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Zn-g-CN photocatalyst for dye photodegradation in aqueous medium its fabrication and characterization

Aamir Iqbal[1], Zeeshan Ahmed Siddiqui[*], Muhammad Saeed [3], Muhammad Ammar[4] and Fatima Siddiqui[5]

[1] *Department of Chemistry, Government College University Faisalabad Pakistan*
[2] *Mechanical Engineering Department, University of Engineering and Technology Taxila, Pakistan*
[3] *Department of Chemistry, Government College University Faisalabad Pakistan*
[4] *Mechanical Engineering Department, University of Engineering and Technology Taxila, Pakistan*
[5]*Department of Physics, Fatima Jinnah Women University Rawalpindi, Pakistan*

[*]*(zeeshan88397@gmail.com)*

Abstract –This study focuses on the formation of photocatalyts Zn/g-CN composite's, characterization, and inquiry for the degradation of Rhodamine B dye in aqueous medium. Thermal calcination of urea produced graphitic carbon nitride (g-CN). The heterojunction between Zn and g-CN increased the photocatalytic activity of g-CN. Zn and g-CN were subjected to a 3-hour, 550°C thermal treatment in a muffle furnace to create the heterojunction. Various analytical techniques like scanning electron microscopy (SEM) and UV-visible spectroscopy were applied for the investigation of physicochemical properties of synthesized g-CN and Zn/g-CN composite. Analyzing the catalytic breakdown of dyes under the influence of sun light was done in a Pyrex glass beaker. For the study of dye degradation, the impact of various experimental variables including catalyst dose, temperature, and dye concentration was examined. The UV-visible spectrophotometer was used to evaluate the reaction mixture. The findings showed that Zn/g-CN nanocomposite has superior catalytic properties to pure g-CN. Using the Arrhenius equation, the activation energy of the catalyst for the degradation of rhodamine B dye was found to be 30.06 kJ/mol, significantly less than the activation energy of bare g-CN, which was 40.06 kJ/mol.

Keywords – Heterojunction, g-CN, Photocatalyst, Dye Degradation

I. INTRODUCTION

One of the biggest challenges relating to environmental problems nowadays is water contamination. The employment of numerous types of organic dyes across all industrial sectors, causes water pollution [1]. Among the various industrial effluents, dyes have a significant impact on water contamination [2]. It has been determined that 10 to 15 percent of the dyes used in various industries drain into different water channels as industrial effluents, seriously polluting the water. The synthetic dyes impart very intense color to water and reduces the sunlight penetration to water. The small amount of these dyes has adverse effect to growth of aquatic life [3]. Now a days advanced oxidation process (AOPs) is used to eliminate these industrial effluents [4]. Among these (AOPs) semiconductor photocatalysis is one of most effective and green method for dye degradation [5]. Graphitic carbon nitride (g-CN) is one of most effective photocatalyst has most efficient optical and physiochemical properties with vide band gap [6]. Various methods are used to enhanced photocatalytic ability and life time of charge careers. One of the most effective ways to raise the bandgap of g-CN and subsequently its capacity for photodegradation is to combine it with other semiconductor materials, such as metal nanoparticles [7]. The development of heterojunction between copper and manganese on the surface of g-CN enhanced catalytic efficiencies up to 98% due to reduction rate of excitons [8]. Copper nanoparticles enhances anticorrosive

properties of mild steel tank material [9]. The formation of heterojunction between zinc NPs and g-CN increases lifetime of photoinduced excitons and lower their rate of recombination [10]. The doping of zinc NPs on the surface of g-CN by simple and cost-effective procedure developed a most efficient photocatalysis with tremendous catalytic abilities under irradiation of sunlight [11]. The developed photocatalyst Zn-g-CN convert industrial organic matter into simplest inorganic substances more efficiently than pure g-CN [12].

II. Materials and Method

Distilled water, urea, rhodamine B and reactive orange dye were used in this research.

A. Synthesis of g-CN

By heating urea, polymeric graphitic carbon nitride was prepared. In a ceramic crucible with a lid, the urea crystals were heated for three hours in a muffle furnace at 550°C. The yellow substance was obtained and crushed with a mortar and pestle after cooling at room temperature. The tiny yellow powder was gathered and stored for later examination.

B. Synthesis of Zn-g-CN nanocomposites

For the development of nanocomposites Zn-g-CN, zinc powder and (g-CN), were employed as precursor materials. The right proportions of graphitic carbon nitride and zinc nanoparticles were combined. The mixture was placed in a ceramic crucible with a lid and heated in a muffle furnace for one hour at 400°C. The mixture was collected and ground with a mortar and pestle after cooling at room temperature.

III. Results

A. UV. Visible DRS Spectra

The optical characteristics of the synthesised Zn-g-CN nanocomposite were studied using UV-visible defused reflectance spectroscopy. The UV-vis DRS spectra of a Zn-g-CN catalyst with varying amounts of Zn NPs and pure g-CN are shown in Figure 1. The Zn reflectance band edge is at 390 nm in the provided spectra. In comparison to Zn NPs, the composite's reflectance band edge shifts to a significantly longer wavelength and lower energy area after the addition of g-CN. This suggests that composite materials are manufactured to respond to a larger range of visible light. Enhancing the synthesised composite's catalytic capabilities is particularly beneficial.

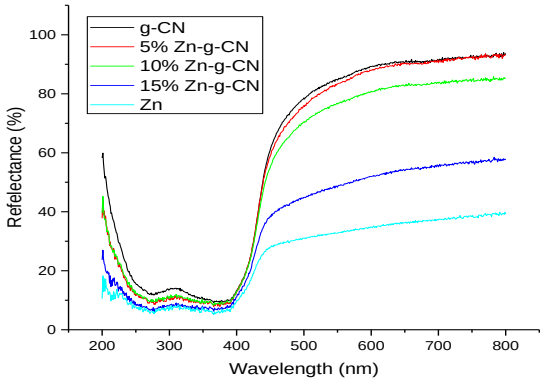

Fig.1 UV-DRS Spectra of Zn-g-CN

B. Scanning electron microscopy (SEM)

The generated Zn-g-CN nanocomposite's morphological information is shown in Figure 2. The particles are seen to be cubic in form, nonhomogeneous, and scattered. The creation of a Zn and g-CN nanocomposite is supported by the surface morphology of the synthesized nanocomposites, which contains a mixture of nonhomogeneous, scattered, and disk-shaped Zn NPs that are attached to the surface of the g-CN. Additionally, it is possible that the Zn-g-CN nanocomposite's rough surface is caused by the stacking of nanosheets, which provide the reaction sites for catalytic reactions and increase the likelihood that pollutants will interact with the catalyst.

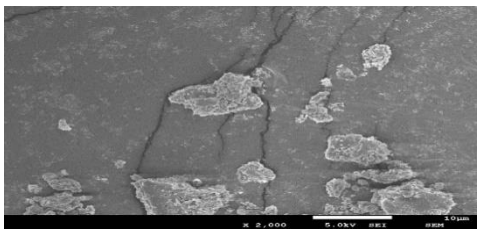

Fig.2 SEM of Zn-g-C

IV. DISCUSSION

The effect of loading of Zn powder on the g-CN surface was noted by varying amount Zn NPs for the decolorization of RhB dye. The table 1 one shows that the sample having 5% Zn content on the surface of g-CN exhibit maximum absorption. The high content of Zn powder decreases the absorbance of reaction mixture due to blockage of reaction sites. Furthermore, the graph 1 between concentration vs

time showed that the sample with 5% Zn content has **Hata! Belgede belirtilen stilde metne rastlanmadı.**

Time(min)	5%Zn-g-CN	10%Zn-g-CN	15%Zn-g-CN
0	2.412	2.412	2.412
30	1.669	2.112	2.179
60	0.899	1.715	1.859
90	0.550	1.119	1.515

greater catalytic ability.

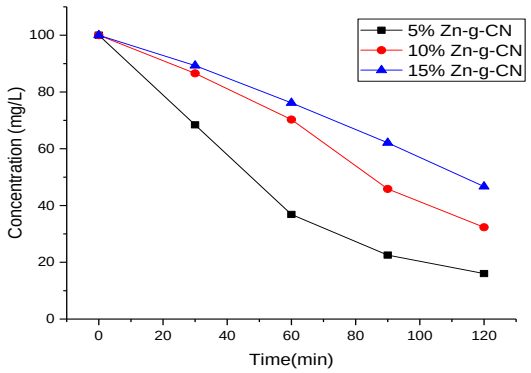

Fig 3: comparision of catalystic activities in therm of concentrations

V. CONCLUSION

Graphitic carbon nitride (g-CN) was prepared by heating urea to 550°C for three hours in a muffle furnace. By calcining Zn and synthesising g-CN, the Zn-g-CN nanocomposite was synthesized. Rhodamine B was degraded using the resulting Zn-g-CN nanocomposite as a catalyst when exposed to sun light. The effects of different experimental variables, such as dye solution content, temperature, and catalyst dose, were examined. It was discovered that doping the Zn on the surface of g-CN improved its capacity for degradation. Additionally, it was discovered that 5% Zn-g-CN is superior to 10% Zn-g-CN nanocomposite and 15% Zn-g-CN nanocomposite for the degradation of dyes in aqueous medium. Using the Arrhenius equation, the activation energy of the catalyst for the degradation of the rhodamine B dye was calculated to be 30.06 kj/mol, which was less than bare g-CN.

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