

**NANOCOBALT FERRITE CATALYTIC Dynamic
PHOTOCATALYTIC PERFORMANCE SYNTHESIZED WITH
Using CITRATE PRECURSOR TECHNIQUE**

K Prathibha Bharathi, Research Scholar, Department of Chemistry,
Monad University, Hapur, U.P.

Dr.Richa Yadav, Professor, Supervisor, Department of Chemistry,
Monad University, Hapur, U.P.

ABSTRACT

By eliminating the need for combustion engines in densely inhabited regions, supercapacitors and other breakthrough electric energy production and storage technologies have the potential to drastically improve the environmental situation in densely populated cities. The development of nanomaterials for supercapacitors has provided researchers with a new and expanded platform for determining the best electrode material capable of supplying high power and energy densities. The nanostructured electrode material is expected to boost the supercapacitor's power output and cycle life. Many different forms of agricultural waste might be seen as a plentiful, low-cost carbon source for large-scale production of graphene-type compounds with added value. We show how widely accessible coconut waste (coconut coir and coconut shell) can be efficiently transformed into reduced graphene oxide by simple catalytic oxidation in a muffle furnace using ferrocene as an efficient and low-cost catalyst. XRD, SEM, TEM, and XPS methods were used to characterize the structure and morphology of the as-prepared materials. The findings backed up the fabrication of high-quality reduced graphene oxide. The electrochemical performance of as-prepared graphene oxide in 2M KOH aqueous solution was then investigated as an electrode material for supercapacitor applications. The material has a high cycle stability and performs well as an electric double layer capacitor (EDLC). When exposed to visible light, the rGO from Coconut coir material shown improved photocatalytic activity, destroying around 65% of the malachite green dye in 120 minutes. We created innovative nickel-based reduced graphene oxide (rGO) nanostructured composites with enhanced energy storage and photocatalytic characteristics to improve the electrochemical and photocatalytic capabilities of rGO

generated from coconut coir. rGO nanoflakes were made from negative value coconut coir biowaste using a simple hydrothermal process and then adorned with functional NiO and NiFe₂O₄ nanoparticles to generate hierarchical functional nanocomposites. Using the synergies created by combining NiFe₂O₄ nanoflakes with rGO nanoflakes, the resulting nanocomposites demonstrated a remarkable specific capacitance of 599.9 F/g at current density of 1 Ag-1 and retention rate of 86.5% even after 2000 cycles. Furthermore, the composite demonstrated 96.5% photocatalytic degradation efficiency driven by visible light. These results support the development of multifunctional nanostructured composites as a feasible material for energy and environmental remediation applications. There has recently been a surge of interest in nano/micro-scale Fe-based ferrites with superior electrochemical properties. We created a simple one-pot hydrothermal approach for manufacturing a wide range of cobalt oxides and nanocomposites using biomass waste-derived reduced graphene oxide for alternative spinal metal oxide electrode material as a sustainable energy source. The homogeneous distribution of metal oxide on the rGO sheets was verified by SEM and TEM pictures. The FTIR and XPS tests were used to identify the functional group and individual components. The specific capacitance of composite materials is greater than that of pure materials. At 1A/g, the rGO spinal metal oxide nanocomposites exhibited the highest specific capacitance, which was 396 F/g. Furthermore, the hybrid supercapacitor has a high cyclic stability of up to 2000 cycles, with a retention of 95.6%. To assess the photocatalytic capabilities of rGO nanocomposites, malachite green dye was utilized. Finally, we'd like to highlight the electrochemical and photocatalytic characteristics of the electrode material in relation to the supercapacitor and dye degradation processes. The microstructure, greater specific surface area, and high electrical conductivity of diverse metal oxide nanostructures have a significant influence on their electrode performance. CCF (rGO obtained from Coconut coir) had the maximum specific capacitance of 111.1 F/g in 2M KOH electrolyte, whereas CSF (rGO derived from Coconut shell) had the lowest specific capacitance of 60.2 F/g. They are also 99% stable after 3,000 charge/recharge cycles. Similar research using NiFe₂O₄ nanoflakes and rGO nanoflakes produced a good specific capacitance of 599.9 F/g at a current density of 1 Ag-1 and a retention rate of 86.5% after 2000 cycles. Furthermore, the composite demonstrated 96.5% photocatalytic degradation efficiency driven by visible light. rGO spinal metal oxide nanocomposites, on the other hand, had a maximum specific capacitance of 396 F/g at

1A/g. Furthermore, the hybrid supercapacitor has a high cyclic stability of up to 2000 cycles, with a retention of 95.6%. The photocatalytic capabilities of the generated rGO nanocomposites were examined using malachite green dye, and the photocatalytic findings reveal that rGO/CoFe₂O₄ demonstrated a remarkable efficiency of visible light-driven photocatalytic degradation of 80.8%. Simultaneously, all of the suggested electrode materials have shown excellent electrochemical stability for long-term usage.

1 INTRODUCTION

"Eric Betzig Stefan W. Hell and William E. Moerner are presented with the Nobel Prize in Chemistry 2014 because they have overcome a scientific restriction that states an optical microscope cannot provide a resolution greater than 0.2 micrometers. By using the luminescence of molecules, scientists are able to detect the interactions between the molecules in cells. They can also see the formation of proteins associated with disease and can monitor cells' development at a Nano level" This is the Royal Swedish Academy of Sciences The world has seen a dramatic change into our current system by the advancements in nanotechnology. The award of this award of the Nobel Prize is certainly landmark recognition of how the research and observations of human beings are now from the micro-level up to nano levels. Nano technology has permeated the entire spectrum of technology and science from space to medicine, from the paper and cloth to

computer memory devices. Nano technology's influence on chemistry is evident when atoms expand to create molecules. Their size can be adjusted to nano-sized to be used in specific ways. Magnetically-recyclable catalysts (MRCs), which are prepared through loading small catalytic active particles on magnetic supports, have proved to be able to combine the advantages of high activity and easy recycling in heterogeneous catalytic processes. Utilizing the full potential of the materials is of paramount significance as the studies in this area provide huge opportunities to develop of catalysts with new systems that can be used for efficient development of catalysts.

The term "nano" originates from the Greek word "nano," which translates to dwarf. It refers to something small. If it's utilized as a suffix for the measurement of length or time that is one billionth of the unit. Therefore, one nano meter (nm) equals 10⁻⁹ meters. Nano-materials are those which have functional structures

that include of at minimum one particular measurement in nanometers. Nano materials have the size of particles as well as morphological properties less than 100 nanometers. Nanotechnology is the name that covers the development manufacturing, development and use of these materials. In light of the numerous applications for nano substances, an-chemistry has been developed following the advent of electron microscopes. A large number of researchers from different fields are involved in research and development of connected to the field of nano-chemistry. One of the main features that has been observed is that completely distinct properties and character traits can be observed in the nano-sized materials within the nano-scale.

Nanomaterials can include materials made of ceramics, metals, substances, or composite materials. Nanomaterials comprise various substances, including nano-crystalline materials and nanocomposites. They also include Nano tubes, nano particles and quantum dots. Due to their unique structure nanomaterials exhibit distinct physical and chemical, optical, mechanical, electrical, and magnetic properties than traditional material. The intriguing and surprising features of nanomaterials

result from their large surface area ratio, where the proportion of atoms that are located on their surface is significant. The alteration in the physical properties of the nanomaterials when compared with bulk materials is a massive change. This increase in dimension of the nanomaterials makes them possess different electronic modifications with regard to energy as well as quantity of levels. These materials perform differently in terms of electronic properties. This alters the chemical behavior of substances. Nanomaterials have properties which differ from bulk include variations in the properties of redox as well as band gap changes and anomalous melting points. improve strength and toughness unique crystal structures (in the case of metals).

2 LITREATURE SURVEY

The use of heterogeneous catalysis in organic synthesis simplifies reaction management, with specific care paid to product purification. Another benefit is the ability to execute reactions with no solvent and in extremely short time frames. Some heterogeneous catalysts, such as clays (Montmorillonite K-10 and KSF [53]) and zeolites [54], are commercially accessible; others, such as supported acids [55], bases [56], and transition metal complexes [55], must be

made explicitly. Sartori provided several instances of selective protection of multifunctional compounds in a review [57]. The separation of heterogeneous catalysts, generally achieved by filtering, often results in diminished catalyst activity. One appealing feature of MNPs as a heterogeneous catalyst is their ease of separation using external magnets, which reduces catalyst loss during separation. Fe₃O₄ micro particle immobilized or supported catalysts have been effectively shown in a number of ways [58]. Ferrites of the general formula MFe₂O₄ (where 'M' is a divalent metal such as Mg, Cu, Co, Zn, Fe, and Mn, for example) have been utilized as aromatic alkylation catalysts in recent years. Ferrites used in catalytic applications are typically synthesized using low temperature co-precipitation methods[59-64], which overcome drawbacks associated with high temperature preparation, such as low surface area, varying morphology, inhomogeneity at an atomic level, and large particle with grain boundary. A wide range of physicochemical approaches, as well as a wide range of probe molecules, have been used to assess the strength and number of acid-base sites on catalysts.

When pyridine is chemisorbed on a surface possessing acid properties, it can interact with acidic protons, electron acceptor sites and H from neutral or weakly acidic hydroxyl groups.[70,71] However, CO₂ has been used to probe basic surface properties due to its amphoteric character (also known for its acidic nature) and hence it is expected to adsorb on both acidic and, more strongly, on basic sites.[72,73] On the other hand, adsorption of electron acceptor (EA) molecules like 7,7,8,8-tetracyanoquinodimethane (TCNQ), 2,3,5,6-tetrachloro-1,4-benzoquinone (chloranil) and p-dinitrobenzene (PDNB) on the oxide surface will provide insight into the strength and distribution of electron donor sites on the oxide surfaces.[74,75] By probing the interaction of all the above molecules adsorbed on the ferrosphenel surface, information can be obtained about the oxidation state of the metal ion, the coordination symmetry, the degree of coordination unsaturation of the surface hydroxyl groups and the nature of surface Lewis and Brønsted acid sites.

12 Transition metal oxides are predominantly redox catalysts, and little research has been conducted on their acid-base characteristics. Although transition metal oxides include both acidic and basic sites, they are

commonly categorized as acidic oxides or A-type oxides, as reported by Auroux and Gervasini.[76] The acid-base characteristics of oxides such as ferrosphenel may be critical in determining their catalytic activity.

In industry, catalytic operations induced by a heterogeneous catalytic system are preferred over those done in a homogeneous system because the former is simpler to handle, involves less workup, and avoids metal contamination. The method may be improved by making it high yielding, sensitive to mild reaction conditions, and efficient in the presence of multifunctional groups with catalyst recyclability. The use of metal nanoparticles as effective catalysts in organic synthesis is well known, has piqued the curiosity of many researchers, and has seen great increase in applications in recent years. According to recent research, magnetic nano particles are effective catalytic supports in a variety of organic transformations. [77] In general, nanoscale catalysts provide a more effective process and greater advantages over traditional methods in organic reactions because they have a higher surface area, fewer coordination sites, and reactive

morphologies that maximize reaction rates while minimizing catalyst consumption. [78] Due to their capacity to form inner-sphere bidentatebinuclear complexes with iron oxides, iron oxides have been shown to have a high affinity for arsenic and arsenate adsorption [79-81]. Iron oxide nanoparticles with a high surface area show promise for arsenic removal.

3 METHODOLOGY

Sintering's value As material synthesis and processing have grown more important in recent years for material development, sintering's value as a material processing technique is growing. Sintering is one of the earliest human technologies, dating back to the ancient age and the firing of pottery. Sintering also enabled the manufacturing of tools from sponge iron. Nonetheless, it wasn't until the 1940s when sintering was researched in depth and scientifically. Since then, great advances in sintering science have occurred. The manufacture of sintered parts of various types, including powder-metallurgical parts and bulk ceramic components, is one of the most significant and advantageous applications of sintering in the current period.

Sintering is a thermal energy-based manufacturing method used to create density-controlled materials and components from metal or ceramic powders. As a result, sintering is classified as a synthesis/processing element among the four fundamental components of materials science and engineering. The sintering step includes heating a pelletized sample to a high temperature in air or oxygen. Sintering includes large-scale diffusion and erasure of chemical potential gradients, which results in the production of the final product. The pace of sintering in final sintering must be managed since it influences the electrical and magnetic characteristics of composites. Controlling the quantity of oxygen in the sintering process promotes the creation of high-quality composites [17, 18]. This increases density and so decreases porosity. The final microstructure, as well as the equilibrium oxygen concentration and cation distribution, are affected by the sintering duration and temperature [19]. To eliminate the remaining carbon, the as-synthesized powder was calcined in a furnace at 5000C for 2 hours. The precipitated powder samples were structurally determined using X-ray characterisation, and the patterns were evaluated and indexed using powder-X

software. The 'd' value and the associated (h.k.l) parameters were used to calculate the lattice parameters. The Powder-X program was used to improve the predicted lattice parameters (). The determination of the crystal size and lattice strain of Nano crystalline materials is one of the most popular uses of XRD analysis. The finite size effect causes peak broadening patterns in X-ray diffraction of nanomaterials. When a nano crystal grows to a certain size, the number of X-ray rays reflected from consecutive lattice planes that are added to form constructive or destructive interference becomes finite and so cannot be entirely reinforced or cancelled. Other reasons that might produce diffraction peak widening include inhomogeneous lattice stresses, differences in a crystallite's lattice constants, and other structural flaws. If the nano crystalline size is smaller than 100 nm, the size of the material may be estimated from the peak broadening using Scherrer's equation.

Where d is half the dimension perpendicular to the reflecting crystalline phases, λ is the x-ray wavelength, θ is the Bragg angle, and $\Delta 2\theta$ is the finite size broadening. K is a constant close to unity that is connected in both crystalline form and as specified

way, i.e., as the full width at half maximum (FWHM) or as the peak area ratio to peak. The pattern has all of the spinel structure's distinctive peaks and validates the phase development, confirming the lack of additional impurity phases. The lattice parameters were determined using XRD data, and there is compositional variation in the lattice parameter. Table 3.1 shows the particle size and other properties of the cobalt ferrite nano particles determined from the XRD pattern using Scherer's formula [14-15].

4 EXPERIMENTS & RESULTS

Dyes are colored, ionizing, aromatic organic chemicals that have a strong affinity for the substrate to which they are applied. It is often used in aqueous solutions. Dyes may also need a mordant to improve the dye's fastness on the substance to which it is applied. Dyes and pigments seem colored because they absorb some wavelengths of light more than others. A pigment, unlike a dye, is normally insoluble and has no affinity for the substrate [24, 25].

Dyes are classed in a variety of ways based on their chemical composition, application, origin, and usage. Their origin determines whether they are natural or manufactured. Based on their usage, dyes are classed as acidic, basic,

mordant, direct, reactive, vat, dispersion, sulphur, azo, and so on. Their exposure to the environment produces natural water coloration, toxicity, mutagenicity, and carcinogenicity, as well as pollution, eutrophication, and disruption in aquatic life in the eco-system [26-32]. Many businesses employ dyes to color their goods and discharge a large amount of colored waste water into the wastewater. The discharge of dye-bearing effluent from the textile, paper, carpet, leather, distillery, and printing industries into natural streams and rivers causes serious concerns. The treatment of wastewater is one of the most severe environmental issues of our day. The discharge of dyeing industrial effluent into natural water bodies is undesirable because the color limits re-oxygenation in receiving water by blocking sunlight penetration. It also raises BOD levels and reduces the amount of dissolved oxygen available to aquatic life. Furthermore, most dyes used as coloring materials are poisonous to certain microorganisms and aquatic life, even at extremely low concentrations, and may cause immediate destruction or inhibition of their enzymatic capacities.

Many colors are resistant to aerobic digestion, making them difficult to breakdown. Dye allergies and skin

irritation may also be caused by dyes. Some have been shown to be carcinogenic and mutagenic. As a result, dye pollution is not only a major public health risk, but it may also create substantial environmental difficulties owing to its persistence. This disrupts the biological activity in bodies of water. Because of the poor removal effectiveness of traditional wastewater treatment facilities, a considerable proportion of reactive and other anionic dyes are still present in waste

Methylene Blue (MB) is a cationic dye that is widely utilized in a wide range of industrial applications, the most common of which are in the textile and coir industries. It is primarily used to color cotton, wood, paper stocks, and silk. It is also used in the medical profession.

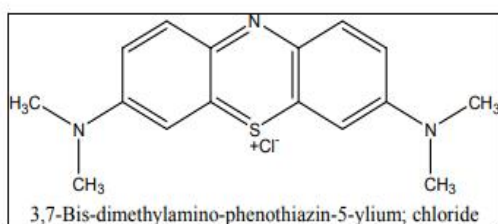


Figure 4.1 Methylene Blue

Severe methylene blue exposure produces aromatic amines (e.g., Benzedrine, Methylene) and is a probable carcinogen. In humans, it causes accelerated heart rate, vomiting, shock, cyanosis, and tissue necrosis. Methylene blue should be removed from

the human environment due to these serious detrimental impacts. Its presence, even at low concentrations, is extremely apparent and will have an impact on aquatic life as well as the food chain. It raises the BOD level in water and is detrimental to aquatic life

5 CONCLUSION

PMMA was chosen as the host matrix for the LN nanoparticles because it is an isotropic organic solid material with very high transmittance (90%) in the visible spectrum region of electromagnetic radiation. It is known as acrylic glass and has thermoplastic properties. The most essential feature of this transparent polymer is its low weight, great mechanical strength, chemical stability, and flexibility when it is in the shape of a film. This PMMA was created by polymerizing the monomer, methyl methacrylate (MMA), via a free radical chain reaction, as explained below. Figure 4.1 depicts the structural formulas of MMA and PMMA. The polymerization process began in the presence of a polymerization agent, 2,2'-azobisisobutyronitrile (AIBN), a very unstable chemical whose structural formula is also shown in figure 4.1. The AIBN molecule has four nitrogen atoms, two of which are linked together by a double covalent connection. With a small temperature increase from room

temperature, these two nitrogen atoms combine via trivalent bonds and release as nitrogen gas molecules (N₂), leaving behind two identical molecular species, each with one unpaired electron (represented by the star symbol in figure 4.1). This sort of molecular species is very unstable and is referred to as a free radical. This free radical has the ability to break the carbon-carbon double covalent bond (i.e. C=C) of the MMA molecule to a single covalent bond by donating the unpaired electron, and through this process, the free radical generated from the AIBN molecule combine with the MMA molecule through a single covalent bond, resulting in a new bigger free radical molecule that also has the ability to combine with another MMA molecule by transferring its unpaired electron, and this reaction process The liquid state of MMA molecules is polymerized to generate solid PMMA through this free radical chain reaction.

REFERENCE

1. Buschow, KHJ & De Boer, FR 2004, 'Physics of Magnetism and Magnetic Materials', Kluwer, London.
2. Wolf & Edward, L 2006, 'Nanophysics and Nanotechnology- An Introduction to Modern Concepts in Nanoscience', 2nd edition , Wiley, John & Sons.
3. De Heer, WA 2000, 'Nanomagnetism Characterization of Nanophase Materials', Wiley-New York.
4. Coey, JMD & Khalafella, K 1972, 'Superparamagnetic Y-Fe₂O₄', Physica. Status Solid (A), vol. 11, pp. 225-241.
5. Nalwa, HS 2002, 'Magnetic Nanostructure', American Scientific Publishers, California.
6. Goya, GF & Rechenberg, HR 1999, 'Magnetic Properties of ZnFe₂O₄ synthesized by ball milling', Journal of Magnetism and Magnetic Material, vol. 203, pp. 141-142.
7. Voltairas, PA, Fotiadis, DI & Michalis, LK 2002, 'Hydrodynamics of magnetic drug targeting', Journal of Biomechanics, vol. 35, pp. 813-821.
8. Auzans, E, Zins, D, Blums, E & Massart, R 1999, 'Synthesis and properties of Mn-Zn ferrite ferrofluids', Journal of Material Science, vol. 34, no. , pp. 1253- 1260.
9. Alexiou Ch, Schmidt, A, Klein, R, Hulin, P, Bergemann, Ch & Arnold, W 2002, 'Magnetic drug targeting bio-distribution and dependency on magnetic field strength', Journal of Magnetism and Magnetic Material, vol. 252, pp. 363-366.

10. Akin, Y, Obaitdat, IM, Issa, B & Haik, Y 2009, 'Ni_{1-x}Cr_x alloy for self controlled magnetic hyperthermia', *Crystal Research Technology*, vol. 44, pp. 386-390.
11. Parvatheeswara Rao, B, Chong-Oh Kim, CheolGikim, Dumitru, I, Spinu, L & Caltun, OF 2006, 'Structural and magnetic characterizations of co precipitated Ni-Zn and Mn-zn ferrite nano particles', *IEEE Transactions on Magnetics*, vol.42, pp. 2858-2860.
12. Nalwa, HS 2002, 'Nanostructured materials and Nanotechnology', Academic press, London San Diego, Academic Press.
13. Decker, AJ 1995, 'Solid State Physics', The Mc Millan Press Ltd, London.
14. Smit, J & Wijn, HPJ 1959, 'Ferrities', Wiley, New York.
15. Viswanathan, B & Murthy, VRK 1990, 'Ferrite Materials', Narosa Publishing House, New Delhi.
16. Shannon, RD 1976, 'Revised effective ionic radii and systematic studies of interatomic distances in halides and chalcogenides', *Acta Crystallographica*, vol. A32, pp. 751-767.
17. Standley, KJ 1972, 'Oxide Magnetic Materials', Clarendon Press, Oxford.
18. Willard, MA, Nakamura, Y, Laughlin, DE & Mechenry, ME 1999, 'Magnetic properties of ordered and disordered spinel – space ferrimagnets', *Journal of American Ceramic Society*, vol. 82, pp. 3342-3346.
19. Ghosh, B, Kumar, S, Poddar, A, Mazumdar, C, Banerjee, S, Reddy, VR & Gupta, A 2010, 'Spin like behavior and magnetic enhancement in nanosized nickel zinc ferrite system' *Journal of Applied Physics*, vol. 108, no. 034307, pp. 1-7.
20. Teja, AS & Koh, PK 2009, 'Synthesis, Properties, and applications of magnetic iron oxide nanoparticles', *Progress in Crystal Growth and Characterization of Materials*, vol. 55, pp. 22-45.
21. Kim, CS, Yi, YS, Park, KT, Namgung, H & Lee, JG 1999, 'Growth of ultrafine Co--Mn ferrite and magnetic properties by a sol--gel method', *Journal of Applied Physics*, vol. 85, no. 8, pp. 5223-5225.
22. Fecht, HJ 1995, 'Nanostructure formation by mechanical attrition', *Nano structured Materials*, vol. 6, no. 1-4, pp. 33-42.
23. Manova, E, Kunev, B, Paneva, D, Mitov, I, Petrov, L, Estournès, C, D'Orléan, C, Rehspringer, JL & Kurmoo, M 2004, 'Mechano synthesis, characterization and magnetic properties of nanoparticles of cobalt ferrite CoFe

204', Chemistry of materials, vol.16, no.26, pp.5689-5696.

24. Tavakoli, A, Sohrabi, M & Kargari, A 2007, 'A review of methods for synthesis of nanostructured metals with emphasis on iron compounds', Chemical Papers, vol. 61, no. 3, pp. 151-170.

25. Pardavi-Horvath, M & Takacs, L 1995, 'Magnetic nanocomposites by reaction milling'. Scripta Metallurgica et Materialia, vol. 33, no. 10-11, pp. 1731-1740.