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Evolution of anticancer, antioxidant and photocatalytic activities of biosynthesized MnO_2 nanoparticles using aqueous extract of *Sida acuta*

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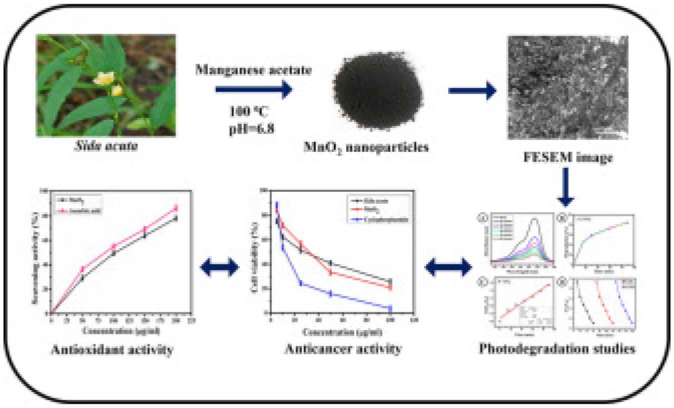
Abstract

Recently, scientists have become interested in the biosynthesis of nanoparticles due to the need to develop new methods of synthesis that are cost-effective, safe, and efficient. In a diversity of applications, nanoparticles of metal oxide are gaining increasing attention. In this study, biosynthesized MnO_2 nanoparticles using Sida acuta extract, a non-toxic hydrocolloid, a natural, and investigated their potential anticancer and antioxidant applications. MnO_2 nanoparticles were characterized using XRD, FESEM, UV-visible, and FTIR spectroscopies. The results demonstrated that the synthesized MnO_2 nanoparticles possess a significant capacity for scavenging free radicals. However, MnO_2 nanoparticles could serve as anticancer and antioxidants. MnO_2 nanoparticles are highly harmful to a renal cancer cell line (ACHN), as shown by invitro cytotoxicity studies. In the presence of xenon lamp radiation, the synthesized MnO_2 nanoparticles exhibited photocatalytic activity against the degradation of rhodamine-B and methylene blue dyes. The degradation efficiency of chemically and biosynthesized MnO_2 nanoparticles against rhodamine-B and methylene blue dyeswas determined to be 90% and 84%, respectively.

Graphical abstract



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Introduction

The advancement of science and technology has improved human existence more pleasant; nevertheless, these conveniences are often accompanied by an increase in the strain placed on the environment. Particularly concerning is the issue of polluted water seen in every region of the globe. Organic contaminants originating from industrial waste were one of the primary contributors to water contamination. As a result, a wide variety of methods for treating wastewater have been thoroughly researched. These methods can be broadly categorized as physical, chemical, and biological approaches, and they include things like physical adsorption, oxidative degradation, coagulation, and photodegradation, as well as numerous others [1], [2], [3]. Among them, the removal of organic dye by adsorption has shown to be the most cost-effective way owing to the fact that it utilizes solid adsorbents that are both simple and effective [4,5]. This has led to its widespread use as the method with the greatest number of applications.

Several researchers are interested in MnO_2 phases due to their unique chemical and physical characteristics, which make them excellent candidates for application as adsorbents, selective heterogeneous catalysts, and battery materials [6]. Many industrial catalytic uses have been developed for them, including nitric oxide reduction, photocatalytic oxidation of organic pollutants, ozone destruction, breakdown of hydrogen peroxide, selective oxidations of carbon monoxide, and many more [7]. MnO_2 has been reported to be prepared in a number of different ways in the literature [8]. It has been reported that sodium hypophosphite, potassium borohydride, and sodium dithionate may be used to reduce $KMnO_4$ to MnO_2 [9]. Furthermore, MnO_2 precipitation from $Mn(CH_3COO)_2$ and $KMnO_4$ aqueous solutions has also been observed [10]. Nanostructured materials have increased in popularity in recent years due to their improved and novel chemical and physical characteristics. Manufacturing MnO_2 nanostructures of various morphologies has received a lot of attention [11,12].

WO_3, ZnO, TiO_2, and bismuth compounds have been used to study dye photocatalytic degradation [13], [14], [15]. Manganese dioxide is useful due to its low cost, excellent redox activity, and abundance [16]. Several MnO_2 shapes have been developed to enhance catalytic performance [17,18]. Yin et al. [19] employed a straightforward hydrothermal production of MnO_2 nanorods for UV-light-induced degradation of eosin red, congo red, and methyl orange. Dang's group used a wet chemical method to decolorize methyl orange and methylene blue with a MnO_2-coated diatomite composite [20]. Combariza's bio-nano composite eliminated indigo carmine dye by in situ synthesis of nanostructured MnO_2 onto natural fique fibres [21]. Cui et al. used refluxing to synthesize manganese oxides with various crystal forms (α-MnO_2, β-MnO_2, and -MnO_2) and decolorized Rhodamine-B (RhB) dye at different pH levels [22]. Adsorption, flocculation, coagulation, and reverse osmosis are just a few of the traditional techniques that have been used in the past to deal with these organic dyes. Adsorbents have been investigated for use in wastewater treatment in a number of different ways [23,24]. Although this method has been shown to be efficient for the elimination of organic and inorganic contaminants, it is time-consuming, costly, requires significant disposal expenditures, and is sometimes unsuccessful in eliminating stubborn chemicals [25]. A lot of work has gone into finding ways to get rid of these contaminants through technology [26,27]. One of the most promising strategies for cleaning up polluted environments is the photocatalytic reaction, which makes use of sunshine, a free and plentiful energy source [28].

Photocatalytic degradation, a green technique that degrades organic and inorganic wastewater pollutants, has gained global interest to solve these problems. CV dye adsorbents have been studied [29]. This method degrades harmful colors into harmless compounds, which is great. Semiconductor photocatalysts including ZnO, TiO_2, and SnO degrade organic dyes under UV and visible light for wastewater treatment and environmental remediation [30]. Due to their chemical stability, non-toxicity, and strong photocatalytic activity, TiO_2 NPs have been widely researched for organic pollutant degradation [31]. Copper, nickel, vanadium, tungsten, manganese, and their oxides are also employed as sophisticated, cheap, green, and sustainable photocatalysts to oxidize organic effluents/dyes under moderate circumstances. Manganese oxides are popular photocatalysts because they contain more than five easily exchangeable transition states and various structural configurations over large temperature ranges (up to 1200 °C).

This is the first report of MnO_2 nanoparticles being synthesized from *Sida acuta* leaf extract. *Sida acuta* is used as a reducing agent and natural stabilizer to synthesize MnO_2 nanoparticles in a unique way. Methylene blue and Rhodamine-B dyes were examined for their degradation in the presence of UV-A irradiation and the photocatalytic activity of MnO_2 nanoparticles.

Section snippets

Materials

The *Sida acuta* plant's leaves were collected in March from locations in Tamil Nadu, India, namely the region near Chennai. Manganese acetate ($C_4H_6MnO_4$)), Ethanol (C_2H_5OH, 99.5%), were purchased from Sigma Aldrich, distilled water from Lab. Congo red and Rhodamine-B dyes were purchased from Merck.…

Preparation of MnO_2 nanoparticles

200 g of Sida acuta leaves were cooked for 10 minutes in 200 millilitres of water after first being washed with distilled water. The hot extract was allowed to cool to ambient temperature before being…

Morphological studies

FESEM was used to examine the surface morphology of synthesised manganese oxide nanoparticles. Fig. shows that MnO_2 nanoparticles are spherical and well agglomerated, with particle sizes in the 20-40 nm range. An EDX analysis was done to find out what elements were present in the nanoparticles. The EDX image of synthesised nanoparticles, together with their atomic weight distribution, is shown in Fig. 1. Spectra with separate peaks for manganese and oxygen show that MnO_2 nanoparticles develop.…

Conclusion

Nanoparticles of manganese oxide (MnO_2) were synthesized using the extract from the leaves of the *Sida acuta* plant. The maximum absorption in the UV-Vis spectrum was detected at 379 nm. The FTIR spectra of the synthesised nanoparticles show peaks indicative of functional groups such as O-H, -C=O, N-H, and C-N. Using the aforementioned equation, we can determine from the XRD pattern that the average crystal size of the nanoparticles is 8.64 nm. The FESEM image reveals that the MnO_2 nanoparticles …

Authors contributions

The authors read and approved the final manuscript.

K. Kala - Interpreting the data, Manuscript correction.

M. S. Jeyalakshmi- Design the paper, write and interpret data.

S. Mohandoss- interpret data.

R. Chandrasekaran- interpret data, Manuscript correction.…

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.…

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