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SYTHESIS AND CHARACTERIZATIONS OF CuO/GCN NANOCOMPOSITE

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ABSTRACT

CuO (Copper Oxide) nanoparticles and GCN (Graphitic Carbon Nitride) polymeric material were synthesised by pyrolysis. Thermal pyrolysis was used to produce the CuO/GCN nanocomposite. With a monoclinic structure, copper oxide (CuO) is a non-toxic p-type semiconductor material. CuO is the most researched material in the last ten years due to its vast range of uses, particularly when it took the form of microstructure. The tri-s-triazine structure of GCN did not result in the formation of any secondary phase in the CuO/GCN nanocomposite. Only the monoclinic CuO formation is conformed. Using XRD, TG-DTA, and SEM the structural, thermal, and elemental analyses of CuO/GCN nanocomposite was investigated.

KEYWORD

CuO, GCN, CuO/ GCN

INTRODUCTION

Due to its simple production procedure, low band gap energy, visible spectrum light absorption, and practicality, graphitic carbon nitride (GCN), a semiconductor polymeric photocatalyst, has gained increasing attention in the field of visible light-induced hydrogen evolution reaction (HER). Graphitic carbon nitride is a modern name for a semiconductor material with a structure similar to graphite (GCN). Weak Van der Waals forces cause its tris-s-triazines-based 2D-planar layers to stack on top of one another [1]. GCN is an inexpensive material that can be generated in large quantities quickly and sustainably. Melamine [2], urea [3], cyanamide [4], and among other chemical compounds with a high nitrogen concentration, are examples of precursors. Carbon nitrides were one of the first synthetic polymers (from 1834), but due to their unclear structure at the time, they were not widely used [5]. The essential structure of carbon nitrides is gradually being defined as a result of intensive study carried out in recent years. The most stable allotrope of carbon nitrides, GCN, has generated a great deal of interest because of its distinctive visual and photocatalytic properties [6]. It also possesses remarkable thermal stability and chemical inertness because to its high condensation level. Previous studies [7-11] have described its promising applications in fluorescence spectroscopy [12–13] and photo-catalysis [7–11]. Moreover, this beneficial molecule has electrochemical uses including electrocatalysis and electrochemiluminescence [14–17]. Based on its catalytic activity, GCN was typically used in the construction of sensitive electrochemical sensors [18–19]. Recently, a number of goods, including photocatalysts, solar cell devices, lithium-ion batteries gas sensors, and super capacitors, have experienced a surge in the use of copper oxide (CuO). Copper oxide is a monoclinic chemical having a semiconducting structure (CuO). CuO has attracted a lot of interest due to its simplicity and a variety of potentially useful physical properties, including high temperature superconductivity, electron correlation effects, and spin dynamics [20-21]. Copper oxide is easily combined with polymers and polarised liquids, has good chemical and physical stability, and is very affordable (such as water). Highly ionic nanoparticulate metal oxides, such as CuO, may be particularly effective antibacterial agents due to their capacity to be synthesised with extraordinarily high surface areas and distinctive crystal morphologies [22]. Copper oxide (CuO) nanoparticles with specific physical and chemical properties have been researched for potential antibacterial applications.

2. MATERIALS AND METHODS

2.1 Materials

Urea, Copper nitrate trihydrate were obtained from Nice Chemicals Private Limited.

2.2 Synthesis of GCN

GCN is produced by calcined 10g of urea at 550°C for two hours in a muffle furnace.

2.3 Synthesis of CuO/ GCN

Copper nitrate trihydrate was dissolved in 10 ml of distilled water and thoroughly stirred. 10g of urea was dissolved, then mixed once more. The solution was heated to 60°C for two hours in an oven. The powder was extracted, thoroughly ground, and deposited in a crucible in a muffle furnace where it was calcined at 550°C for two hours.

3. CHARACTERIZATIONS

A Field-Emission Scanning Electron Microscope (HITACHI, SU-6600, FESEM) were used to examine the structural morphology of the products. Using X-ray diffraction (Bruker Kappa APE XII) the crystalline structure of the as-prepared samples was examined. A Netzsch STA449F3 system was run at a heating rate of 10°C/min to accumulate thermogravimetric analysis-differential thermal analyser (TG-DTA) data.

4. RESULT AND DISCUSSION

4.1 XRD

Using X-ray diffraction (XRD), the crystal structure and phase composition of pure GCN and CuO/GCN composites were investigated (Fig. 1 and Fig 2). Two typical peaks are seen at 13.1° and 27.4°, which are attributed to the (100) and (002) lattice planes of GCN, respectively [24]. The stacking of conjugated aromatic rings makes up the peak of (002) for GCN, while the in-plane arrangement of nitrogen-linked heterocyclic rings makes up the peak of (100) [23,24].In CuO/GCN nanocomposite Diffraction peaks for CuO were found at 32.6°, 35.4°, 38.5°, 48.8°, 53.5°, 58.3°, 61.5°, 65.2°, and 67.8°, 72°, 75° which, respectively, correspond to the CuO crystal planes (110), (111), (111), (202), (020), (202), (113), (022), (220), (312), and (203) (JCPDS No. 05-0661). CuO/GCN composites with CuO coupled to GCN show the diffraction peaks of (111) and (111) of CuO, and the peak intensities increased with the CuO concentration.

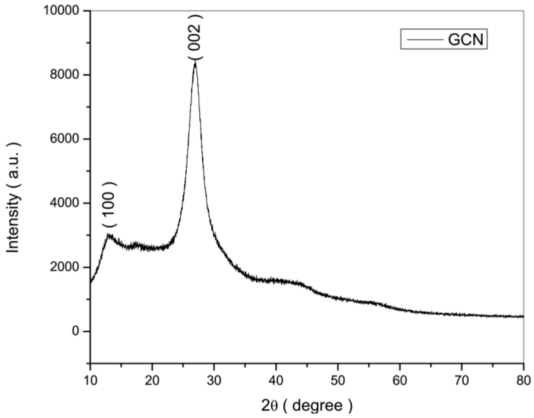

Figure: 1

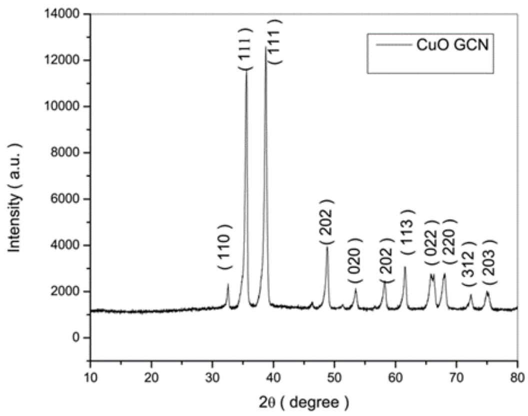

Figure: 2

4.2 TG-DTA

The sample showed weight decrease in two distinct phases, as shown in Figure 3. Due to the hydrophilic nature of graphitic carbon nitride, the first weight loss (about 8%) at temperatures up to 200°C is attributed to the removal of physically adsorbed water. The second weight loss, which showed a sharp and one combustion process in the range of 600°C to 750°C, can be attributed to the loss in tri-s-triazine-based units or other advanced condensates [25-27]. In line with this, the DTA thermogram displayed a high endothermic peak at 750°C that was consistent with the sublimation or disintegration of GCN [25].

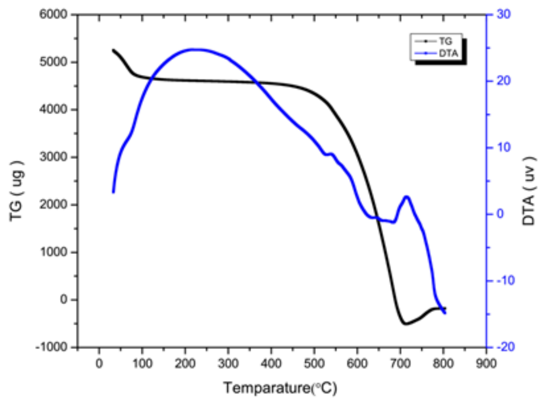

Figure: 3

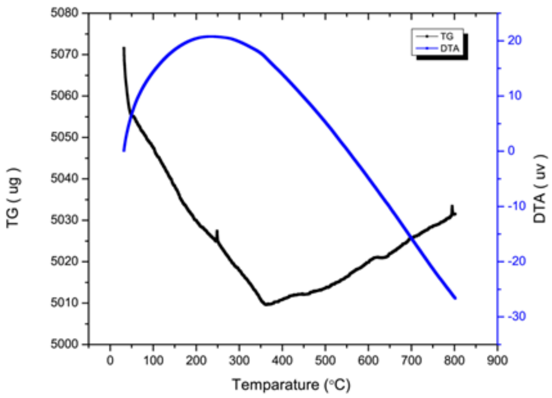

Figure: 4

The results of the TG-DTA studies for the CuO/GCN composite material are shown in Figure 4. The endothermic peak in the DTA curve at 73°C correlated well with the water adsorption on the composite material's surface [28]. The peak that occurred at 570°C related to the disintegration of GCN [30] and the exothermic peak that was observed at 486°C assembled to carbon reaction in GCN powder [29]. The GCN might break down into intermediates like C2N2 and NH3 when the temperature exceeded 500°C [31]. According to the TG curves, the weight loss of 0.3% that was seen between 20°C and 100°C was caused by the elimination of water molecules from the samples. In the second stage of weight loss, which occurred at a temperature of 480°C, urea condensation and NH3 ejection were seen [30]. The GCN disintegrated with a weight loss of roughly 0.5% in the 486°C –516 °C temperature range. About 98% of the original material was left over.

4.3 SEM-EDS

Figure 5a depicts the morphology and microstructure of CuO/GCN. It is evident that CuO particles cover GCN sheets, maintaining CuO's structural integrity while roughening the surface. Additionally, CuO/GCN contains C, N, Cu, and O elements, as shown by the EDS element mapping (Figure 5b). It gives proof that GCN and CuO may coexist.

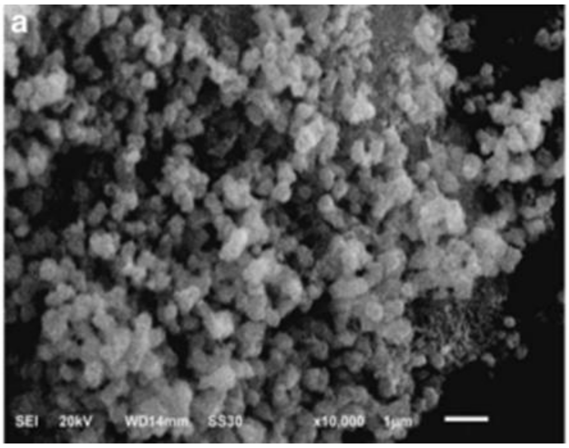

Figure:5a

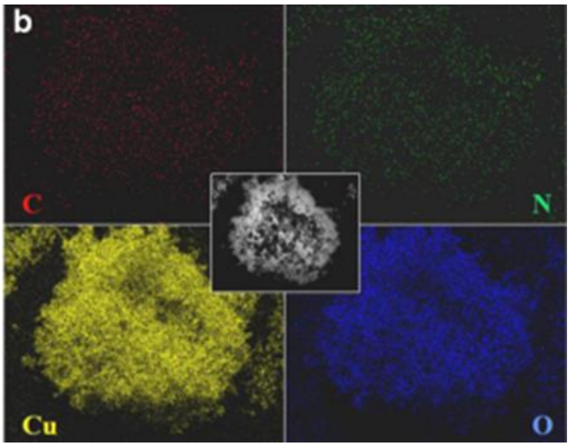

Figure: 5b

5. CONCLUSION

The CuO/ GCN composite was simple to make, and it was investigated with the use of the XRD, TG-DTA, and SEM-EDS. The crystal structure and phase composition of pure GCN and CuO/GCN composites were examined using X-ray diffraction (XRD). CuO/GCN composites containing CuO coupled to GCN exhibit the diffraction peaks of (111) and (111) of CuO, and the peak intensities increased with the CuO content. TG-DTA was used to investigate sample weight loss. It is clear from the morphology and microstructure of CuO/GCN that CuO particles cover GCN sheets, preserving the structural integrity of CuO while roughening the surface.

6. DECLARATIONS

6.1 Funding

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6.2 Conflict of competing interest

The authors affirm that they have no known financial or interpersonal conflicts that would have appeared to have an impact on the research presented in this study.

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