Influence of Polyaniline Synthesis Conditions on its Capability for Removal and Recovery of Chromium from Aqueous Solution

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ABSTRACT: *Absorptive characteristics of polyaniline synthesized in different solvents were studied. Water and mixture of water with other solvents were implemented for polyaniline synthesis. Synthesized polyanilines in powder shape is used as an adsorbent to remove toxic hexavalent chromium from aqueous solutions. Experiments were conducted in batch mode. Removal mechanism involving polyaniline is the combination of surface adsorption and reduction. The kind of solvent used at synthesizing stage can affect the capacity of produced polyanilines for removal of heavy metals including chromium. Synthesized polyaniline in water had the maximum chromium removal efficiency. The morphology study of polyanilines show that the type of solvent used for polymer synthesis affect the morphology of polyaniline.*

KEY WORDS: *Polyaniline, Chromium, Synthesis Condition, Adsorption, Reduction.*

INTRODUCTION

New group of polymers have been synthesized that are conductive of electricity. Therefore, they are called conducting polymers. One of the most conducting polymers is "polyaniline" that is synthesized easily at low cost and excellent environmental stability [1]. Polyaniline is synthesized chemically and electrochemically in the shape of powder and film. The synthesis condition has noticeable effect on properties of the produced polyaniline [2,3]. Reaction temperature, molar ratio of aniline/oxidant, types and concentration of acids used in synthesis will influence morphology and conductivity of polyaniline [4-6].

With rapid industrial development and population

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explosion in the world an increasing amount of different pollutants are discharged into environment every day. Some of these pollutants, noticeably heavy metals such as chromium are potentially hazardous to human health even in minute quantities. Various methods used for the removal of chromium from aqueous solutions include chemical precipitation, reverse osmosis, ion exchange and adsorption [7]. Among these methods surface adsorption has been considered more effective than others when low concentrations are present [8]. Recently new adsorbents have been studied for chromium removal including "Polyaniline" which has shown good potential for absorbing heavy metals from effluents [9,10]. In this paper, polyaniline was synthesized by oxidation of aniline in various solvents including water, mixture of water and acetonitrile in 50/50 volume ratio and mixture of water and ethylacetate in 50/50 volume ratio. Synthesized polyanilines were tested as an adsorbent for removal and reduction of toxic hexavalent chromium from aqueous solutions.

EXPERIMENTAL SECTION

Sulfuric acid, acetonitrile, ethylacetate, potassium dichromate, ammonium persulfate, powder activated carbon and aniline were all provided from Merck chemical company. Chemicals were used without any purification, with the exception of aniline which was distilled under vacuum prior to use. The magnetic stirrer (MR 3001 K, Heidolph) and analysis scale (BP 211 D, Sartorius) were applied to experiments. Cr(VI) concentration was measured using UV-Visible Spectrophotometer (Cary 300, Varian) at 375 nm wavelength (maximum intensity seen at this wavelength). Total chromium concentration was measured by Atomic Absorption Spectrophotometer (Spectra AA, Varian) using air–acetylene flame at 429 nm wavelength and slit width of 0.5 nm.

Polyaniline was chemically synthesized by oxidizing aniline monomer under acidic conditions (1M H_2SO_4) in various solvents using ammonium persulfate as an initiator of oxidative polymerization. Water, mixture of water and acetonitrile in volume ratio of 50/50 and mixture of water and ethylacetate in volume ratio of 50/50 were implemented as solvent for polyaniline synthesis. Synthesized polyaniline was grounded and used in powder form.

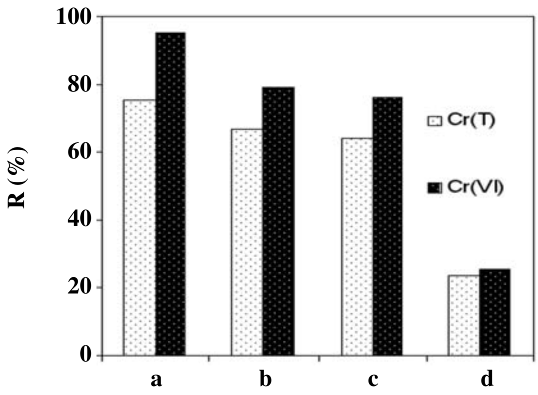

Fig. 1: Removal percentage of Cr(T) and Cr(VI): (a) Synthesized polyaniline in water, (b) Synthesized polyaniline in mixture of water and acetonitrile, (c) Synthesized polyaniline in mixture of water and ethylacetate, (d) Powder activated carbon.

RESULTS AND DISCUSSION

Synthesized polyanilines in a powder shape were used as an adsorbent to remove Cr(VI) from solution. In this experiment 0.1 g sample of various polyaniline powders were added to 100 mL of solution containing 50 ppm Cr(VI) at pH 7. The exposure was performed in 30 min followed by filtration and separation of polyaniline particles. Results show (Fig. 1) all polyanilines have about three times more removal efficiency than powder activated carbon have. When polyanilines were used, total and hexavalent chromium removal rate were not equal. It means that after contact time between polyanilines and Cr(VI) solutions, Cr(III) appears in solutions, which indicates that polyaniline is responsible for reduction of Cr(VI) to Cr(III). Another mechanism is the surface adsorption. It is well known that nitrogen atom in amine derivative makes co-ordinate bond with positive charge of metals due to the presence of electron in s^2p^3 orbit of nitrogen. This co-ordinate bond is the plausible mechanism for adsorption of Cr(VI) and Cr(III) from solution by polyanilines. Under acidic conditions the surface of polyanilines is high protonated due to its nature [11]. The protonated form of polyanilines can form bonds with solution anions (chromate and dichromate) by electrostatic attraction.

Synthesized polyanilines in various solvents have different Cr(T) and Cr(VI) removal efficiency. The kinds of solvents can affect the capacity of polyanilines for removal of chromium. SEM micrographs of synthesized

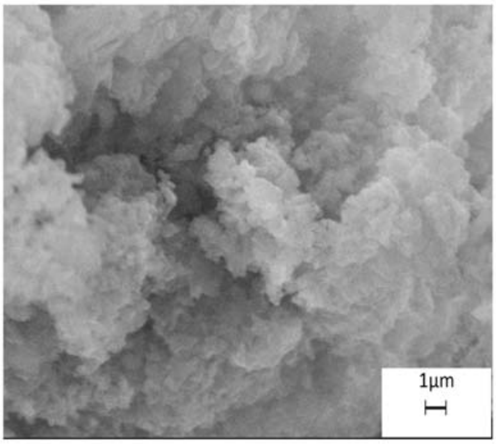

Fig. 2: SEM micrograph (×8000) of synthesized polyaniline in water.

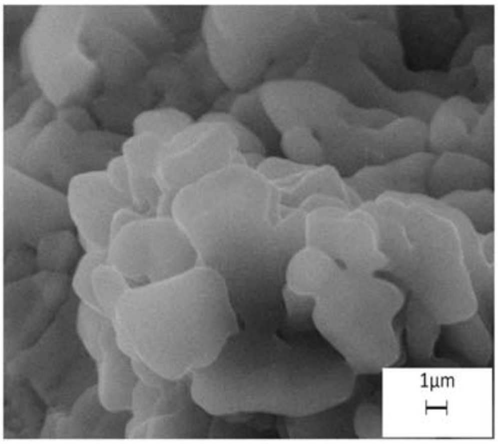

Fig. 3: SEM micrograph (×8000) of synthesized polyaniline in mixture of water and acetonitrile.

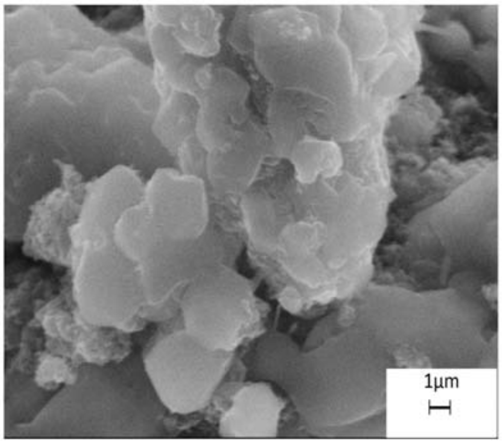

Fig. 4: SEM micrograph (×8000) of synthesized polyaniline in mixture of water and ethylacetate.

polyanilines in various solvents show that the type of solvent used affects surface morphology of synthesized polyanilines (Fig.s 2, 3 & 4). Synthesized polyaniline in water has a steady pore on its surface, but synthesized polyanilines in mixture of water with other solvents have scale like surfaces. This variation of polyanilines surfaces affect the capacity of prepared polyaniline for chromium removal due to changes of interface between polyanilines and chromium solution.

CONCLUSIONS

The kind of solvent used in preparation of polymer has noticeable effect on capacity of chemically synthesized polyaniline in powder shape for removal of hexavalent chromium from aqueous solution. The removal mechanism is a combination of Cr(VI) reduction and adsorption of Cr(VI) and Cr(III). Synthesized polyaniline in water has steady surface pores and has the best total and hexavalent chromium removal efficiency. Synthesized polyanilines in mixture of water and other solvents have a scale like surface. These results indicate all polyanilines can be used as good adsorbents for removal of chromium in solutions. This research shows that the type solvent used for syntheses of polyaniline has a special effect on the capacity of polyaniline for chromium removal from aqueous solutions.

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