

Photodegradation of Basic Brown 16 Dye from Aqueous Solution Using Bio-Synthesized ZnO Nanoparticles in Bitter Gourd Peels Extract: A Review

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Abstract: Most metal-based nanoparticle synthesis methods are known to generate hazardous by-products. Green synthesis, however, is more eco-friendly in producing metal nanoparticles. In this research, bitter gourd peel extract was synthesised as a method to detect the breakdown of Basic Brown 16. This review is designed to help water treatment organisations address the need for coloured wastewater treatment. Liquid waste including hair dye leftovers and other industrial waste is a source of environmental pollution. Basic Brown 16 dye is the major topic of this study. The dye itself, as is mentioned above, is Brown 16. ZnO NPs photocatalytic efficacy will be evaluated based on decolorization of Basic brown 16. The review shows that the bitter gourd peels extract is able to produce zinc oxide nanoparticles. Besides, the past research about the dye removal shows that there were limited research about the photodegradation of Basic Brown 16.

Keywords: Photodegradation, ZnO Naoparticles, Basic Brown 16

1. Introduction

Contamination of the environment is one of the most serious and pressing problems facing the developing world. Industries are the primary pollutants, with the garment industry generating a disproportionate amount of liquid effluent contaminants due to the massive amount of water needed in fabric manufacturing. This industry generates wastewater of varying composition, from which the coloured water released during fabric dyeing may be the most problematic, since even a trace of dye can stay very apparent. Additionally, other industries such as paper and pulp mills, dyestuffs, distilleries, and tanneries produce highly coloured effluent. The dyes may have a negative impact on the environment, including plants, animals, and other living things. Certain types have been linked to bladder cancer, splenic sarcomas, and hepatocarcinomas, and have been shown to cause nuclear abnormalities in laboratory animals and chromosomal aberrations in cultured mammalian cells.

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According to Tomczak and Tosik (2017), dyes in natural water may lead to decreased clarity, damage to photosynthesis, harm to animals and plant development, and alter the solubility of oxygen and self-cleaning processes [1]. According to Dardouri and Sghaier(2017)., the dyes may be transported into a river and have an effect on the water's consistency due to their high water solubility [2]. Nowadays, society should be aware of the detrimental effects of dye on the environment. Now, researchers are examining methods for treating wastewater contamination caused by the colourant industry. Adsorption has been shown to be an efficient and cost-effective method of removing a wide variety of pollutants. Solar energy in the visible spectrum may be utilised in dye photocatalysis. In recent years, the use of industrial solid waste as an adsorption or catalytic support has been suggested for material processing and reuse. The production of zinc ion nanoparticles in bitter gourd peel extract was used to determine the process of degradation of Basic Brown 16. The application of nanotechnology to water and wastewater treatment demonstrates not only its capacity to overcome the various challenges associated with conventional technology, but also to investigate novel treatment technologies for wastewater treatment and reuse that meet economic feasibility and water quality standards.

2. Findings

According to previous study, there were several types of dyes removal using the ZnO nanoparticles. The synthesized of ZnO nanoparticles in the bitter gourd peels extract and hair dyes removal are shown belows.

2.1 Hair Dyes Removal methods

There was various types of hair dyes. There were many methods to remove various types of dyes in previous research. Table below shows the method and the types of that that were used in previous study:

Table 1: Methods of hair dye removal

No.	Types of dyes	Methods	Efficiency	References
1	Basic Red 51	Photodegradation	1. 70.93 (%) of BR51 removal 2. 83.56% of COD removal	G. Yashni, et al. (2020) ^[3]
2	3.16 Burgundy	Adsorption	1. 92.6% of hair dye was removed	Sai Rashmi Manippady et al. (2020) ^[4]
3	Basic Brown 16	Photoelectrocatalytic	1. 59% for visible irradiation 2. 53% UV irradiation	Fraga, et al. (2017) ^[5]
4	Basic Blue 99	Photoelectrocatalytic	1. 44% for visible irradiation	Fraga, et al. (2017)

			2. 39% UV irradiation	
5	Enterobacter cloacae	Microbial decolorization (adsorption)	1. 76% absorbance for 508nm of dyes	Swati Maiti (2017) ^[6]
6	Acid Yellow 1	Photoelectrocatalytic degradation	1. 75% of total carbon removal	Guilherme Garcia Bessegato et al. (2015) ^[7]
7	Basic yellow 57	Adsorption	1. 105 per gram of adsorbent	Habib Zahir et al (2014) ^[8]

For the photodegradation of Basic Red 51, the hydroxyl radical attacks the carbon atoms with the chromophoric azo bond (C–N=N). As a result, the fragments formed by the BR51 molecule's azo bond breakage must constitute the main reaction intermediates. The assault of a hydroxyl radical on azo-linked carbons results in the production of 7,9-di-tert-butyl-1-oxaspiro, deca-6,9-diene-2,8-dione and isoshyobunone. These chemicals are main breakdown products of the BR51 dye, resulting from the oxidative cleavage of the azo group linking the two aromatic rings. Furthermore, an aliphatic intermediate was shown to be an organic acid such as propanedioic acid propyl-. Furthermore, the hydroxylation of propanedioic acid propyl- leads the aromatic ring to be cleaved, resulting in the formation of oxygen-containing aliphatic compounds such as alpha-aminoxy-propionic acid, ethyl ester, n-capric acid, and isopropyl esterethyl ester. Lastly, these aliphatic by-products were converted into heptanoic and hexanoic acid. It is generally understood that heptanoic acid and hexanoic acid are less deadly than BR51. Finally, the aliphatic by-products are mineralized, yielding CO₂ and H₂O. CO₂ is produced through the “photo-Kolbe” process, which involves the decarboxylation of carboxylic acids according to G. Yashni, et al. (2020) [3].

For the removal by the absorption, Adsorbents CF-0 and CF-2 were initially employed in the adsorption investigation to assess their activity toward dye adsorption. In 24 minutes, CF-0 and CF-2 demonstrate 38.7 percent and 99.9 percent MB adsorption, respectively. At optimum pH, CF-0 and CF-2 demonstrate 32.3 percent and 96.6 percent CR adsorption, respectively. As a result, the adsorption activity of CF-2 is shown to be greater for MB and CR than for CF-0 according to Sai Rashmi Manippady et al. (2020) [4].

Lastly for the Photoelectrocatalytic degradation, in 1.0 M Na₂SO₄, pH 6, with a bias potential of +1.2V and UV/vis irradiation, the photoelectrocatalytic degradation of 50 ppm of AY1 was measured to compare the doped and naked photoanodes. All of the electrodes that were examined had complete discoloration. For bare TiO₂ NTs electrodes, a maximum of 70% TOC reduction is obtained according to Guilherme Garcia Bessegato et al. (2015) [7].

2.2 Removal of Basic Brown 16 dye

The removal of Basic Brown 16 is using the adsorbent method. Photodegradation of Basic Brown 16 was new research and not yet been done by the researcher. Table 2 below shows the method, advantages, and efficiency of Basic Brown 16 removal:

Table 2: Basic Brown 16 removal

Basic Brown Types	Method	Advantages	Efficiency	References
Basic Brown 16	Durian Shell Adsorbent, Optimisation and Techno-Economic Analysis	a low-cost and environmentally acceptable adsorbent for dye adsorption in aqueous solution.	1. Decolourisation (77.61%) 2. OD removal (80.60%) at pH 8	Yashni Gopalakrishna , Adel Al-Gheethi (2020) [9]

In the current study, the optimisation of C.I Basic Brown 16 adsorption reached more than 77.61 percent, indicating the role of RSM design in achieving the maximum and optimal conditions for C.I Basic Brown 16 adsorption. The presence of a strong synergic connection between the factors would reflect the high efficacy of C.I Basic Brown 16 adsorption in response to the studied independent variables. These findings are consistent with the findings of the authors in the literature, who stated that the examined variables have a substantial role in the adsorption of C.I Basic Brown 16. The RSM-based optimization approach determines the optimal operating parameters to achieve high adsorption efficiency, Yashni Gopalakrishna (2020) [9].

2.3 Characterization of ZnO nanoparticles in bitter gourd peels extract

The *Momordica Charantia* characterization ZnO nanoparticles is importance in order to photodegraded the BB16 dyes. Green synthesizes Zinc Oxide nanoparticles have the potential to be an excellent environmentally acceptable method for removing hair colour from dye effluent.. According to P. Rajiv Gandhi et al, (2017), UV visible spectroscopy research was used to evaluate the optical absorption characteristics of produced ZnO NPs. Because of the surface plasmon resonance, the produced ZnO NPs had a high absorbance peak at 374 nm. The XRD patterns of produced ZnO NPs clearly demonstrated the crystalline structure of the nanoparticles, with different Bragg's diffraction peaks at 31.53°, 34.16°, 36.01°, 47.27°, 56.33°, 62.58°, 66.09°, 67.66°, 72.29°, and 76.68° of 2θ. FTIR research verified the potential functional groups responsible for the effective stabilisation of ZnO NPs. The FTIR spectra revealed strong peaks at 3406.93, 1622.96, 1424.93, 1096.00, 863.80, and 604.88 cm⁻¹. The SEM micrograph of the ZnO NPs revealed that they were spherical in form with smooth edges. The EDX spectroscopy examination of the ZnO NPs revealed that the chemical components contained in the sample were zinc oxide [10].

2.4 Photodegradation of hair dyes

The photodegradation of various types of hair dyes by ZnO nanoparticles are as shown in the table below:

Table 3: Dye degradation by Zinc oxide photocatalysts

No	Photocatalyst	Dyes	Degradation (%)	References
1	Zinc Oxide (ZnO)	Reactive red 4	85	Daneshvar et al (2006) [11]
2	Zinc Oxide (ZnO)	Reactive blue 4	29	Sakthivel et al (2003) [12]

3	Zinc Oxide (ZnO)	Reactive red 2	49	Behnajady et al (2006) ^[13]
4	Zinc Oxide (ZnO)	Reactive yellow 17	40	Nagaraja et al (2012) ^[14]
5	Zinc Oxide (ZnO)	Rhodamine 6G	98	Tian et al (2012) ^[15]
6	Zinc Oxide (ZnO)	Methyl Orange	98	Kansal et al (2007) ^[16]
7	Zinc Oxide (ZnO)	Rhodamine B	98	Neppolian et al (2002) ^[17]
8	Zinc Oxide (ZnO)	CI yellow 23	90	Neppolian et al (2002) ^[17]
9	Zinc Oxide (ZnO)	Acid Brown 14	85	Neppolian et al (2002) ^[17]
10	Zinc Oxide (ZnO)	Acid Red 14	70	Neppolian et al (2002) ^[17]

The table above shows that the ZnO photocatalyst for Rhodamine 6G, Methyl Orange and Rhodamine B had the highest percentage of degradation with 98% respectively. Besides, the degradation that below 50% were Reactive Yellow 17, Reactive red 2 and Reactive red 4. The reactive red 4 has the lowest percentages of degradation with 29% only.

3. Conclusion

As a conclusion, ZnO nanoparticles can be synthesized from the bitter gourd peels extract. The ZnO nanoparticles has high absorbance peak. Besides the XRD shows the patterns of produced ZnO NPs clearly demonstrated the crystalline structure of the nanoparticles. FTIR research verified the effective stabilizations of ZnO nanoparticles and revealed strong peak spectra. SEM microscopy showed that the ZnO NPs were spherical in shape with smooth edges. The EDX spectroscopic analysis of the ZnO NPs showed that the sample's chemical components were zinc oxide. For the photodegradation of Basic Brown 16 by ZnO nanoparticles, there were limited research about this keyword. The research about this topic should be carried on in the future to assist the knowledge of removing Basic Brown 16 in wastewater treatment.

This review purposely to help the researcher to upgrade the wastewater treatment facility. The hair dye wastewater is major problem because the hair dye wastewater from the saloon and any cosmetic facilities are not treated as industrial wastewater. The wastewater that contains hair dye could really harm the environment. By continuing this study, the problem of hair dye wastewater could help to saves the environment and help to gain a knew knowledge about the ability of photodegradation of Basic Brown 16 in the future.

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References

- [1] Tomczak, Elwira ; Tosik, Paweł, Waste Plant Material as a potential adsorbent of a selected Azo dye ,vol. 38; pp. 283, 2017
- [2] Dardouri, S., & Sghaier, J. “Adsorptive removal of methylene blue from aqueous solution using different agricultural wastes as adsorbents”. Korean Journal of Chemical Engineering, 34(4), 1037–1043. doi:10.1007/s11814-017-0008-2
- [3] G. Yashni Adel Al-Gheethi Radin MohamedSiti Nor Hidayah Arifin · Siti Nor Aishah Mohd Salleh “Photodegradation of basic red 51 in hair dye greywater by zinc oxide nanoparticles using central composite design” Reaction Kinetics, Mechanisms and Catalysis
<https://doi.org/10.1007/s11144-020-01792-x>
- [4] Sai Rashmi Manippady, Ashish Singh, Bhavya Moodalegowda Basavaraja, Akshaya Kumar Samal, Sachchidanand Srivastava, and Manav Saxena “Iron–Carbon Hybrid Magnetic Nanosheets for Adsorption-Removal of Organic Dyes and 4-Nitrophenol from Aqueous Solution” ACS Applied Nano Materials 3 (2), pp 1571-1582, 2020 DOI: 10.1021/acsanm.9b02348
- [5] Fraga, L. E., Guaraldo, T. T., Araujo Souza, B. C., & Zanoni, M. V. B. (2017). Semi-permanent hair dyes degradation at W/WO³ photoanode under controlled current density assisted by visible light. Journal of Advanced Oxidation Technologies, 1–10. <https://doi.org/10.1515/jaots-2016-0168>
- [6] Swati Maiti, Sudarson Sekhar Sinha, Mukesh Singh “Microbial decolorization and detoxification of emerging environmental pollutant: cosmetic Hair dyes” Journal of Hazardous Materials, May 2017 <http://dx.doi.org/10.1016/j.jhazmat.2017.05.034>
- [7] G.G. Bessegato, et al., “Enhanced photoelectrocatalytic degradation of an acid dye with boron-doped TiO₂ nanotube anodes,” Catal. Today (2014), <http://dx.doi.org/10.1016/j.cattod.2014.03.073>
- [8] Zahir H, Naidoo M, Kostadinova R-M, Ortiz KA, Sun-Kou R and Navarro AE (2014) Decolorization of hair dye by lignocellulosic waste materials from contaminated waters. Front. Environ. Sci. 2:28. doi: 10.3389/fenvs.2014.00028
- [9] Gopalakrishnan Y, Al-Gheethi A, Abdul Malek M, Marisa Azlan M, Al-Sahari M, Radin Mohamed RMS, Alkhadher S, Noman E. Removal of Basic Brown 16 from Aqueous Solution Using Durian Shell Adsorbent, Optimisation and Techno-Economic Analysis. Sustainability. 2020; 12(21):8928.
- [10] P. Rajiv Gandhi, C. Jayaseelan, R. Regina Mary, D. Mathivanan, S.R. Suseem, “Acaricidal, pediculicidal and larvicidal activity of synthesized ZnO nanoparticles using Momordica charantia leaf extract against blood feeding parasites”, Experimental Parasitology, Volume 181, 2017, pp 47-56 <https://doi.org/10.1016/j.exppara.2017.07.007>.
- [11] Daneshvar, N.; Salari, D.; Khataee, A. R. “Photocatalytic degradation of azo dye acid red 14 in water on ZnO as an alternative catalyst to TiO₂. J. Photochem. Photobiol”. A: Chem. 2004, 162, pp 317–322
- [12] Sakthivel, S.; Neppolian, B.; Shankar, M. V.; Arabindoo, B.; Palanichamy, M.; Murugesan, V. “Solar photocatalytic degradation of azo dye: Comparison

- of photocatalytic efficiency of ZnO and TiO₂.” Sol. Energ. Mat. Sol. C. 2003, pp 65–82
- [13] Behnajady, M. A.; Modirshahla, N.; Hamzavi, R. Kinetic “study on photocatalytic degradation of C.I. Acid Yellow 23 by ZnO photocatalyst.” J. Hazard. Mater. 2006, volume 133, pp226–232
- [14] Nagaraja, R.; Kottam, N.; Girija, C. R.; Nagabhushana, B. M. “Photocatalytic degradation of Rhodamine B dye under UV/solar light using ZnO nanopowder synthesized by solution combustion route”. Powder Technol. 2012,, pp 91–97.
- [15] Tian, C. G.; Zhang, Q.; Wu, A. P.; Jiang, M. J.; Liang, Z. L.; Jiang, B. J.; Fu, H. G. “Cost-effective large-scale synthesis of ZnO photocatalyst with excellent performance for dye photodegradation”. Chem. Commun. 2012, pp 2858–2860.
- [16] Kansal, S. K.; Singh, M.; Sud, D. “Studies on photodegradation of two commercial dyes in aqueous phase using different photocatalysts”. J. Hazard. Mater. 2007, pp 581–590.
- [17] Neppolian, B.; Choi, H. C.; Sakthivel, S.; Arabindoo, B.; Murugesan, V. “Solar/UV-induced photocatalytic degradation of three commercial textile dyes.” J. Hazard. Mater. 2002, pp 303–317.