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ORIGINAL PAPER

$Zn_{0.99-x}Nd_{0.01}Cr_xO$ Synthesis Via Sol–Gel Route: Effect of Doping on Structural, Optical, magnetic and Photocatalytic Properties

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Abstract
Pristine ZnO and a series of Cr- and Nd-substituted zinc oxide nanoparticles have been prepared via the sol–gel method. The X-ray diffraction spectra confirm the hexagonal wurtzite structure of the samples, with no undesirable phases present. The bandgap of the fabricated ZnO nanoparticles shows a redshift toward the visible region due to co-doping. The formation of the hexagonal wurtzite crystal structure is also supported by Raman spectra. The photoluminescence (PL) spectra of the co-doped nanoparticles reveal various emissions and structural defects. Magnetic hysteresis loops indicate that the co-doped ZnO nanoparticles are ferromagnetic, with ferromagnetism increasing as Cr ion concentrations rise. The degradation of methylene blue (MB) and rhodamine B (RhB) dyes under solar irradiation was conducted at room temperature. The co-doped ZnO nanoparticles (5% Cr and 1% Nd) exhibit the best photocatalytic and ferromagnetic properties, making them suitable candidates for addressing industrial pollutants and for spin-based electronic devices.

Keywords ZnO · Co-doping · Bandgap · Ferromagnetism · Photocatalysis · Pollutants · Solar light

1 Introduction

Society needs to develop pollution-free technologies to remove organic contaminants from the air and water [1]. Therefore, safeguarding the environment from the negative effects of heavy metal ions and chemical waste is crucial. Wastewater containing organic pollutants cannot be effectively treated using conventional materials or methods [2]. To provide safe and clean water, the water industry needs to adopt affordable, sustainable, efficient, and effective treatment processes [3]. Several industrial applications and water treatment strategies successfully utilize nanotechnology [4]. Among the many nanotechnology-based remediation methods, semiconductor-mediated heterogeneous advanced oxidation technologies have emerged as viable alternatives. The semiconductor-based photocatalysis technique is one of the most commonly studied methods for utilizing solar energy among various green strategies [5]. Wide bandgap semiconducting zinc oxide (ZnO) is favored over titanium dioxide due to its excellent absorption efficiency across a significant portion of the solar spectrum [6]. Although ZnO demonstrates superior activity compared to TiO_2 in degrading various organic pollutants, as documented in the literature [7], its large bandgap energy and rapid charge carrier recombination limit its practical applicability [8]. The electron–hole pairs generated by photon energy cannot easily reach the surface of the catalysts because of the rapid recombination of charge carriers, which restricts their effective use. Consequently, it is necessary to enhance optical responsiveness while reducing the rate of charge carrier recombination for metal oxides to be more effective as photocatalysts. Considerable efforts have been devoted to enhancing the optical, magnetic, and photocatalytic activity of metal oxides through methods such as doping with metal ions, forming heterojunctions, grafting

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Cyclohexane-1,3-dione derivatives: Versatile precursors for total synthesis of natural products

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ABSTRACT

Natural product synthesis is highly demanding but challenging area considering the limitation in the availability of starting materials. The synthesis of such natural products form commercially available cyclohexane-1,3-dione derivatives as inexpensive and versatile building block has stirred undisputable advancements. This review highlights the importance of cyclohexane-1,3-dione derivatives for the construction of bicyclic to hexacyclic natural products having diverse range of biological activities. A pool of 57 representative studies published in the last two decades has been covered with the discussion of the key components of each strategy.

1. Introduction

A plethora of reports in the last two decades witnessed profusion of derivatives of cyclohexane-1,3-dione as an important precursor for the synthesis of several bioactive molecules [1–5], a diverse range of heterocycles [6–11], and natural products in the synthetic organic chemistry [12–18]. These synthetic protocols have a great demand to obtain commercially important herbicidal and pesticidal compounds,[19–22] synthesis of *O*- and *N*-heterocycles having bioactivities such as anticancer, anti-inflammatory, antibacterial, antitubercular, antimicrobial, antioxidant, antiproliferative, anticonvulsant [7,23–33]. The synthesis of all these molecules from cyclohexane-1,3-diones, a cheap and commercially available precursor offers a great alternative to the scientific community. Moreover, cyclohexane-1,3-diones and its derivatives can be easily synthesized via Michael-Claisen

strategy, followed by cyclization in the presence of a strong base [34–37] and de-aromatization of resorcinol derivatives [38–41].

Our group has also achieved the challenging synthesis of 4-substituted cyclohexane-1,3-diones [42–44] from acetone [45,46]. The applications of these derivatives have been documented for the synthesis of heterocycles, enaminones, and other value-added organic compounds [7,47–55].

Although, efforts have been made for summarizing the synthetic application of cyclohexane-1,3-dione derivatives for the synthesis of different products [1,6,7,37,56], but the synthesis of natural products has not been documented to date. To expedite the research in this field, it is therefore imperative to compile all of the recent papers on their synthesis. Inspiring from our previous reviews published in this area, herein we summarize the synthesis of 57 natural products from 2001 to the present (Figs. 1–6), that has been classified into bicyclic to hexacyclic, spirocyclic, and miscellaneous categories of natural products.

2. Natural products involving hexacyclic skeleton

2.1. (−)-Aspidophytine (Qiu, 2013)

Aspidophytine, an aspidosperma alkaloid has been obtained for the first time by acid-mediated degradation of haplophytine, by Cava and Yates in 1973 [57]. However, it was first isolated from dried leaves of *Haplophyton cimicidum* in 1954 [58,59]. The synthesis of aspidophytine

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A Revisit to Food Security System Modelling in Sub-Saharan Africa

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Abstract: *Sub-Saharan African countries, since the attainment of independence have been the bone of contention for the global community for abundance of natural resources, untapped potentiality and for frequent natural calamities that causes for human apathy and misery, in one or another form. It is uncontested truth that the concept of Food Insecurity was conceived in the era of post 1974famine and continuously be relevant in 21st century. Now with the induction of African Union in G-20 under the aegis of Delhi declaration in 2023, the region attained central place on the global forum for its chronicle food-insecurity and its new version namely Acute-Food insecurity which is claiming lives and livelihood concerns of the people. The question arises that despite policy- flux, food security still seems a far distant dream which confirms that food security instrumental mechanisms have badly failed to deliver at grass root level. Why? Food aid failed to transcend till last man and simultaneously failed to convert food aid as a stimulant for development. Thus, it makes it inevitable to think up-on and revisit, the existing food system mode, to draw some use-full insight for a brighter future.*

Key Words: *Acute -food insecurity, food aid, least immune class, policy –flux, world food order.*

1. INTRODUCTION:

In recent past, the food security concern of masses, across the globe has attained the central place in the global discourse and policy-planning at all sphere. Irrespective global developmental momentum especially developing countries have been striving hard for the attainment of hunger -free society, but unfortunately it still seems a long distant dream for the mechanism in place. Since, Food Insecurity term had been believed to recognised and evolved from Sub -Saharan Africa and now a day its being used across the world to refer critical and chronicle apathy of masses on the planet who don't have access to suffice food to maintain their productive (workability) capacity. In this context, SSA region's ongoing food security status along with plans and policy on the ground have been subject to empirical investigation in the light of present study especially to ascertain the real player of the game among i.e. home production, crop pattern, land holdings, agriculture produce export pattern and pace-pattern and direction of foreign funds etc. Asia and African countries have been housing most of the hungry people on the planet. The World Bank's latest update reveals the food price inflation across the globe, observed that about 52.4 percent low-income countries experienced above 5 percent inflation, 88.6 percent lower middle income and 61 percent upper middle-income countries have been suffering from double-digit inflation while high income countries were also facing acute high food price inflation.. Since Ukraine and Russia have been exporter of about 29 percent wheat and 62 percent sunflower oil to the world, consequent up on their conflict, it has aggravated the food price inflation for developing and vulnerable countries. It is admitted fact that Ukraine war has badly jolted the world food order. The World Bank Policy research Working Paper(WBPRWP-2005) investigated macro level progress in achieving the Millennium Development Goal in Sub-Saharan African Countries rather gave a Macro Model established linkages between operational agents(foreign aid, public investment, supply side and poverty) for the elimination of poverty. The research devised a composite MDG (Millennium Development Goal) indicator that is entrusted to serve as land mark strategy for human development in the region. As a recent report on impact of climate change reveals that the Indian agriculture is one of the most vulnerable sectors which engaged 40 percent labour force. It also highlighted temperatures' effects, deteriorating crop yields combined with gradual surge in food prices which has attained double digit mark in 2023 i.e.,11.51 percent. It has reported the chronology of changing pattern of summer monsoon since last century with devastating effects, especially on rain-fed agriculture of the central

Annexture-1

Probing the symmetry energy and asymmetric dense nuclear matter properties in light of neutron skin thickness of ^{208}Pb

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Introduction

Neutron stars, some of the most dense and asymmetric nuclear systems in the universe, exhibit central densities reaching five -six times the nuclear saturation density. Their internal structure may host exotic components, including hyperons and quarks, adding complexity to their study. Understanding key properties of neutron stars such as their maximum mass, radius, and tidal deformability requires robust models of the equation of state (EoS). One such model, the Relativistic Mean Field (RMF) formalism, is widely employed to describe the interactions between nucleons through the exchange of mesons like σ, ω, ρ and δ. Recent astrophysical discoveries, such as neutron stars with maximum masses around $2M_{\odot}$ PSR J0740+6620, have placed significant constraints on the EoS at high densities. Additionally, gravitational wave observations, particularly from the GW170817 event, have driven a deeper focus on tidal deformability, prompting refinements in EoS models. The recent PREX-II experiment [1], which provided model-independent measurements of neutron skin thickness through parity-violating electron scattering, has also shown significant impact on our understanding of symmetry energy critical for describing the EoS. This work aims to propose relativistic interactions capable of predicting neutron star masses close to $2M_{\odot}$, while also aligning with neutron skin thickness data for ^{208}Pb within PREX-II measurements, thus integrating recent observational and experimental constraints into a refined EoS model.

Theoretical model

The RMF model's effective Lagrangian density represents the interaction of baryons through the exchange of σ, ω, ρ, and δ mesons up to quartic order. The Lagrangian density for the RMF model [2] of the nucleon system is given as

$$\begin{aligned}\mathcal{L} &= \sum_{N=n,p} \overline{\Psi}_N [i\gamma^\mu \partial_\mu - (M_N - g_\sigma \sigma - g_\delta \delta.\tau_N + g_\omega \gamma^\mu \omega_\mu \\ &+ \frac{1}{2} g_\rho \gamma^\mu \tau_{3N}.\rho_\mu + e\gamma_\mu \frac{1+\tau_{3N}}{2} A_\mu)] \Psi_N \\ &+ \frac{1}{2}(\partial_\mu \sigma \partial^\mu \sigma - m_\sigma^2 \sigma^2) - \frac{\overline{\kappa}}{3!} g_{\sigma N}^3 \sigma^3 - \frac{\overline{\lambda}}{4!} g_{\sigma N}^4 \sigma^4 \\ &- \frac{1}{4}\omega_{\mu\nu}\omega^{\mu\nu} + \frac{1}{2} m_\omega^2 \omega_\mu \omega^\mu + \frac{1}{4!} \zeta g_\omega^4 (\omega_\mu \omega^\mu)^2 - \frac{1}{4}\rho_{\mu\nu}\rho^{\mu\nu} \\ &+ \frac{1}{2} m_\rho^2 \rho_\mu \rho^\mu + \frac{1}{2}\Lambda_v g_\omega^2 g_{\rho N}^2 \omega_\mu \omega^\mu \rho_\mu \rho^\mu + \frac{1}{2}(\partial_\mu \delta \partial^\mu \delta - m_\delta^2 \delta^2) \\ &+ \frac{1}{4} F_{\mu\nu} F^{\mu\nu} + \sum_{\ell=e,\mu} \overline{\Psi}_\ell (i\gamma^\mu \partial_\mu - M_\ell) \Psi_\ell \end{aligned} \quad (1)$$

The equation of motion for nucleons and mesons can be obtained by solving the standard Euler-Lagrange equation of motion [2, 5] as:

$$\partial_\mu \left(\frac{\partial \mathcal{L}}{\partial(\partial_\mu \phi)} \right) - \frac{\partial \mathcal{L}}{\partial \phi} = 0 \quad (2)$$

From Lagrangian density, one can also obtain energy-momentum ($\mathcal{T}^{\mu\nu}$) tensor, which can be used to find pressure ($\mathcal{P}$) and energy density ($\mathcal{E}$) [5]

$$\mathcal{T}^{\mu\nu} = \sum_{\phi_a} \frac{\partial \mathcal{L}}{\partial(\partial_\mu \phi_a)} \partial^\nu \phi_a - g^{\mu\nu} \mathcal{L} \quad (3)$$

$$\mathcal{P} = \frac{1}{3} \sum_{j=1}^{3} \left\langle \mathcal{T}^{jj} \right\rangle \quad (4)$$

$$\mathcal{E} = \left\langle \mathcal{T}^{00} \right\rangle \quad (5)$$

Results and Discussion

In the present work, we investigate the effect of neutron skin thickness of ^{208}Pb from PREX-II on nuclear matter and neutron star properties. To aim this, six sets of relativistic interactions named as S20, S22, S24, S26, S28 and S30 are generated by reproducing the ground state properties like binding energies, charge radii of some closed/open shell nuclei and simulatneously fitting the various values of neutron skin thickness (Δr_{np}) which range from 0.20 to 0.30 fm within PREX-II limits 0.283±0.071 fm in fiiting data used for model optimization. We use simmulated annealing

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Exploring Characteristics of NiO Nanoparticles using Sol-Gel Method

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ABSTRACT

In this article, production of nioxide nanopaticles and its lattice parameters are reported using sol-gel method. The structural & crystallite size studies were performed by utilizing X-ray diffraction. The identification of cubic structure of NiO nanocrystallite is ascertained. X-ray diffraction (XRD) results indicates that the crystallite size is in 20-30nm range with average size of 25nm, lattice parameter a= 4.175A^0 for cubic structure of NiO. Here NiO nanoparticles were annealed at temperature 700°C.

Keywords: nanoparticles, Precursor, zinc oxide, Sol-gel , X R D

1. Intoduction:

Nickel oxide is a chemical compound with the formula NiO. It is the principal oxide of nickel. It is classified as a basic metal oxide. Several million kilograms are produced annually of varying quality, mainly as an intermediate in the production of nickel alloys. The mineralogical form of NiO, bunsenite, is very rare. Other nickel oxides have been claimed, for example: Nickel (III) oxide (Ni_2O_3) and NiO_2, but they have yet to be proven by X-ray crystallography in bulk. Nickel (III) oxide nanoparticles have recently (2015) been characterized using powder X-ray diffraction and electron microscopy. It is an interesting material because of its chemical stability as well as optical electrical and magnetic properties. Its nanoparticles are used in electro chromic devices smart windows, optical fibres, gas sensors solar thermal absorbers, batteries, transparent conducting layers. Numerous techniques, such as chemical precipitation, magnetron sputtering, and sol-gel have been used to fabricate NiO nanoparticles. Among different techniques for controlled synthesis, sol-gel technique was used to synthesize crystalline and impurity free NiO nanoparticles.The nickel oxide has a history that dates back to 1899, when it was described in a German patent by **'Michalowski'**.[1-20]

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Exploring Characteristics of CuO Nanoparticles by Sol-Gel Method

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Abstract—**In this article, production of Copper oxide nanopaticles and its lattice parameters are reported using sol-gel method. The structural & crystallite size studies were performed by utilizing X-ray diffraction. The identification of monoclinic structure of CuO nanocrystallite is ascertained. X-ray diffraction (XRD) results indicates that the crystallite size is in 20-34nm range with average size of 27nm, lattice parameters are a = 3.735 A°, b = 3.415 A°, c = 5.9104 A° for monoclinic structure of CuO. Here CuO nanoparticles were annealed at temperature 700°C.**

Index Terms—**nanoparticles, Precursor, Copper oxide, Sol-gel, X R D**

I. INTODUCTION

CuO nanoparticle is a brownish black colored powder with a density of 6.3-6.4 g/cm^3 and a melting point of 1326°c. The particle size of CuO is calculated between 1 and 100nm. CuO is a p-type semiconductor with a narrow band gap of 1.4ev and has a monoclinic unit cell. CuO is an anti-ferromagnetic material. It is also exhibiting non-toxicity and excellent chemical stability. In addition, the high availability and low material cost make CuO a potential candidate for diverse applications including gas sensors, solar cell, lithium-ion batteries and field effect transistors Reports suggest that CuO can also be used as an efficient heterogeneous catalyst for reactions including C-N cross coupling of amines with halogenated benzene oxidation of alcohol and benzene to phenol oxidation and nitroarene reduction. There are reports on the fabrication of various nanoscale CuO possessing varying shapes and dimensions such as nanowires, nanosheets using various techniques. The properties of CuO vary strongly on going from bulk to the nanoscale and the properties influences strongly on size, morphology as well as the aspect ratio of the CuO nanostructure. CuO nanoparticles possess various significant properties and have diverse applications. CuO nanoparticles have been used as batteries, catalyst, and gas Sensors, high temperature superconductors and tools for solar energy conversion among others. Also, CuO has a well documented antimicrobial effect with efficiency against bacteria, yeast and fungi. Because of its biocidal and anti-viral properties, these nanoparticles are used as antimicrobial coatings in textile, wound dressings and plastics. Furthermore, CuO nanoparticles have shown anti cancer properties. However, many tests suggest that CuO nanoparticles are more toxic compared to other available metal-oxide nanoparticles. [1-10]

II. EXPERIMENTAL WORK

To synthesise CuO nanoparticles, 0.2M of copper acetate monohydrate and 0.2M of NaOH are weighed using a weighing balance. Then 50mL of distilled water is measured using a measuring cylinder for each sample. Both the copper acetate and NaOH are dissolved separately in 50ml of distilled water with constant stirring for about 30 minutes to ensure complete dissolution. The NaOH solution is then added to the copper acetate solution with constant stirring using a magnetic stirrer for about one hour. After that, a burette is filled with 100ml of polyvinyl alcohol (PVA) and titrated dropwise into the solution containing the copper acetate and NaOH, continuing the constant stirring. This process leads to the formation of gel from sol Fig.1. Then gel dried, and calcinated at about 700 degrees Celsius for 24 hours in a muffle furnace to produce copper oxide nanoparticle. [11-16]

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