

# Studying the Effect of pH on the Removal of Dichromate from Aqueous Solution using Polyaniline Nanocomposites

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**ABSTRACT:** The effect of pH on the removal of dichromate anion from an aqueous solution using polyaniline nanocomposite as an adsorbent was studied. The conductive polyaniline composites were prepared using KIO<sub>3</sub> as an oxidant at room temperature. The results indicate that the polyaniline nanocomposites are able to remove the dichromate anion from aqueous media. The dichromate removal percentage increased in alkaline solution. The structure of polyaniline nanocomposite was also characterised by FTIR spectroscopy.

**Keywords:** polyaniline, nanocomposite, FTIR, removal, dichromate

## Introduction

Removal of Cr (III, VI) from waste water is essential due to their toxicity. A main source of water contamination with chromium ions is industrial waste water from the surface metal treatment plants and from tannery. Activated carbon may be regarded as a unique class of ion-exchange adsorbent (Garten and Weiss, 1957). Various techniques such as chemical sedimentation, surface absorption, ion-exchanger and reverse osmosis can be used for the removal of chromium from waste water (Selvaraj et al., 1997). Activated carbon with low polar properties is a typical adsorbent and is commonly used for the removal of non-polar organic material in water (Ying et al., 1990). Bentonite is used widely for the adsorption of particles due to its high activated surface and its tendency to adsorb water in the inter-layer sites (Christids et al., 1997). The interest in chromium is governed by the fact that its toxicity depends critically on its oxidation state. In the environment, chromium, a redox active metal element, usually exists as Cr (III) or Cr (VI) species (Namasivayam and Sureshkumar, 2008).

Conductive polymers such as polyacetylene, polyaniline, polythiophene and polypyrrole have attracted much research interest in wide range applications, including rechargeable batteries (Li et al., 1992), electromagnetic interference (EMI) shielding (Epstein and MacDiarmid, 1995),

antistatic coatings (Ohtani et al., 1993), gas sensors (Matsuguchi et al., 2002), optical devices (Falcao and De Azevedo, 2002) and removal of heavy metals (Eisazadeh, 2007; Eisazadeh, 2007a; Eisazadeh 2008).

The insolubility property in common solvents and the infusibility of conducting polymers, in general, make them poorly processable either by solution technique or by melt processing methods (Machado et al., 1988; Yin et al. 2001). Several attempts have been made to overcome these problems, essentially by fabrication of composites, which combine the conductivity of conducting polymers with the mechanical and optical properties of a matrix polymer such as poly(vinyl chloride) (Paoli, 1984) and poly(vinyl alcohol) (Lindsey and Street, 1984/85).

The aim of this research is to investigate the ability of polyaniline nanocomposites to remove dichromate anion from water and to study the effects of pH variation on this ability.

## Experimental

### Instrumentation

Magnetic mixer (model MK20), digital scale (model GF600), pH meter (model pH211), scanning electron microscope (SEM, XL30), Fourier transform infrared (FTIR) spectrometer (Shimadzu 4100) and inductively coupled plasma (ICP) (Vista-pro)

### Reagents and standard solutions

All reagents were used as received without further purification, unless stated otherwise. Distilled deionized water was used throughout this work.

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Aniline monomer was purified by a simple distillation. Potassium iodate (KIO<sub>3</sub>), and sulphuric acid were purchased from Merck.

*Polyaniline preparation*

For preparation of polyaniline (PAn), 1 g of KIO<sub>3</sub> was added to 100 mL of sulphuric acid (1M) and mixed with a magnetic mixer. Then, 1 mL of fresh distilled aniline monomer was added to the stirred aqueous solution. The reaction was carried out for 5 h at room temperature. The resulted polymer was filtered using filter paper to separate the oligomers and impurities. The product was washed several times with deionized water and dried at room temperature.

*Method of removal*

Completely mixed batch reactor (CMBR) technique was used to remove dichromate from

water. The three pH values of each solution used in these experiments were approximately 4, 7, and 10, respectively. A 50 mL of solution was added to the beaker containing 0.5 g of one of the polyaniline nanocomposites and mixed for 2 h by magnetic mixer at 700 rpm. Then the adsorbent was separated from the solution using filter. The dichromate concentration was analyzed by atomic adsorption method.

**Results and Discussion**

The chemical method can be a general but useful procedure to prepare the conductive polymers and their composites. The results indicate that the removal of dichromate from the solution is depended on the ability of surface absorption. The effects of various pH in the removal of dichromate are shown in **TABLE 1**.

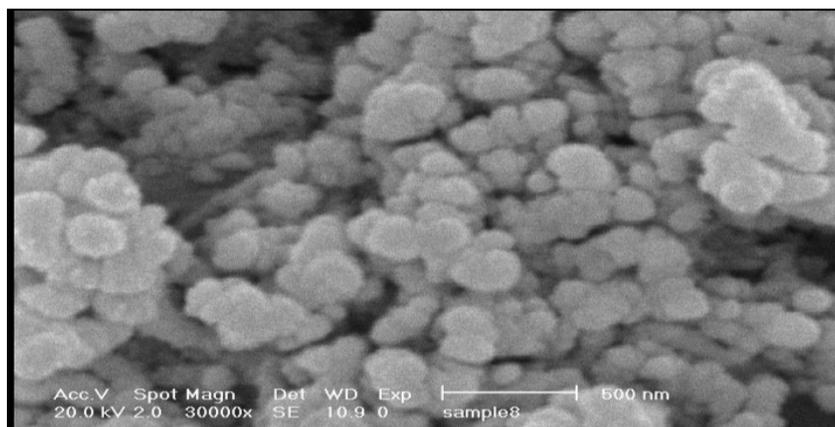
**TABLE 1-** The effect of pH in dichromate removal percentage

Type of adsorbent	pH	Initial conc. (ppm)	Final conc. (ppm)	Removal percentage (%)
Pan	4	100	86.8	13.2
	7	100	36.3	63.7
	10	100	9.7	90.3
nanocomposite of PAn with DBSNa	4	100	85.6	14.4
	7	100	26.6	73.4
	10	100	12.9	87.1

The removal of dichromate is influenced by pH with removal percentage being increased by increasing the pH of the solution.

**FIG. 1** shows SEM micrograph of polyaniline nanocomposites in aqueous media (Reaction conditions: KIO<sub>3</sub> = 10 g/L, aniline monomer = 10.7 × 10<sup>-2</sup> mol/L, volume of solution = 100 mL

(H<sub>2</sub>SO<sub>4</sub> 1M), reaction time = 5 h at room temperature), while **FIG. 2** is a SEM micrograph of polyaniline nanocomposites in aqueous media using DBSNa as the surfactant (Reaction conditions: KIO<sub>3</sub> = 10 g/L, aniline monomer = 10.7 × 10<sup>-2</sup> mol/L, volume of solution = 100 mL (H<sub>2</sub>SO<sub>4</sub> 1M), reaction time = 5 h at room temperature).



**FIG. 1-** Scanning electron micrograph of pure polyaniline in aqueous media

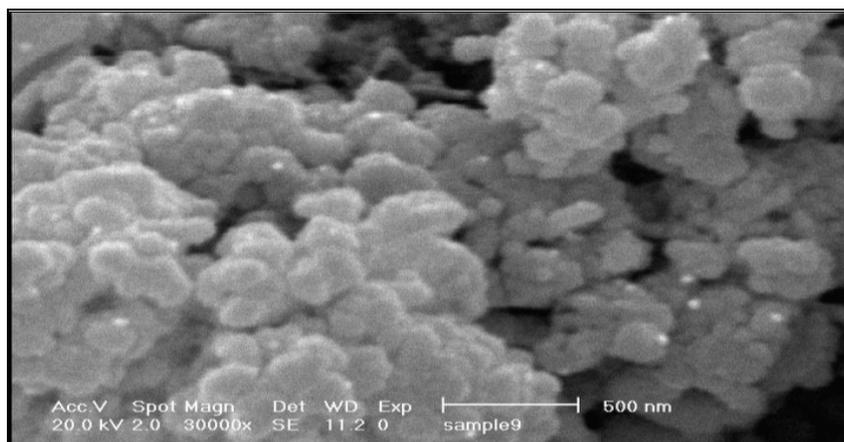


FIG. 2- Scanning electron micrograph of polyaniline nanocomposites in aqueous media using DBSNa as surfactant

The FTIR spectroscopy provides a valuable information regard on the formation of polyaniline composites via its characteristic peaks of product.

FTIR spectrum in the 2500-400  $\text{cm}^{-1}$  region for PAn is shown in FIG. 3. The peak at 1559.18  $\text{cm}^{-1}$  is assigned to the C=C stretching vibration of the

quinoid ring, 1486.91  $\text{cm}^{-1}$  is assigned to the stretching vibration of C=C of the benzenoid ring, 1304.46  $\text{cm}^{-1}$  corresponds to C-N stretching vibration, 1142.25  $\text{cm}^{-1}$  to C-H in-plane deformation and 810.44  $\text{cm}^{-1}$  for C-H out-of-plane deformation.

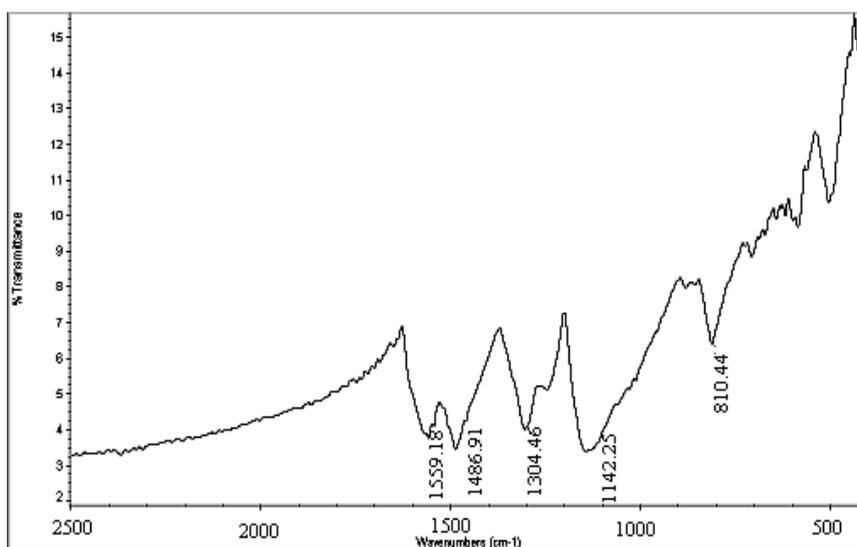


FIG. 3- FTIR spectra of pure polyaniline in aqueous media

### Conclusion

The effect of polyaniline nanocomposites on the removal of dichromate anion from aqueous media was investigated. The results indicated that the removal percentage was related to the pH of solution. Removal percentage increased in the alkaline solution. SEM micrographs show that surface morphology plays a major role in the removal of dichromate.

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