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Research Article

Reduction of 2-nitroaniline using AgNPs

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Article Info

Article history:

Received 8-6-2023

Received in revised form 20-6-2023

Accepted 20-6-2023

Available online 30 -6 -2024

Keywords: AuNPs, Nanocatalyst, CDs, Karbala.

Abstract

In this research, the Gold Nanoparticles (AuNPs) in size of 14-38 nm were prepared from $AuCl_3$ using CDs solution as a reducing agent. The CDs capability for direct reduction of gold ions to elemental gold (Au^0) without additional reducing and stabilizing agents was investigated. The catalytic activity of nanoparticles in the hydrogenation reaction of 2-nitroaniline was determined. The results show that the nanoparticles had high catalytic activity in the sodium borohydride-mediated hydrogenation of nitroaromatic compounds.

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Peer review under responsibility of Iraqi Academic Scientific Journal and University of Kerbala.

1. Introduction

In aqueous solutions, the approach of reducing harmful organic solvents for transforming organic debris in reusable mixtures by using fewer toxic means has attracted a great response from scientific centers. Many studies have been performed to determine the availability of nitroaromatic materials [1-4]. The 2-nitroaniline (2-NA) is hazardous and toxic waste pollutants and are included on the United States Environmental Protection Agency (USEPA) list1[5-9]. Therefore, developing effective approaches to eliminate them is an important task. In addition, to produce dyes and drugs that can be synthesized from 2-NA, o-phenylenediamine (o-PDA) and 4-aminophenol (4-AP) are important intermediates [10-14]. Water contamination and environmental pollution are among the crucial issues in today's advanced world [15,16]. intermediate in the organic synthesis of products such as oxidizing agents, drugs, dyes, and pesticides [17,18]. Nitroaromatic compounds have a detrimental impact on human health and the environment, such as nitroarenes, which can result in many diseases like anemia and lung injury through breathing, feeding, and absorption through the skin [19]. Nitroanilines as a pollutant has been listed by several countries that need careful control due to their difficulty in the degradation process [20]. Various techniques have been employed for water treatment purposes, including physical, chemical, and biological [21,22]. Physical techniques cannot completely remove pollution, thus resulting in further contamination [23]. The benefit of using chemical reduction of nitroaromatic compounds to amino compounds is the production of non-toxic or low-toxic amino compounds. In addition, amino compounds are used as a raw material in the preparation of medicines; for example, the reduction product of 2 nitroaniline is orthophenylene diamine (o-PDA) [24]. Nowadays, one of the most common ways to reduce nitroaromatic compounds is utilizing nano-catalysts. [25]. The aim of this research is to use the nano CDs to reduce metal ions namely silver to nanoparticle and stabilize it against aggregation. In addition, to investigate that the prepared AuNPs have been used as excellent catalytic to provide evidence from the kinetics of hydrogenation of nitroaromatics.

2. Materials and Methods

2.1 Materials

The $NaBH_4$ was obtained from Central Drug House (P) Ltd – CDH, and $AgNO_3$ was obtained from Thomas Baker, while $AuCl_3$ was purchased from the Central Drug House (CDH) in India

2.2 Preparation of Metal Nanoparticles

In this procedure, 200, 400, and 600 µL of CDs were added to the solution of (9.8 ml) distilled deionized water including 1 mM of $AuCl_3$. Then, the solutions were left unstirred for 10 or 12 hrs. The formation of NPs confirms when the color of the solution is changed by using 200 µL of CDs and 10 hrs.

2.3 Representative procedure for hydrogenation of nitroaromatics

Nitrocompounds (4-nitrophenol, 4-nitroaniline, and 4-methyl-2- itroaniline) showing an absorbance in the visible region was selected to follow the hydrogenation reaction. The absorbance of 4- nitrophenol, 4-nitroaniline, and 4-methyl-2-nitroaniline were observed at 400 nm, 408 nm, and 427 nm, respectively. The hydrogenation reaction was performed by adding 10 mg of sodium borohydride (NaBH4) and 100 µL of NPs (1 mM) to 100 µM of nitroaromatic compounds dissolved in 3 mL of water. The change in absorbance with respect to time was recorded to determine the kinetics of the reaction. The catalytic hydrogenation of 2-Nitro-Aniline (2-NA) was followed by measuring the UV-vis absorption spectra of the reaction mixture with and without NPs.

2.4 Instrumentations

Ultraviolet-Visible (UV–Vis) (Shimadzu) spectrometry 700 MHZ NMR Spectrometry.

3. Results

The use of the AuNPs as an efficient catalyst was evaluated through studying nitroaromatic reduction kinetics. The catalytic hydrogenation of 2-Nitro-Aniline (2-NA) was followed by measuring the UV-vis absorption spectra of the reaction mixture with and without NPs.

4. Discussion

4.1 Hydrogenation of nitroaromatics

The mixture color gradually vanished, confirming the 2-NA reduction. Typically, the 2-NA yellow colored solution presented two distinguished absorption peaks at 228 and 383 nm (Figure 1) [25].

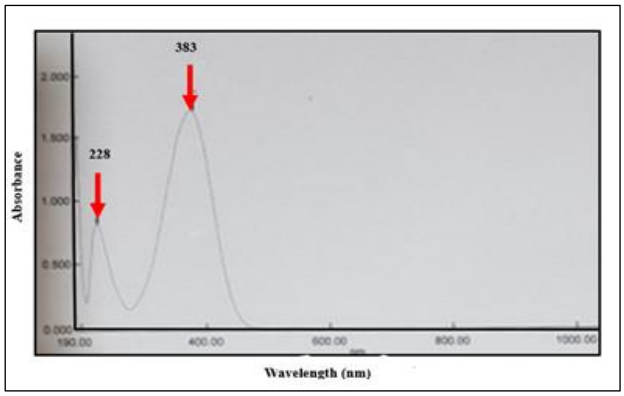

Figure 1: UV–visible spectra of 2-nitroaniline (2-NA)

By adding the $NaBH_4$ solution, the intensity of the peaks did not reduce (Figure 2), while the intensity of the above-mentioned peaks gradually reduced upon the addition of NPs solution into the mixture (Figure 3). However, the addition of AuNPs to this mixture resulted in hypochromic and hypsochromic shift, indicating the reduction of 2-NA. During this reduction reaction the color of the 2-NA turns from pale yellow to yellow and then ends colorless, suggesting that the chromophore -NO_2 gets reduced to -NH_2.

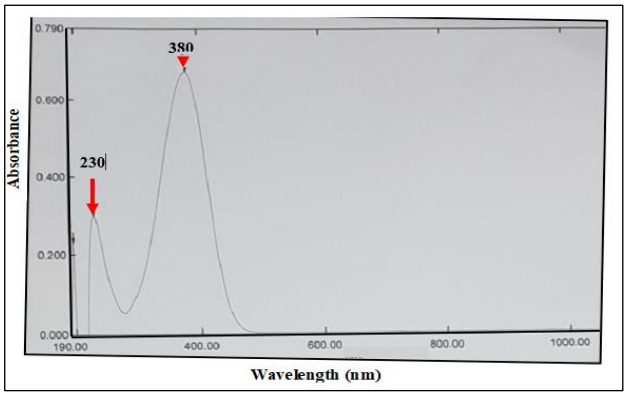

Figure 2: UV–visible spectra of 2-nitroaniline + $NaBH_4$

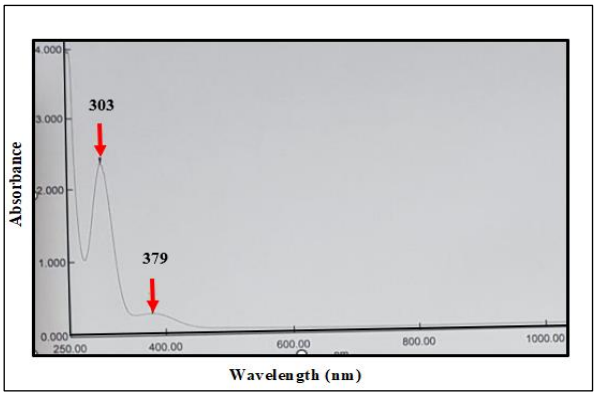

Figure 3: UV–visible spectra of the reduction product 2-aminoaniline (2-AA).

5. Conclusions

The prepared CDs have an ability to reduce metal ions like gold to nanoparticles and stabilize them against aggregation. As prepared AuNPs display excellent catalytic activity as evidence from the kinetics of hydrogenation of nitroaromatics.

6. Conflicts of Interest

The authors confirm that there are no conflicts of interest regarding the publication of this article.

7. Acknowledgement

We gratefully acknowledge the assistantship from the Department of Chemistry/College of Science at Kerbala University. The MOHESR for financial support. We thank the advanced laboratory in the Chemistry Department for the FTIR facility.

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