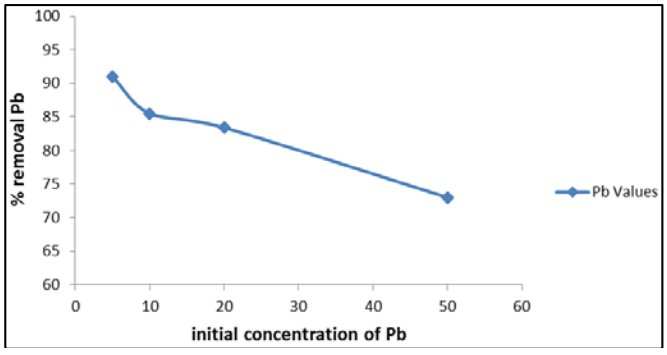

Fig 5: Effect of concentration on percentage removal of Pb ion Ppy adsorbent (Parameter- 30 min contact time, 0.6g adsorbent dose, 5pH.)

6. Conclusion

The results demonstrate that Ppy composites adsorbent is suitable for removal of lead from aqueous solution. The study indicate that the optimum condition for removal of lead are

found to be 30 minutes contact time, 5 pH and 0.6 gm adsorbent dose by using Polypyrrole adsorbent. Maximum 91 % removal occurs at 5 ppm initial concentration of lead in aqueous solution. Hence Polypyrrole has effective adsorbent for removal of lead from aqueous solution.

7. References

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