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The Synthesis of Fingerprint Powder Using Curcumin-Loaded Magnesium Oxide Nanoparticles

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Abstract: Fluorescent nanoparticles have gained increasing importance in forensic and analytical science due to their high surface reactivity, optical properties and eco-friendly potential. Magnesium oxide nanoparticles functionalized with natural fluorophores represent a promising alternative to conventional synthetic fluorescent nano particles. The present study focused on the synthesis and characterization of curcumin-loaded magnesium oxide nanoparticles (Cur-MgO NPs) intended for potential application as a fluorescent fingerprint powder. The nanoparticles were synthesized using an alkaline precipitation method with magnesium nitrate hexahydrate [$Mg(NO_3)_2 \cdot 6H_2O$] as the magnesium precursor, sodium hydroxide (NaOH) as the precipitating agent, and curcumin as the organic fluorescent compound. Curcumin dissolved in ethanol was incorporated into the magnesium nitrate solution, followed by the dropwise addition of NaOH until pH 12 was reached. The synthesized nano particles were collected by centrifugation, washed with ethanol, and dried at 100°C.The synthesized nano particles was characterized using scanning electron microscopy (SEM) and energy-dispersive X-ray spectroscopy (EDS). The results provided morphological and elemental evidence for the formation of a Mg–O-containing nanostructured nano particles with an organic compound. Further characterization and fingerprint-development studies are required to evaluate its fluorescence behaviour and effectiveness for latent fingerprint visualization.

***Keywords*: MgO NPs, Curcumin loaded, Fluorescent Fingerprint Detection, SEM, EDS.**

I. INTRODUCTION

Nanostructured nano particles with characteristic dimensions in the range of 1–100 nm exhibit distinct physicochemical properties compared with their bulk counterparts due to their high specific surface area, increased surface energy, surface defects, and size-dependent physicochemical behaviour [1]. These characteristics significantly influence adsorption, surface reactivity, interfacial interactions, catalytic activity, and optical behaviour, enabling the application of nano particles in chemical sensing, environmental remediation, biomedical systems, catalysis, and forensic science [1]. The physicochemical properties of nanoparticles are primarily governed by their chemical composition, crystallinity, morphology, particles size, surface chemistry, and synthesis conditions. Among nanostructured nano particles, metal oxide nanoparticles have received considerable attention because of their structural stability, surface reactivity, and tuneable physicochemical properties [1], [2]. Among various metal oxide nano particles, magnesium oxide (MgO) nanoparticles have attracted significant interest because of their characteristic surface properties and physicochemical behaviour [2]. At the nanoscale, the increased surface-to-volume ratio and surface defect density can enhance adsorption and interfacial interactions [2]. MgO nanoparticles can be synthesized through various approaches, including sol–gel synthesis, hydrothermal synthesis, combustion methods, and chemical precipitation [1], [2]. Among these techniques, chemical co-precipitation is a comparatively simple and effective method for nanoparticles preparation [3]. Magnesium nitrate hexahydrate [$Mg(NO_3)_2 \cdot 6H_2O$] can be employed as a magnesium precursor, while sodium hydroxide (NaOH) acts as an alkaline precipitating agent [3]. Under alkaline conditions, Mg^{2+} ions interact with hydroxide ions (OH^-), resulting in the nucleation and precipitation of magnesium hydroxide species. The morphology and physicochemical characteristics of the resulting nanostructured nano particles can be influenced by parameters such as precursor concentration, pH, reaction conditions, mixing rate, purification, and thermal treatment. The incorporation of organic molecules into metal oxide nanostructures represents a potential approach for modifying their surface chemistry and functional properties. Curcumin, a naturally occurring polyphenolic compound derived from Curcuma longa, possesses phenolic hydroxyl groups and a β-diketone moiety. These oxygen-containing functional groups can participate in hydrogen bonding, adsorption, and coordination interactions with metal ions, including Mg^{2+} [5]. Curcumin has previously been incorporated into MgO-containing nano particles to produce organic–inorganic nanostructured systems [4], [6].

The incorporation of curcumin during the formation of magnesium-containing nanostructures may therefore modify their surface and optical characteristics. Nevertheless, appropriate physicochemical characterization is required to determine the crystalline phase, surface association of curcumin, morphology, elemental composition, and optical properties of the synthesized nanoparticles. Nanotechnology has also gained increasing importance in forensic fingerprint examination. Latent finger-mark residues are chemically heterogeneous and contain constituents originating primarily from eccrine and sebaceous secretions, including inorganic ions, amino acids, fatty acids, glycerides, and other organic compounds [7]. Powder-based latent fingerprint development primarily depends on the adhesion and physicochemical interaction of particulate nano particles with residual finger mark constituents [7], [8]. Consequently, properties such as particles morphology, particles dimensions, specific surface area, surface chemistry, and optical characteristics are important considerations in the development of fingerprint visualization nano particles. Nanostructured particles have been investigated as latent fingerprint developing agents because their surface properties may facilitate interaction with fingerprint residues [8]. Furthermore, fluorescent nano particles can enhance the contrast between developed ridge details and the substrate background when examined under appropriate excitation conditions [9], [10].

The combination of a magnesium-containing nanostructured nano particles with curcumin provides a scientific basis for investigating curcumin-loaded magnesium oxide nanoparticles (Cur-MgO NPs) as a prospective fluorescent latent finger-mark developing nano particles. Accordingly, the present study focuses on the synthesis of curcumin-loaded magnesium oxide nanoparticles through an alkaline precipitation approach, followed by their morphological characterization using scanning electron microscopy (SEM) and elemental characterization using energy-dispersive X-ray spectroscopy (EDS). Subsequent studies will evaluate the synthesized Cur-MgO Nano powder for latent finger mark development by assessing fluorescence response, ridge-detail visualization, contrast enhancement, and performance on different substrate surfaces. This approach is intended to establish a reproducible synthesis framework and provide preliminary physicochemical evidence before detailed evaluation of the nano particles as a fluorescent powder for forensic visualization of latent fingerprint ridge patterns applications.

II. MATERIALS AND METHODS

A. *Materials and Chemical Reagents*

Magnesium nitrate hexahydrate [$Mg(NO_3)_2 \cdot 6H_2O$], curcumin powder, sodium hydroxide (NaOH), ethanol, and distilled water. The major equipment used during the synthesis included an Ultrasonicator, Magnetic Stirrer, Centrifuge, Hot-Air Oven, Ph Indicator Paper.

B. *Preparation* of Precursor Solutions

1) *Preparation of Magnesium Nitrate Solution:* A solution was prepared by dissolving 1.6 g of magnesium nitrate hexahydrate [$Mg(NO_3)_2 \cdot 6H_2O$] in 250 mL of distilled water.
2) *Preparation of Curcumin Solution:* The solution was prepared by dissolving 6 mg of curcumin powder in 6 mL of ethanol. The mixture was subjected to ultrasonication until a clear and homogeneous solution was obtained, ensuring adequate dispersion of curcumin in the solvent.
3) *Preparation of Sodium Hydroxide Solution:* A 0.5 M NaOH solution was prepared by dissolving 2.0 g of sodium hydroxide pellets in 100 mL of distilled water.

C. *Synthesis* of Curcumin-Loaded Magnesium Oxide Nanoparticles

Curcumin-loaded magnesium oxide nanoparticles (Cur-MgO NPs) were synthesized using a precipitation-based method. Initially, the prepared curcumin solution was slowly added to 250 mL of the magnesium nitrate solution. The resulting mixture was stirred continuously using a magnetic stirrer at 500 rpm for 20 min to achieve uniform mixing. Subsequently, 0.5 M NaOH solution was added dropwise to the reaction mixture under continuous stirring. During the addition of NaOH, a gradual change in the color of the reaction mixture from yellow to reddish-brown was observed. The addition of NaOH was continued until the reaction mixture reached pH 12. Once the desired pH was attained, further addition of NaOH was discontinued. The reaction mixture was centrifuged at 10,000 rpm for 10 min to collect the nanoparticles. The supernatant was discarded, and the nanoparticles pellet was washed 2–3 times with ethanol to remove residual reactants, unbound curcumin, and impurities. The purified nanoparticles pellet was transferred to a suitable container and dried in a hot-air oven at 100°C until a constant weight was obtained.

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The resulting dried reddish-brown powder was designated as curcumin-loaded magnesium oxide nanoparticles (Cur-MgO NPs).

Fig. 1. Visual observations during the synthesis and recovery of curcumin-loaded magnesium oxide nanoparticles (Cur/MgO NPs): (a) reddish reaction mixture during alkaline precipitation under magnetic stirring, (b) formation of a dark-coloured pellet following centrifugation, and (c) dried reddish-brown solid obtained after purification and oven drying

TABLE I

POWDER TYPE	MAIN COMPOUNDS	PROPERTY
Black Powder	Carbon black/charcoal with carrier	Produces dark ridge contrast on light surfaces.
White Powder	Titanium dioxide or zinc oxide with carrier	Produces light ridge contrast on dark surfaces.
Bi-Chromatic Powder	Carbon black + aluminium particles	Provides contrast on both light and dark backgrounds.
Magnetic Powder	Iron-based particles + pigment	Applied using a magnetic wand, reducing direct brush contact with the fingerprint.
Fluorescent Powder	Fluorescent dye/pigment + carrier	Produces fluorescent ridge contrast under UV/ALS; useful on complex backgrounds.
Thermoplastic Powder	Synthetic polymers + pigments	Promotes interaction with fingerprint residues, particularly lipid-containing compounds.
Cur-MgO Powder	Curcumin + MgO-based nanostructured nano particles	Combines nanoscale surface properties of MgO with the optical properties of curcumin for potential fluorescent latent fingerprint visualization.

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Table 1 presents a comparison of commonly used latent fingerprint powders based on their main compounds and forensic applications. Conventional powders such as black, white, bi-chromatic, magnetic, fluorescent, and thermoplastic powders are designed to enhance fingerprint visibility under different surface and lighting conditions. In comparison, the proposed Cur-MgO powder, composed of curcumin-functionalized magnesium oxide nanostructures, combines the high surface area of MgO nanoparticles with the fluorescent properties of curcumin, offering enhanced potential for the visualization of latent fingerprints, particularly on complex and non-porous surfaces.

III.RESULTS

A. Morphological Characterization by SEM

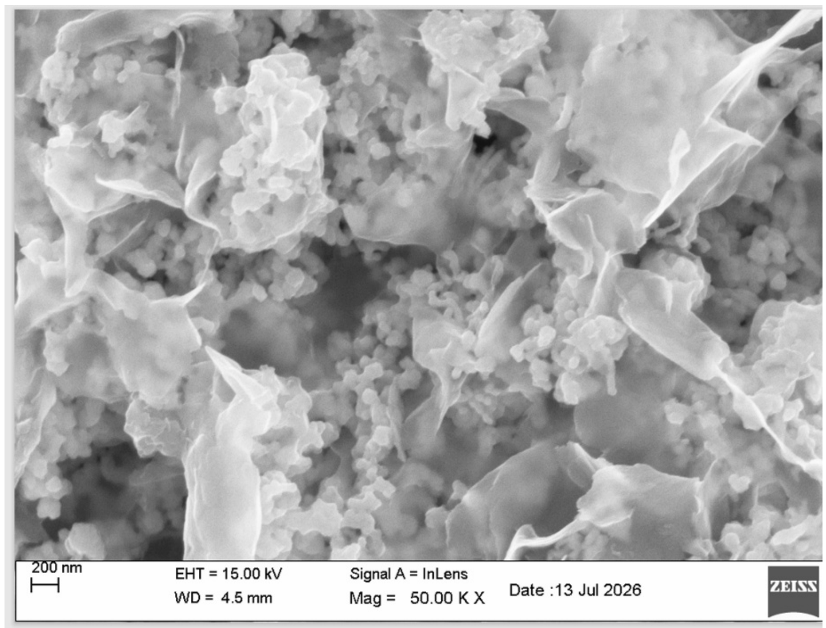
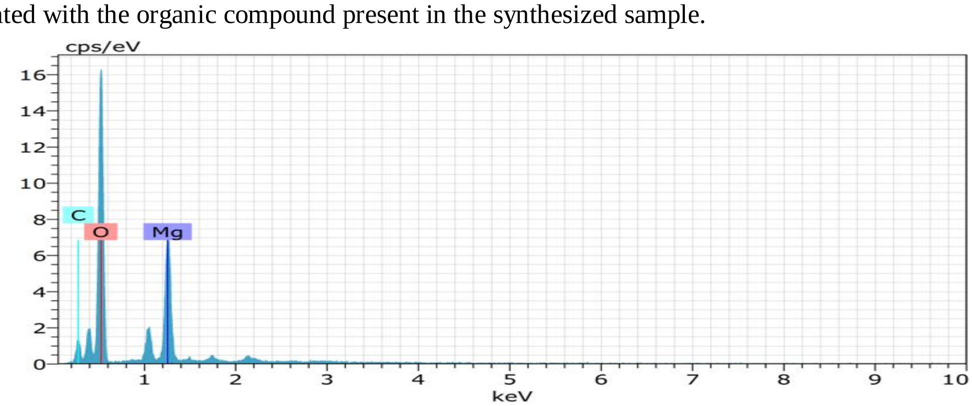


Fig. 2. SEM image of curcumin-loaded magnesium oxide nanoparticles (Cur/MgO NPs) at 50,000× magnification

SEM analysis was performed to examine the surface morphology of the synthesized curcumin-loaded magnesium oxide nanoparticles (Cur-MgO NPs). The SEM image at 50,000× magnification shows the presence of nanoscale particles with an irregular and agglomerated morphology. The particles appear clustered together, forming larger aggregates with non-uniform shapes.

B. Elemental Analysis by EDS

EDS analysis was performed to determine the elemental composition of the synthesized Cur-MgO NPs. The spectrum showed the presence of magnesium (Mg), oxygen (O), and carbon (C). The elemental composition was found to be 71.56 at. % O, 9.99 at. % Mg, and 18.45 at. % C. The presence of Mg and O is consistent with the magnesium–oxygen-based nano particles, while the carbon signal may be associated with the organic compound present in the synthesized sample.



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Spectrum: BM 6910

El	AN	Series	unn. C [wt.%]	norm. C [wt.%]	Atom. C [at.%]	Error (1 Sigma) [wt.%]
O	8	K-series	78.86	71.14	71.56	10.26
Mg	12	K-series	16.72	15.09	9.99	0.98
C	6	K-series	15.27	13.77	18.45	3.23
		Total:	110.84	100.00	100.00	

Fig. 3. EDS spectrum and elemental composition of curcumin-loaded magnesium oxide nanoparticles (Cur-MgO NPs)

IV. DISCUSSION

The morphological and elemental characteristics of the synthesized curcumin-loaded magnesium oxide (Cur-MgO) nanoparticles were evaluated using scanning electron microscopy (SEM) and energy-dispersive X-ray spectroscopy (EDS). SEM analysis at 50,000× magnification revealed an irregular and agglomerated morphology, characterized by fine-scale structures arranged as closely packed clusters. The observed agglomeration can be attributed to the high surface energy, inter-particles attractive forces, and particles association during post-synthesis processing.

EDS analysis revealed the presence of oxygen (71.56 at. %), carbon (18.45 at. %), and magnesium (9.99 at. %). The detection of Mg and O is consistent with a magnesium–oxygen-containing nanostructured phase, while the carbon signal is compatible with the presence of an organic compound within the analyzed nano particles. Collectively, the SEM and EDS findings demonstrate the agglomerated microstructural morphology and Mg–O–C elemental profile of the synthesized Cur-MgO nanoparticles.

Compared with conventional fingerprint powders, Cur-MgO NPs offer potential advantages by combining the surface characteristics of a nanostructured magnesium-containing nano particles with the optical properties of curcumin. Conventional black and white powders mainly depend on visible colour contrast, whereas fluorescent powders require suitable fluorescent compounds for visualization under UV or alternative light sources. Cur-MgO NPs are designed to provide both fine-scale surface interaction with fingerprint residues and fluorescence-based visualization. The nanostructured nano particles provide a high surface-to-volume ratio and surface-active sites, while curcumin acts as the organic fluorescent compound. This combination may improve ridge visibility and contrast, particularly under suitable excitation conditions.

Therefore, Cur-MgO NPs represent a promising alternative fluorescent fingerprint developing nano particles. However, superiority over conventional powders should be established through comparative fingerprint experiments involving ridge clarity, contrast, fluorescence response, substrate compatibility, and reproducibility. The current study establishes the morphological and elemental characteristics of the synthesized nano particles, while comparative fingerprint performance remains to be evaluated.

V. CONCLUSIONS

A curcumin-loaded magnesium oxide (Cur-MgO) nanoparticles was synthesized through an alkaline precipitation approach, followed by centrifugation, ethanol purification, and thermal drying. SEM characterization demonstrated an irregular, agglomerated fine-scale morphology, whereas EDS analysis established an elemental profile comprising Mg, O, and C. These findings provide morphological and elemental evidence supporting the formation of the synthesized Cur-MgO nanoparticles.

The integration of a magnesium-based nanostructured matrix with curcumin provides potential forensic relevance through the combination of surface-mediated interactions and fluorescence-related photophysical properties. The synthesized Cur-MgO nanoparticles therefore represent a promising candidate for fluorescence-assisted latent fingerprint visualization. Further characterization using FTIR, XRD, TEM, and fluorescence spectroscopy, together with evaluation of ridge-detail quality, fluorescence intensity, contrast, substrate compatibility, reproducibility, and comparative performance with conventional fingerprint powders, will provide comprehensive assessment of its forensic applicability.

REFERENCES

[1] N. Patil, R. Bhaskar, V. Vyavhare, R. Dhadge, V. Khaire, and Y. Patil, “Overview on methods of synthesis of nanoparticles,” International Journal of Current Pharmaceutical Research, vol. 13, no. 2, pp. 11–16, 2021.

[2] F. Mirza and H. Makwana, “Synthesis and characterization of magnesium oxide (MgO) nanoparticles by co-precipitation method,” International Journal of Innovative Research in Technology, vol. 8, no. 6, pp. 436–441, 2021.

[3] G. Swathi, G. Rajasekhara Reddy, M. Rajesh, M. Venkataswamy, B. Deva Prasad Raju, and N. John Sushma, “Synthesis and characterization of curcumin loaded magnesium oxide nanoparticles: pH dependent in vitro release behavior of loaded curcumin and its antioxidant activity,” International Journal of Scientific & Technology Research, vol. 9, no. 2, pp. 3748–3753, 2020.

[4] P. Peni, R. Sasri, and I. H. Silalahi, “Synthesis of metal–curcumin complex compounds (M = Na^+, Mg^{2+}, Cu^{2+}),” Jurnal Kimia Sains dan Aplikasi, vol. 23, no. 3, pp. 75–82, 2020.

[5] N. Sarkar, S. Bose, and A. Mitra, “In vivo and in vitro properties evaluation of curcumin loaded MgO doped 3D printed TCP scaffolds,” Journal of Nano particles Chemistry B, vol. 11, no. 21, pp. 4725–4738, 2023.

[6] R. S. Croxton, S. M. Bleay, and M. De Puit, “Composition and properties of fingermarks,” in Fingerprint Development Techniques: Theory and Application. Wiley-Blackwell, 2018, pp. 35–68.

[7] A. A. Ansari, K. M. Aldajani, A. N. AlHazaa, and H. A. Albrithen, “Recent progress of fluorescent nano particles for fingerprint detection in forensic science and anti-counterfeiting,” Coordination Chemistry Reviews, vol. 462, Art. no. 214523, 2022.

[8] P. Rasin, V. S. Kumar, K. M. Malappuram, and A. Sreekanth, “Fluorescent nano particles for latent fingerprint detection,” Current Analytical Chemistry, vol. 19, no. 10, pp. 693–703, 2023.

[9] M. Younis, S. A. Khan, and B. Ahmad, “Magnesium oxide (MgO) nanoparticles: Synthetic strategies and biomedical applications,” Crystals, vol. 14, no. 3, Art. no. 215, 2024.

[10] Zhao, X., Liu, Y., & Zhang, H. (2025). A pH-responsive soy flour–montmorillonite–magnesium oxide complex for controlled release of curcumin in antidiabetic therapy. Discover Chemistry, 8(1), Article 14. doi.org.