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Chromium (III) nanoparticle synthesis using the biosorption and bioreduction with *Bacillus subtilis*: Effect of pH and temperature

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Abstract: The present study focussed in recovering and reducing the chromium from the aqueous solution and an attempt has been taken to synthesis the nanoparticle using the microbes in an environmental friendly approach which connects the microbial biotechnology and the nanotechnology. The reduction and recovery using the heavy metal resistant *Bacillus subtilis* were preformed at akin room temperature at the laboratory ambience. The role of pH ranges between 2-9 and the temperature 25-45^{0}C were investigated in the reduction process and size of the nanoparticle. The products obtained from the reduction process were characterised by UV-Vis Spectrophotometer, Fourier transform infrared spectroscopy (FTIR), X-ray diffraction (XRD), scanning electron microscope (SEM), Dynamic light scattering (DLS) were analysed. Finally the study suggests that bioreduction of chromium (IV) to (III) is an ecofriendly method to recover the chromium and for the synthesis of nanoparticles with different size and shape.
Key words: Chromium; Biosorption; Bioreduction; Nanoparticle; *Bacillus subtilis.*

Introduction and Experimental

The main problem of the society in the present scenario is environmental pollution. The pollutants include toxic metals, which increase permanently as a result of increased industrial activity. The heavy metal namely chromium are released into the environment by various means namely wood preservation, electroplating, leather tanneries etc.,[1]. Apart from the above applications it is also an essential trace element for the human nutrition, required for normal carbohydrate metabolism whose deficiency is associated with cardiovascular disease and diabetes [2]. Biosorption is an alternative, clean and simple method. The history of research on biomass and metal interaction is dated back into the year 1960's and it was found that it can change the properties of the metal [3]. The mechanism behind the biosorption may involve intracellular uptake and storage via active cationic transport system, surface binding or some unidentified mechanisms [4]. Such mechanisms include: efflux systems; alteration of solubility and toxicity by changes in the redox state of the metal ions; extracellular complexation or precipitation of metals; and the lack of specific metal transport system

[5]. We consequently attempted different physicochemical parameters like pH (2-8) and temperature (25-45^{0}C) is investigated with the use of *Bacillus subtilis* for the recovery of chromium as nanoparticle.

The following describes the typical procedure for the process of biosorption and bioreduction. 0.1g/l of *Bacillus subtilis* biomass were added to the metal solution of desired concentration of 100mg/l. After that the solution was continuously stirred at a shaker in a constant speed of 150rpm at 37^{0}C for 48 h in a shaking condition. At the end of equilibrium, biomass was separated by centrifugation. The concentration of the residual Cr (VI) was determined using 1, 5- Diphenylcarbazide method and the OD was taken in a spectrophotometer at 540nm. The synthesised nanoparticles was characterised using a method reported early [6].

Result and Discussion

A continuous decrease in the chromium concentration with simultaneous to the growth of the *Bacillus subtilis.* The maximum removal percentage of chromium was 98. 25 % found to be at pH 7. Likewise the removal of chromium was decreased at low and high temperature. The percentage removal of chromium was 98.5 % at 37^{0}C. In the UV spectra the SPR band of the chromium nanoparticle changes in the range of pH 2-8 figure.1. The FTIR spectra of the synthesized chromium nanoparticle showed in figure.2. The peak at 592.21 cm^{-1} were assigned to the alkyl halides or bromoalkane vibrations [7]. Peak at 1382. 02 cm^{-1} can be assigned to the C-N stretching vibrations of the aromatic and aliphatic amines respectively [8]. The strong peak at 1636. 21 cm^{-1} is due to the presence of amide I band, which is primarily a C=O stretching mode [9]. Band at 1674.21 cm^{-1} corresponds to the bending vibration of hydroxyl group [10]. The peak at 3285. 42 cm^{-1} may be due to the phenols, alcohols or carboxylic acids [11].

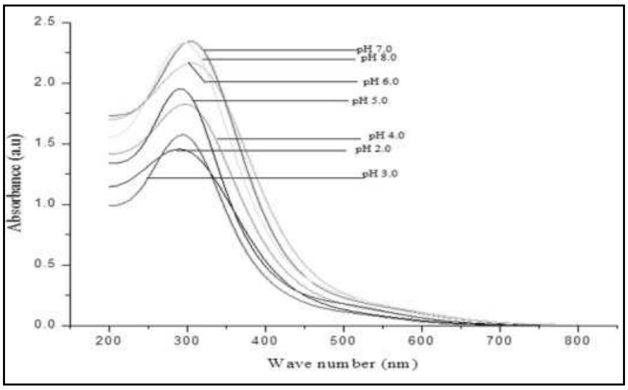

Figure.1: UV-Vis Spectra of chromium nanoparticle with different pH

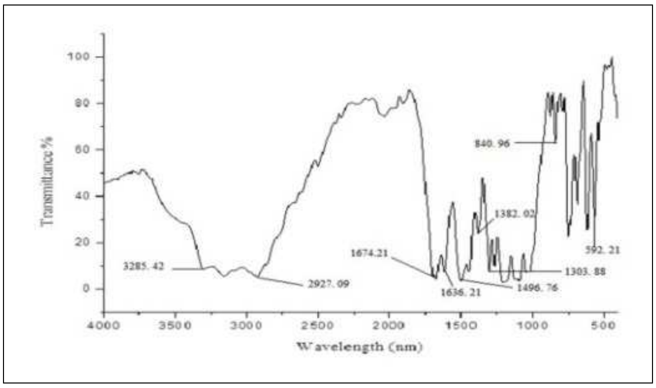

Figure. 2: FTIR Spectra for chromium nanoparticle synthesised using *B. subtilis*

The XRD pattern (figure. 3a) showed a peak at 31. 63, 45. 40, 56.36 corresponds to (122), (041), (433) which is same as the JCPDS # 45-518. The DLS (figure. 3b) of chromium nanoparticle confirms that the mean particle size ranges from 50-78nm. The SEM (figure. 4) shows the morphology of the synthesized nanoparticle was found to be smooth and it was spherical in shape.

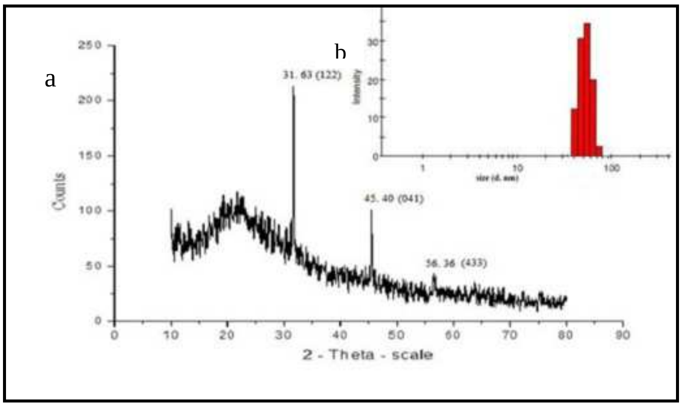

Figure. 3: a) XRD b) DLS of synthesised chromium nanoparicle

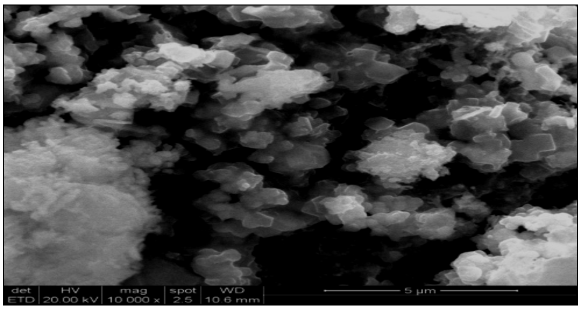

Figure. 4: SEM micrograph of chromium nanoparticle

In conclusion, we demonstrated the successful synthesis of the intracellular chromium nanoparticle, while remediating the chromium from the culture media, with very good monodispersity. The functional groups present in the biomass were found to be involved in the bioreduction and nanoparticle formation. The study seeks to remediate the environmental problem due to the chromium contaminants and thus it provides an advantage for biosynthesizing the metal nanoparticle.

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