POLYSTYRENE EMBEDDED SILVER NANOPARTICLES AS POTENTIAL ZINC HEAVY METALS REMOVAL IN WASTEWATER REMEDIATION APPLICATION

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ABSTRACT

A heavy metal such as Plumbum (II), Copper (II), Zinc (II), and Cadmium (II) is found in contaminated water and needs to be treated to reduce the well being danger to customers either human, verdure or fauna. As of late, polymer-metal nanocomposites found to be potential as a heavy metal safeguard. In this research, report on the concentrate on synthesizing polystyrene entrenched (doped) with silver NPs (polystyrene-silver NPs) as faint-cost metal absorber material which is possible to remove zinc heavy metals from contaminated water is highlighted. The silver NPs in the range of ~ 130 nm were bio-synthesized by Murayakoenigi leaves extract and the polystyrene is synthesised through nanoprecipitation method. The manufactured wastewater was prepared in the centralization of 10, 20 and 50 mg/l as models for lower to higher contaminated wastewater conditions. (FTIR) Fourier Transform Infrared spectrum, which is used to find out the chemical bonding of polystyrene-silver NCs and (AFM) atomic force microscopy is used to determine the topology of the surface and particle distribution. UV-Vis spectroscopy is used to analyze the rate of polystyrene-silver NCs absorbance and the concentration of zinc in synthetic waste water. The polystyrene-silver NCs ability to remove zinc heavy metals was contemplated using two main manipulate parameters, pH value and contact time. The removal of more than 70% of zinc heavy metals by polystyrene-silver NPs from synthetic wastewater are within 30 minutes, in both controlled parameters. The ideal zinc retention by polystyrene-silver NCs for the two proportions of 1:3 and 1:5 of polystyrene-silver NCs was at 91% at ideal state of pH 5 and 50 minutes of contact times. This report shows polystyrene-silver NCs as a potential nano technology base heavy metal safeguard for the application and activity of wastewater development.

KEYWORDS: Metal Nanoparticles, Polystyrene, Silver Nanoparticles, Heavy Metals & Water Remediation

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1. INTRODUCTION

Since the major concern about the amount of made-up wastewater produced has been mounting lately, various heavy metals will be released as by-product industry, thus, contaminating the water which primarily one of the main resources of living things [1]. Heavy metals such as Zinc (Zn) particularly, is arguably obvious that one of the famous heavy metals that subsist in wastewater due to harmful main problems to people's health like anemia, diarrhoea, nausea and stomach cramps [2-4]. This has resulted in numerous technology or methods innovation to

strip heavy metals in waste water treatment applications for example, filtration, absorption and advanced oxidation process [3-7]. Nanotechnology is said as the new technological breakthrough, as it influences to vast scientific fields that focus on atomic and molecular precision [8,9]. Nanotechnology offered a new approach in fabricating materials [10,11] and products [12-15], which innovate advancement in semiconductor device fabrication[16], drug delivery [16,17], microwave absorption [18-21], membrane fuel cell [22,23] or even high durability and strength of materials.

Nanotechnology deals at nano-size dimensions or nanoparticles where a large surface area ratio compared to its volume create strong binding sites (larger surface area to interact with other particles) [24,25]. Thus, the larger number of surface atoms creates a higher absorption rate especially for heavy metals absorption, which is suitable for heavy metals removal of waste water. Polymer (polystyrene (PS)) embedded through metal nanocomposites (Polystyrene-MNCs) which has features of both NPs and polystyrene would be the adsorbent to that heavy sensible metals because of its unprecedented surface district to each volume extent, exquisite mechanical highlights and agreeable fundamental in their polymer lattice [26]. These features certainly provide better performance to the heavy metals removal from the wastewater, knowing a promising and potential class of absorbent materials [27-29]. The overall objective in this research focuses on the synthesis of (polystyrene) embedded (silver) nanoparticles (polystyrene-silver NCs PS-Ag NCs)), characterization and absorption analysis. In this paper, we successfully showed that the absorption of polystyrene-silver NCs gave outstanding removal efficiencies of zink heavy metals. The main manipulate parameters are pH values that absorb zink metal ions and contact time in investigating zink heavy metal absorption.

2. METHODOLOGY

Polystyrene nanoparticles of sizes range were successfully synthesized by nano precipitation [30] method while silver nano particles of ~ 130 nm range were synthesized via bio synthesis leaf extraction of *Murayakoenigi* that act as reducing agents [31]. The arrangement of polystyrene installed with silver nanocomposites was effectively arranged at two proportions of 1 polystyrene: 3 silver and 1 polystyrene: 5 silver. The sample arrangement planning begins by putting 2.5 ml of polystyrene and 7.5 ml (silver NPs) were seen utilizing ultrasonic cleaning machine with a length for 10 minutes and for 1 hour separately, Vortex Mixer, as a total solution of polystyrene-silver NCs of 10 ml. These solutions were coated on the silicon substrate via the dropping method and left evaporated at room temperature for 24 hours for AFM: surface morphology, FTIR: chemical bonding analysis and UV-Vis spectroscopy: absorption analysis.

Zink synthetic waste water was prepared via the conventional method. Stock solution prepared by adding $\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$ into the distilled water of 1 000 ml volumetric flask and shackled at the steady motion to dissolve the zink metal ions [32]. The concentration of 10mg/l, 20mg/l, and 50 mg/l was prepared from the 1 000 mg/l stock solution preparation. The batch mode of absorption analysis utilizing orbital shaker is fixed at room temperature at 150 rpm [33-34]. Various pH of 1,3,4,7 and 9 are controlled by add-in few drops of HCL 1.0 M for acid and NaOH 1.0 M for alkali respectively into the prepared 10, 20 and 50 mg/l zink solution. In investigating the absorption efficiency, the contact time analysis was investigated, starting from 0 minutes, with 10 minutes' interval duration until the maximum of 70 minutes. The mix of polystyrene-silver NCs and zink heavy metal after each process of contact time was filtered with Whatman filter 0.45 μm and later PH of the mixture was analyzed of its zink content corresponding to contact time.

3. RESULTS AND DISCUSSIONS

3.1 Polystyrene Embedded with Silver Nanocomposites

Figure 1 shows the AFM pictures of polystyrene-silver NCs for the two proportions of 1:3 and 1:5. The clear and circular formed part was contemplated as polystyrene (PS) while a couple of little round pinnacles was demonstrated as silver nanoparticles, which inserted in the polystyrene NPs.

Figure 1: AFM of (a) 1:3 Ratios of Polystyrene-Silver NCs and (b) 1:5 Ratios of Polystyrene-Silver NCs.

Figure 2: SEM Images of (a) Bare Polystyrene (b) 1:3 of Polystyrene: Silver NCs and (c) 1:5 of polystyrene: Silver NCs.

In Figure 2 (a), the bare polystyrene nanospheres can be seen clearly, but not in Figure 2 (b) and (c) as the Silver nano particles could have covered more to the polystyrene surfaces. A higher concentration of Silver will let Silver

nanoparticles to agglomerate that lead to bulky shape on polystyrene surfaces. The normal distance across particles for 1:5 and 1:3 polystyrene installed silver NCs are around 362 nm and 256 nm individually. The distribution of silver nanoparticles is not investigated, nevertheless as reported by Raid the silver nanoparticles are small enough at first to fill the polystyrene pores to create a uniform and homogenous distribution of silver nanoparticles in the polystyrene matrices, thus created polystyrene-silver NCs [35, 33]. Nevertheless, the excess Silver nanoparticles on the surface will agglomerate, creating bulky images of Silver particles on polystyrene nanospheres surfaces. Due to the presence of binding spots of the silver NPs, the fascination was strong to its neighboring particles. The strong binding can be seen in Figure 2 (b) as polystyrene is found to be intact with each other, while Silver nanoparticles are seen to fill the voids between polystyrene nanospheres. The head state of silver nanoparticles barely was watched because it was doped into the polystyrene albeit some head was found in specific regions on account of the silver nanoparticles are limited in the outside of polystyrene. The micro-graph of 1:5 polystyrene implanted silver nano composites was spotted with sharp, calling attention to the tallness of particles in light of the estimation cases. Due to the gripping power which is high between the outside of the example and AFM summits, the thickness of the example surface adjusts AFM tips for performing halfway gathering the surface topology favored picture.

Figure 3: FTIR Spectrum for (a) 1:3 of Polystyrene: Silver NCs and (b) 1:5 of Polystyrene: Silver NCs.

FTIR was used to investigate the chemical properties of both ratios polystyrene-silver NCs of 1:3 and 1:5. The control doctrinaire of polystyrene to the synthesis plainly of polystyrene-silver NCs can be viewed in Figure 3, where several slight changes that happened in the FTIR polystyrene-silver NCs spectrum. The turnout of a wide peak was spotted at 3325.93 cm^{-1} and 3307.84 cm^{-1} for ratio 1:5 and 1:3 of polystyrene-silver NCs individually.

These two groups show up among the molecular hydrogen-reinforced of O-H expanding vibrations. Pinnacle band at 1635.46 cm^{-1} and 1635.71 cm^{-1} at Figures 2 (a) and 2 (b) were likewise indicated separately, which proposed, the nearness of aliphatic C-H mutilation vibrations and carbonyl stretch, recognized as the amide gathering. These two previously mentioned spectra toted the qualities of silver NPs, where the framing of silver NPs through Murayakoenigii extraction created was built up in the network of polystyrene-silver NCs. The sorts of polystyrene have shown up at the very little pinnacle of 1217.43 cm^{-1} and 1386.02 cm^{-1} seen in Figure 3 a) and 1229.71 cm^{-1} , 1364.44 cm^{-1} in Figure 3 (b), which coordinated to distortion of aromatic C-H bowing. This guide demonstrated that both a way from silver NPs have altered the vast majority of the synthetic holding that happens in polystyrene-silver NCs, yet at the same time, the polystyrene-kind substance holding trademark is as yet ready to show off its presence.

3.2 Absorption Analysis

The retention test was led to check the activity of pH sums and contact arrange. Figure 4 (an) and (b) show pH activity on zink (heavy metals expulsion efficiencies) using 1:5 and 1:3 of polystyrene-silver NCs. The outcomes educated that the extent expulsion efficiencies to zink heavy metals was superfast from down pH to up at pH 5, at that point declined mutually with the raise of the pH esteems. The pattern of the illustrative diagram was utilized in both 1:5 and 1:3 of polystyrene-silver NCs. At 1:3 of polystyrene-silver NCs, zink heavy metals were viably evacuated at pH 5 with 81.28%, 87.11% and 90.76% for every 50, 20 and 10 mg/l fitted with an essential convergence of zink heavy metals individually. For 1:5 of polystyrene-silver NCs, it was evacuated zink heavy metals at pH 5 with 82.35%, 87.52%, and 91.39%, for each essential centralization of 50, 20 and 10 mg/l.

The end of zink heavy metals by polystyrene-silver NCs was most likely in light of the presence of OH⁻ and H⁺ factor. In less worth pH, the being of H⁺ rivalled M⁺ particles through the exchange spots of particles, where M⁺ showed as mass spectroscopy. thus, extra settled metal particles take-up brings about the higher discharging of H⁺, exhibited that an ascent grouping of zink heavy metals would be discharging rise H⁺. Presented to Al-Asheh et al (1997), protonation of the adsorbent surface (silver surface right now) rise the extensive cacophony of metal particles inside the arrangement of the heavy metal at slice pH, prompting decline the metal adsorption capacity at a run [11].

At greatest pH rates, the equipoise proportion of elimination competences of zink heavy minerals was spotted because of deprotonation. The minimal contest between the cations of the metal andproton, at the turn out of OH⁻. So, the reduction in the positive surface charge of polystyrene-silver NCs outcomes in the depress electrostatic repulsion among the metals ions of the zink heavy metals and the surface of polystyrene-silver NCs. The forming of the tractable hydroxyl congregation was also clearly proposed where additional alkali of the solution produce tractable hydroxyl gleaner to the solution of the particular [12].

Figure 4: Effect of pH values of Zinkheavy Metals via (a) 1:3 of Polystyrene-Silver NCs and (b) 1:5 of Polystyrene -Silver NCs.

The contact time effect was clearly shown in Figure 5 (a) and (b). It shows that at 10 mg/l convergence of zink heavy metals, it demonstrated a steady increment in evacuation abilities, starting at 10 minutes to reach the most extreme expulsion efficiencies. At almost 91% expelled by 1:3 and 1:5 of polystyrene-silver NCs at 50 minutes, which was signified as the most elevated evacuation rate. The practically consistent pace of expulsion following 50 minutes was additionally seen until it arrives at 70 minutes. Similar qualities appeared at 20 mg/l and 50 mg/l, yet have the most extreme evacuation rate at almost 87% and 82% individually.

Figure 5 (b) shows a similar diagram shape like Figure 5 (a) where the zink metal ions begin to expel step by step at 10 minutes until they arrive at the pinnacle limit of evacuation efficiencies. It offers that about 92% of zink heavy metals expelled by 1:5 of polystyrene-silver NCs at 50 minutes, at that point it remains at nearly harmony province of zink particle evacuation until they arrive at 70 minutes of contact time. This is because that the impact of contact time relies upon the underlying centralization of heavy metals. If increasingly heavy metal was available, there will be marginally hard to evacuate because of similar properties of polystyrene-silver NCs arranged, depend upon its coupling locales and ions trade. The harmony state was accomplished for a similar fixation because of reliable mass exchange solid restricting locales of polystyrene-silver NCs towards zink ions.

Note: —●— 10 mg/l —■— 20 mg/l —▲— 50 mg/l
Figure 5: The Effect of Contact Time of Zinkheavy Metals via (a) 1:3 of Polystyrene-Silver NCs and (b) 1:5 of Polystyrene-Silver NCs.

4. CONCLUSIONS

The outcomes fundamentally demonstrate the evacuation of zink heavy metals at pH estimations of 5 about 91% at every centralization of arranged zink engineered wastewater (10,20 and 50 mg/l) while the contact time of zink heavy metals expulsion, with specific pH estimations of five (5) arrived at the most extreme at fifty (50) minutes at almost 91%. The outcomes effectively indicated that polystyrene-silver NCs have great restricting locales properties, which permits the trading of ions with the zink ions. The dynamic mass exchange among silver NPs and zink heavy metals because of solid restricting locales of silver caused huge sum expulsion of zink heavy metals, while polystyrene goes about as the casing specialist between the authoritative of silver NPs and zink. These test results would be extremely valuable in growing new advantages and research, particularly in nano technology applications in heavy metals expulsion ions for modern buildup wastewater or reusable household waste water through nanoparticle application.

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