

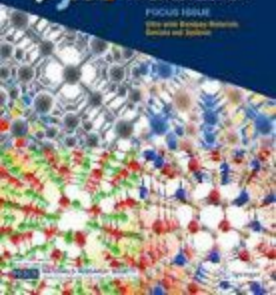


jmr

Journal of
MATERIALS RESEARCH

FOCUS ISSUE

**High and Low-Dimensional
Structures and Interfaces**




Volume 25, Number 10, October 2013

ISSN 0898-0157



In situ tailoring of carbon dots-metal ferrite nanohybrid as multipurpose marker agent of HeLa cancer cells

Siti Febtria Asrini Sugito^{1,2}, Fakhri Firdaus^{1,2}, Yu Aung^{1,2}, Satya Candra Wibawa Sakti^{1,2}, Hsien-Tai Chiu^{1,2}, Mochamad Zakki Fahmi^{1,2,a)} 

¹Department of Chemistry, Supramodification Nano-micro Engineering Research Group, Universitas Airlangga, Surabaya 60115, Indonesia

²Hsien-Tai Department of Chemistry, National Cheng Kung University, Tainan City 701, Taiwan

^{a)}Address all correspondence to this author. e-mail: m.zakki.fahmi@fst.unair.ac.id

Received: 4 March 2022; accepted: 23 May 2022

The development of multifunction material was considered to attain effectiveness on cancer treatment. The present study pursues the potential application of metal ferrite nanoparticles covered with CDs to get dual-active nanomaterial on fluorescent and magnetic responses that were prepared on a one-pot solvothermal method. Some analyses indicated the nanohybrids consisted of amorphous structure. Besides, the optical analysis performed optimum emission with QY percentage up to 0.9 and 0.6, respectively. Magnetic response assessment confirmed CDs@MnFe₂O₄-15 has good superparamagnetic properties with saturation magnetization value of 38.485 emu/g, while CDs@CuFe₂O₄-15 at 9.5245 emu/g. The DLS measurement showed an average size of CDs@MnFe₂O₄-45 at 63.98 nm, while CDs@CuFe₂O₄-45 at 55.46 nm. Then, this nanosized drive to perform good photoluminescent properties and good cytotoxicity due to the nanohybrids of CDs@MnFe₂O₄-45 can easily enter the HeLa cells without harming its original structure. The above finding has well-proven good clinical potency of the nanohybrid as simultaneous fluorescent and magnetic-based detection.

Abbreviations

CDs	Carbon dots
MNPs	Magnetic nanoparticles
CDs-MNPs	Nanohybrid of carbon dots with magnetic nanoparticles
CDs@MnFe ₂ O ₄	Nanohybrid of carbon dots with manganese ferrite oxide
CDs@CuFe ₂ O ₄	Nanohybrid of carbon dots with copper ferrite oxide
Gd-TPA	Gadolinium-diethylenetriamine pentaacetic acid
MRI	Magnetic resonance imaging
QY	Quantum yield
Ms	Magnetization size

Introduction

The necessity on early detection was essential to reduce the prevalence of cancer. Clinically, diagnostic tests prefer to visualize stronger contrasts of tissues and organs imagined by MRI (Magnetic Resonance Imaging) [1, 2]. MRI technology as a

non-invasive methodology has been an essential and valuable imaging technique in the field of biomedical applications that can minimize misdiagnosis of various medical conditions [3, 4]. Despite the excellent imaging of MRI, the role of the contrast agent is necessary, it has been the important element that needs to be marked to improve the sensitivity for the detection of injuries [5]. Commonly, Gd-DTPA (Gadolinium-Diethylene Triamine Pentaacetic Acid) is widely used as MRI contrast to enhance the signal of the aim tissues and body structures [6, 7].

MRI contrast agents have a core based on paramagnetic metal with a possibly outer coating from a biocompatible material and divided into T₁ and T₂ of enhancement mechanism. T₁ contrast agents are usually paramagnetic complexes with the process that can be accelerated to produce brighter T₁-weighted images [7, 8]. It is preferred for clinical diagnosis because the signal on MRI images is bright [9]. T₂ contrast agents are based on iron oxide nanoparticles, which are superparamagnetic [7]. The magnetic field accelerates the process of dephasing the nuclear spin of photons to disrupt the local magnet and produce a darker image [5, 9].

Gd-DTPA is a very great paramagnetic complex with high complex stability, low toxicity, and readily distributed to water

[10]. Despite the advantages of Gd-DTPA as an MRI contrast agent, Gd-DTPA has an unclear effect on the endocytosis process and Gd may exist in a free state with high toxicity when the complexing process is neglected [11, 12]. On the other hand, the cost of importing Gd-DTPA compound is relatively high that causing the diagnosis using MRI is valuable.

The metal ferrite nanoparticle MFe_2O_4 ($M = Mn, Co, Ni$, etc.) are magnetic compound nanoparticles that are primarily used for in-vivo and non-invasive applications to detect clinically important biological targets as highly sensitive [13–17]. One of the reasons for using magnetic nanoparticles as a marker required for contrast agents is the magnetism that can be used as a cellular target through external magnetic fields [18]. The particular physical and chemical characteristics of magnetic nanoparticles present them as fitting materials for biomedical research. Pharmaceutical chemistry and biomedical research have shown that magnetic nanoparticles exhibit magnetic properties at room temperature and are very useful [19].

Metal ferrite nanoparticle MFe_2O_4 synthesized via hydrolysis or non-hydrolysis approach showed superior magnetism and were used as an ultrasensitive as T_1 MRI contrast agent [20–22]. Nanoparticles play an important role in the magnetization of MRI contrast agents, but the image fluoresces insufficiently than the fluorescence of CDs. As demonstrated by MRI studies, coating magnetic nanoparticles with CDs revealed higher fluorescence images compared to magnetic nanoparticles [18, 23]. The CDs are attracting attention in the field of fluorescent sensors because of their great water solubility, excellent photostability, low toxicity, and superior biocompatibility [24–26]. This has led many researchers to use CDs as marker agents, biosensing, bioimaging, and drug delivery in medical field [27, 28].

Despite the numerous studies on CDs synthesis and its application in the imaging fields, research on CDs from ethanolamine is still lacking. In addition, some researchers have succeeded in synthesizing CDs from ethanolamine, showing good fluorescence results. Ethanolamine is suitable as a carbon source on N-doped CDs due to its abundant amino and hydroxyl groups [29]. Herein, high yields of CDs ethanolamine were successfully synthesized using a pyrolysis approach [29–31]. Further development of the previous synthesis led to the adoption hydrothermal approach that exhibits good dispersion stability in water and blue fluorescence emission [29].

The synthesis of CDs can be easily divided into a top-down and a bottom-up approach [24]. The bottom-up approaches link the fluorescence properties, by carefully designing molecular precursor structure and manufacturing process, it is an inducement to customize the CDs with well-defined size, variable surface state, and internal structure [29, 32]. On the other hand, top-down approaches are usually difficult to control the particle size, surface, and internal structure [29, 33]. The bottom-up

methods of synthesis CDs can be further divided into hydrothermal, ultrasonication, microwaves, pyrolysis, and chemical thermal [34].

Furthermore, as precursors of CDs in metal ferrite nanoparticles are used for detection, the potential fluorescence of ethanolamine has been reported [31]. The properties of CDs ethanolamine provide high stability, abundant yields, and good solubility upon the water [35]. Despite the various advantages, the application of CDs ethanolamine has minimal reported use in the medical field. Researches on CDs synthesis are crucial for expanding the application of CDs in the sensing and imaging field [29]. It has been attempted to use magnetic nanoparticles and CDs as marker agents to defeat the problems of expensive precursors and emission loss, which are major factors in MRI contrast agents. No one has proposed the in-situ solvothermal approach of the nanohybrid using the two kinds of combination, mostly multisets, composites, and derivatives of the original properties of each nanoparticle.

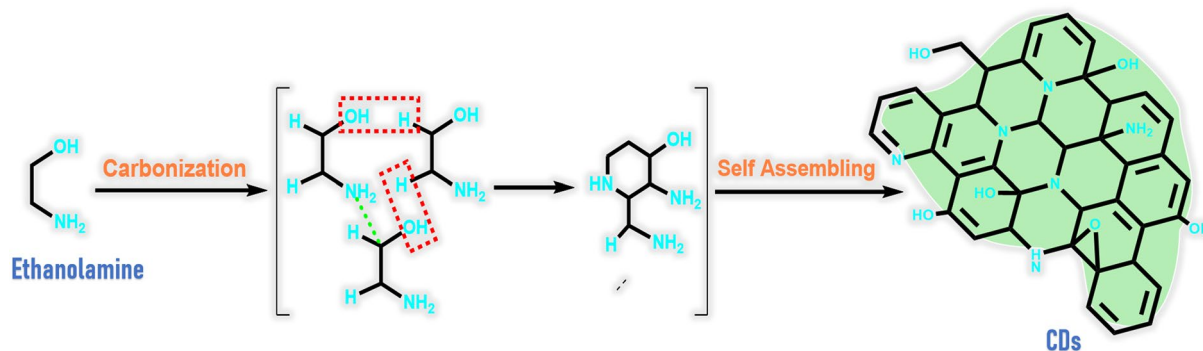
In this study, we improve the synthesis of nanohybrid from metal ferrite nanoparticle and CDs ethanolamine and compare the metal Cu and Mn potential application as contrast agents in MRI. Of the various metal ferrite, the metals Mn and Cu ferrites are less toxic than other ferritic metals, so their potential is valuable and secure in medical applications [18]. The solvothermal approach is chosen because the yields are petite and distributed consistently. Therefore, the application of nanohybrid to cancer has become a pressing priority to observe cancer as a global disease that is still attracting global attention [36]. As a result, studies in toxicity and in-vitro assays of HeLa tumor cells were conducted to confirm that the nanohybrid could potentially be used as a simultaneous marker.

Result and discussion

Characterization of nanohybrids

The synthesis of the nanohybrid combines individual processes MFe_2O_4 and CDs. In particular, the synthesis of CDs initiated the rearrangement of ethanolamine at high temperatures. This treatment allows the molecule to form CDs with a graphene oxide-like structure in dehydration and carbonization, as shown in Scheme 1. This mechanism has the advantage that the process of reaching the high quality of CDs is simple.

During CDs@ MFe_2O_4 synthesis, Mn and Cu elements were selected as the significant components in producing metal ferrite. The interaction of $Mn(acac)_2-Fe(acac)_3$ produced $MnFe_2O_4$, and interaction of $Cu(acac)_2-Fe(acac)_3$ produced $CuFe_2O_4$ by the solvothermal process. In contrast, oleylamine was used as a ligand for magnetic nanoparticles to stabilize and produce hydrophobicity [37]. This study performed CDs

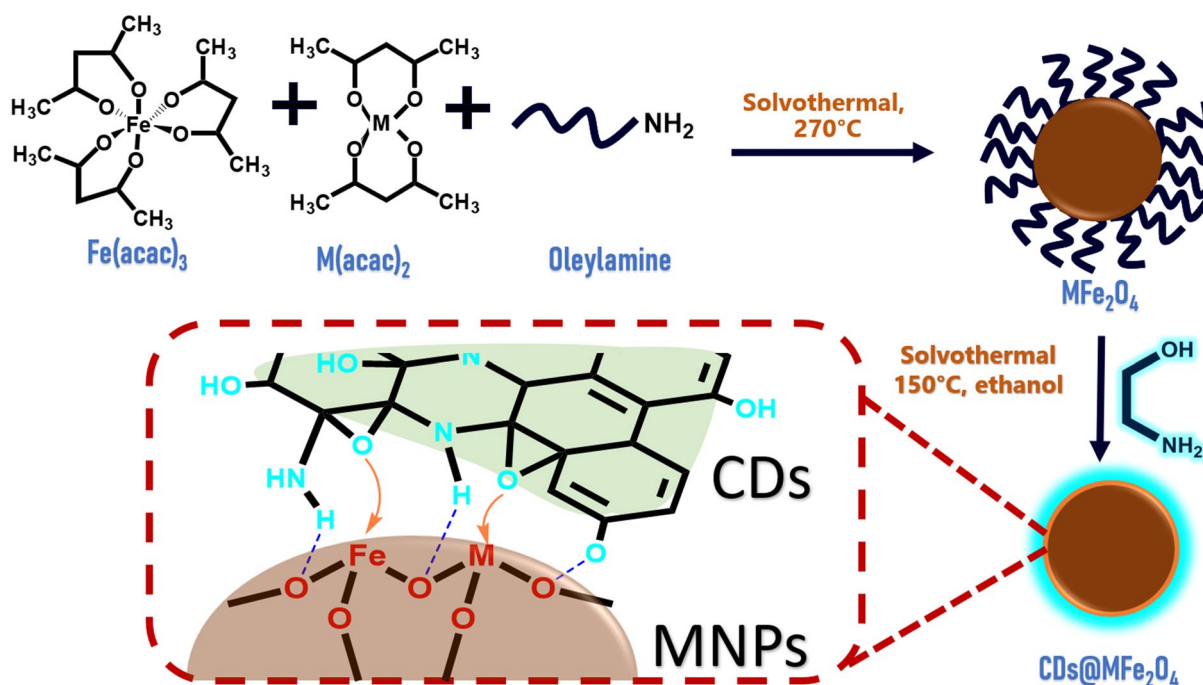


Scheme 1: Schematic illustration of ethanolamine self-assembling to form CDs.

synthesis using high temperatures called the solvothermal process shown in Scheme 2. After adding ethanolamine at 150 °C under the assumption that the reaction of Scheme 1. occurs, MFe_2O_4 covered with CDs is formed in this process as $CDs@MFe_2O_4$ nanohybrid. Therefore, nanohybrids can exhibit the optical properties of CDs and can have the ability to be magnetically induced due to the presence of magnetic nanoparticles with superparamagnetic properties [38].

$CDs@MFe_2O_4$ characterization is an essential part of demonstrating the successful nanohybrid synthesis process. Spectroscopy analysis was first to run to access the optical properties of the nanohybrid. Indeed, $CDs@MFe_2O_4$ served to elucidate the optical properties of nanohybrid. To prove the assumption, this study utilized UV-Vis

absorption by varying the concentration of ethanolamine, as shown in Fig. 1. The spectrum showed that the maximum wavelengths of $CDs@MnFe_2O_4$ were 221 nm and 261 nm, $CDs@MnFe_2O_4-15$ was 259.6 nm, $CDs@MnFe_2O_4-30$ was 246.4 nm, and $CDs@MnFe_2O_4-45$ was 259.4 nm. However, the maximum wavelength of $CDs@CuFe_2O_4-15$ was 268 nm, $CDs@CuFe_2O_4-30$ was 270 nm, and $CDs@CuFe_2O_4-45$ was 272 nm. CDs absorbance peak showed an electron transition $\pi \rightarrow \pi^*$ as a core and an electron transition $n \rightarrow \pi^*$ as a surface state. $CDs@MnFe_2O_4-30$ and $CDs@CuFe_2O_4-45$ spectrum showed the highest absorbance with λ_{max} of 246.4 nm and 272 nm. This maximum wavelength implies an electron transition $\pi \rightarrow \pi^*$ C=C aromatic groups within the nucleus of CDs [39].



Scheme 2: Schematic illustration on synthesis mechanism of $CDs@MFe_2O_4$.

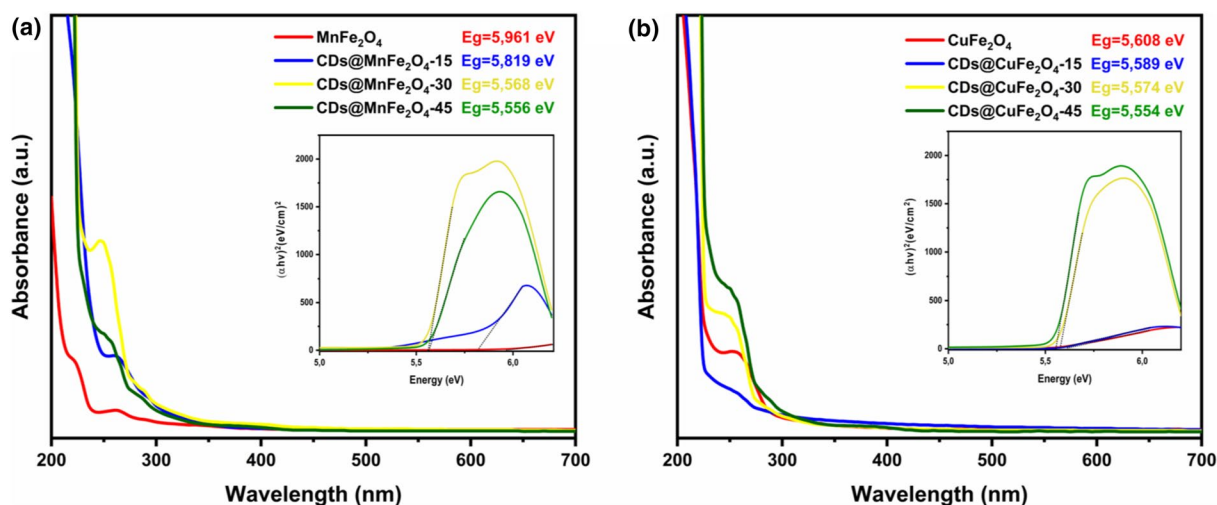


Figure 1: UV-Vis spectra of (a) CDs@MnFe₂O₄ and (b) CDs@CuFe₂O₄. Inset: the Tauc plot of each spectrum.

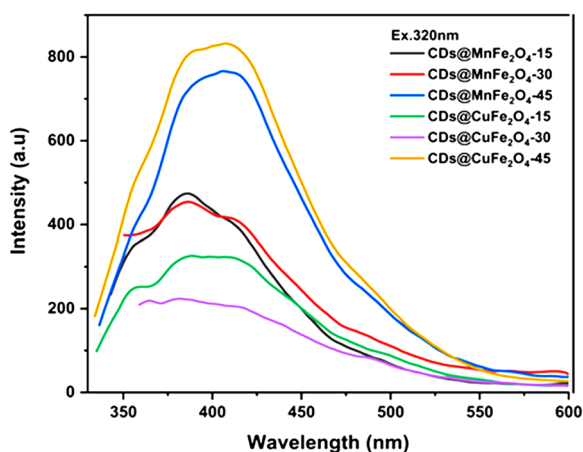


Figure 2: PL spectra of CDs@MnFe₂O₄-15, CDs@CuFe₂O₄-15, CDs@MnFe₂O₄-30, CDs@CuFe₂O₄-30, CDs@MnFe₂O₄-45, and CDs@CuFe₂O₄-45.

Further, in emission observation, the effects of various ethanolamine on nano hybrids can be accessed by photoluminescent instruments. Figure 2 showed the emission characteristics of nano hybrid CDs at excitation wavelengths of 320 nm. One of the characteristics of CDs is emission variation at specific wavelengths called excitation-dependent emission. Traps are known as defective due to an oxygenated group of CDs [40]. The existence of excitation-dependent emission occurs because the electron orbitals of the CDs are various, and emission will change regardless of the energy absorbed by the CDs. Different emission variations are caused by several factors, such as the structure of the CDs formation. In addition, increasing the concentration of ethanolamine in the nano hybrids will increase the emission of the formed nano hybrid. In particular, samples of CDs@MnFe₂O₄, CDs@MnFe₂O₄-15, CDs@MnFe₂O₄-30, and CDs@MnFe₂O₄-45 were analyzed at excitation wavelengths of

320, 340, 360, 380, 400, and 420 nm, which has the highest intensity at the emission wavelength (λ_{em}) of 320 nm. CDs@MnFe₂O₄-15 and CDs@MnFe₂O₄-30 spectra could fluoresce at a wavelength of 386 nm, and CDs@MnFe₂O₄-45 fluoresce higher at 406 nm, while CDs@CuFe₂O₄-15 had the highest intensity at the emission wavelength (λ_{em}) of 410 nm. The relative quantum yields (QY) of MnFe₂O₄ in CDs@MnFe₂O₄-15, CDs@MnFe₂O₄-30, and CDs@MnFe₂O₄-45 were 0.462%, 0.118%, and 0.9%, respectively. CDs@CuFe₂O₄-15, CDs@CuFe₂O₄-30, and CDs@CuFe₂O₄-45 showed that the QY of CuFe₂O₄ was 0.60%, 0.27%, and 0.005%. This indicates that the best fluorescent ability is CDs@MnFe₂O₄-45 and CDs@CuFe₂O₄-45 containing 45 mL ethanolamine. According to the study results, the addition of ethanolamine leads to an increase in the aggregation of ethanolamine during the formation of CDs. Therefore, graphene oxide is more likely to be formed. Copper increases the interaction between CDs and ethanolamine in CuFe₂O₄, which can destroy the original structure of copper itself. It happened because Copper has a higher binding affinity against the organic matter. Thus, aggregations may become high, which it can interfere with the absorbance tracing of CDs by UV-Vis spectroscopy and affect the QY values. To improve above results in which to evaluate contribution of CDs on featuring the optical properties, the observation potential band gap of the nano hybrids Fig. 1. Addition of ethanolamine result in increasing CDs area on nano hybrid that drive to decreasing band gap energy of bare metal ferrite (above 5.6 eV in average) to light area (below than 3.1 eV). CDs overs addition electronic orbital level in the metal ferrite smoothing photoluminescence process.

The FTIR analysis was performed to ensure the nano hybrids design structure of MnFe₂O₄-based and CuFe₂O₄-based nanoparticles shown in Fig. 3. The data specifically showed

the MnFe_2O_4 band at 586.6 cm^{-1} and 410.40 cm^{-1} , while the specific band at 644.22 cm^{-1} in both nanohybrid referred to the metal-oxide absorption [41]. In addition, oleylamine compounds were displayed in several wavenumbers, such as 2928.29 cm^{-1} for CH vibration and 1441.64 cm^{-1} for CN vibration [42]. Both nanohybrids revealed the existence of ethanolamine CDs at each specific band OH at over 3000 cm^{-1} and NH at 1579 cm^{-1} [43]. Therefore, these FTIR data clearly showed that all nanohybrids were composed of a combination of MnFe_2O_4 , CuFe_2O_4 oleylamine, and ethanolamine nanoparticles.

The nanohybrid size distribution was further using Dynamic Light Scattering (DLS). The diagram and the graph in Fig. 4 show the average size and zeta potential. The average

size of DLS was determined using the Polydispersity Index (PDI) parameter. The results indicated that the average size of MnFe_2O_4 , $\text{CDs@MnFe}_2\text{O}_4\text{-15}$, $\text{CDs@MnFe}_2\text{O}_4\text{-30}$, and $\text{CDs@MnFe}_2\text{O}_4\text{-45}$ nanoparticles were 463.1 nm, 195.7 nm, 99.55 nm, and 63.98 nm, while the average size of CuFe_2O_4 , $\text{CDs@CuFe}_2\text{O}_4\text{-15}$, $\text{CDs@CuFe}_2\text{O}_4\text{-30}$, and $\text{CDs@CuFe}_2\text{O}_4\text{-45}$ were 37.84 nm, 45.06 nm, 46.41 nm, and 55.46 nm. Excessive carbonation caused the nanoparticles to be aggregated, thereby forming large particles such as graphene oxide. Therefore, the role of temperature and time in the synthesis process was crucial for particle size control. The zeta potential values of MnFe_2O_4 , $\text{CDs@MnFe}_2\text{O}_4\text{-15}$, $\text{CDs@MnFe}_2\text{O}_4\text{-30}$, and $\text{CDs@MnFe}_2\text{O}_4\text{-45}$ were -0.3635 mV , 0.163 mV , 3.57 mV , and -0.499 mV , while the values of CuFe_2O_4 , $\text{CDs@CuFe}_2\text{O}_4\text{-15}$,

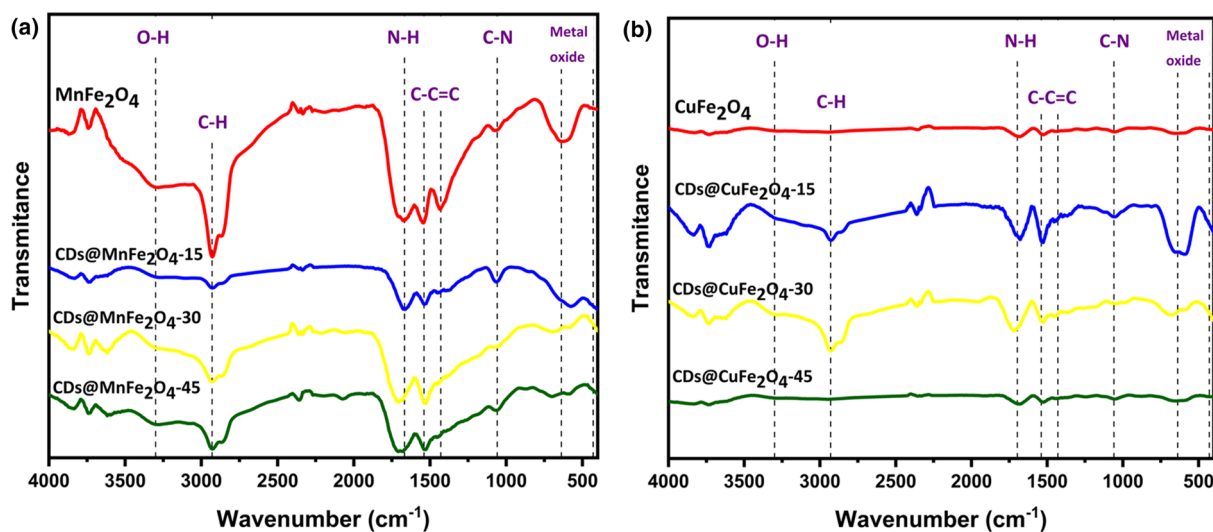


Figure 3: FTIR spectra of (a) $\text{CDs@MnFe}_2\text{O}_4$, $\text{CDs@MnFe}_2\text{O}_4\text{-15}$, $\text{CDs@MnFe}_2\text{O}_4\text{-30}$, and $\text{CDs@MnFe}_2\text{O}_4\text{-45}$; (b) $\text{CDs@CuFe}_2\text{O}_4$, $\text{CDs@CuFe}_2\text{O}_4\text{-15}$, $\text{CDs@CuFe}_2\text{O}_4\text{-30}$, and $\text{CDs@CuFe}_2\text{O}_4\text{-45}$.

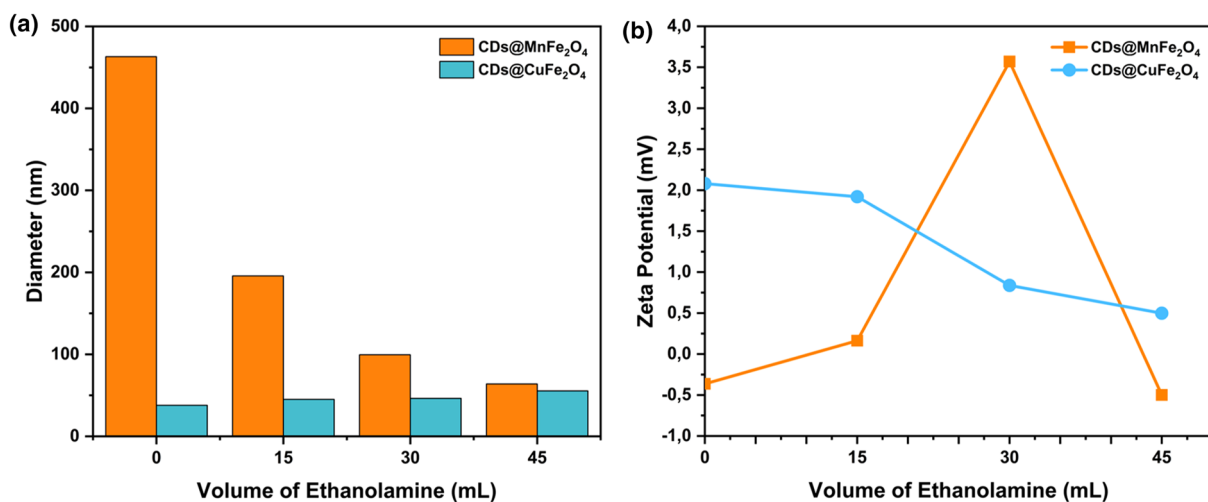


Figure 4: (a) DLS diagram of $\text{CDs@MnFe}_2\text{O}_4\text{-15}$ and $\text{CDs@CuFe}_2\text{O}_4\text{-15}$ and (b) Zeta potential graph of $\text{CDs@MnFe}_2\text{O}_4\text{-15}$ and $\text{CDs@CuFe}_2\text{O}_4\text{-15}$.

CDs@CuFe₂O₄-30, and CDs@CuFe₂O₄-45 were 2.08 mV, 1.92 mV, 0.838 mV, and 0.498 mV. Ethanolamine contains NH₂, increasing the potential zeta's value of nanoparticles [44]. MnFe₂O₄ and CDs@MnFe₂O₄-45 gave negative values due to the adsorption of OH ions or fats such as fatty amines and carboxyl groups on the surface of nanoparticles [37, 45]. Based on the DLS data, the smaller size of nanoparticle implied the bigger effectiveness as contrast agent application. The selected nanohybrids CDs@MnFe₂O₄-45 were considered having the best properties as simultaneous marker and needed further analyses in toxicity assessment for clinical properties.

XRD analysis was used to determine the crystal structures and purity of the materials in solid. When the crystalline size was small, the diffraction peaks became wider because the small crystalline had a large X-ray reflection field [46]. Based on JCPDS 74-2403, MnFe₂O₄ had several 2θ peaks located at 29.6°, 34.9°, 42.4°, 52.6°, 56.1°, and 61.5°, while the JCPDS 010-0173 of CuFe₂O₄ had several 2θ peaks at 30.32°, 35.76°, and 57.36°. The enlarged the broad peak indicated the presence of CDs at 2θ of 19.20° as an amorphous structure of nanoparticles carbon leads caused by the loss of water molecules and material decomposition during the synthesis process [47].

CDs@MnFe₂O₄-15 had peaks at 35.13°, 42.78°, 56.14°, and 62.19°. CDs@MnFe₂O₄-30 had a broad peak of 2θ at 17.75°, which CDs@MnFe₂O₄-15 and CDs@MnFe₂O₄-45 did not have. The broadest peaks were owned by CDs, while the other peaks were 29.61°, 34.10°, 42.44°, 56.24°, and 61.79°. The diffractogram of CDs@MnFe₂O₄-45 had two peaks at 29.46° and 35.02°. These diffractograms are shown in Fig. 5.

The VSM was used to analyze the magnetic properties of a solid sample using a magnetic field in the range of -8 to +8 kOe. The graph of CDs@MnFe₂O₄-15 had a saturated magnetization

value (M_s) at 38,485 emu/g with a coercivity value at 1.0975 G, and the M_s of CDs@CuFe₂O₄-15 was 9,5245 emu/g with a coercivity value at 92,768 G that is shown in Fig. 6. The superparamagnetic shape had a specific magnetization value of 92 emu/g [48]. It concluded that CDs@MnFe₂O₄-15 was classified as coated superparamagnetic because the magnetization is lower than the uncoated particles. This lowering is due to the smaller size of the coated particles and the ethanolamine as CDs was present on the surface of the particles.

Cytotoxicity assessment

The cytotoxicity test was used to determine the toxicity of a liquid sample by HeLa cells in-vitro. The principle of the MTT

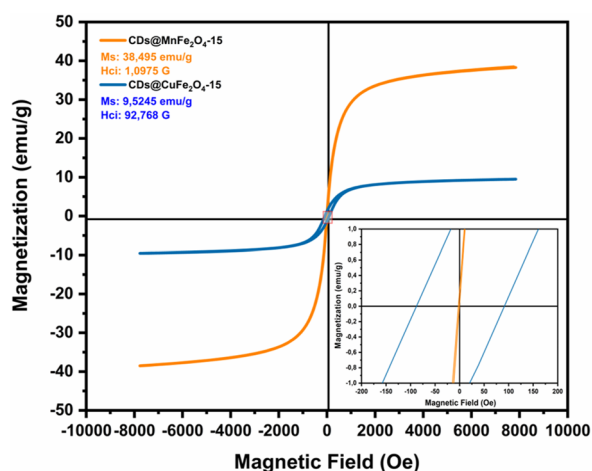


Figure 6: VSM spectra of CDs@MnFe₂O₄-15 and CDs@CuFe₂O₄-15. Inset: high magnification on adjusted area.

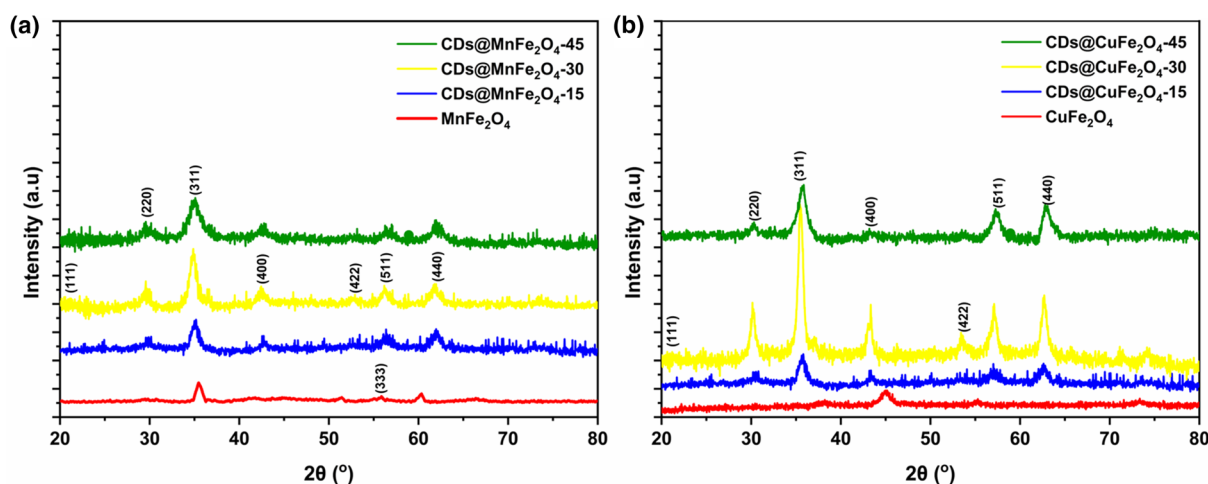


Figure 5: XRD diffractogram of (a) CDs@MnFe₂O₄, CDs@MnFe₂O₄-15, CDs@MnFe₂O₄-30, and CDs@MnFe₂O₄-45; (b) CDs@CuFe₂O₄, CDs@CuFe₂O₄-15, CDs@CuFe₂O₄-30, and CDs@CuFe₂O₄-45.

Assay method was reducing MTT salt (3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide) by dehydrogenation succinate enzyme in the mitochondria to form formazan. If the purple concentration produced was high, the toxicity level was low [49]. Materials with 80% or more cell viability at high concentrations were classified as non-toxic materials [43].

CDs@MnFe₂O₄-45 and CDs@CuFe₂O₄-45 had a high percentage of viability that was almost 90%, despite concentrations of up to 250 µg/mL caused by the preparation process. The preparation was carried out based on statistics, so the number of cells in the well was not precise. The percentage of cell viability at concentrations of 7.5, 15.5, and 31.5 µg/mL exceeded the control, and is shown in Fig. 7. CDs@MnFe₂O₄-45 and CDs@CuFe₂O₄-45 did not cause the decreased viability and drive evidence that the CDs on MnFe₂O₄ and CuFe₂O₄ nanoparticles will not harm cells [50].

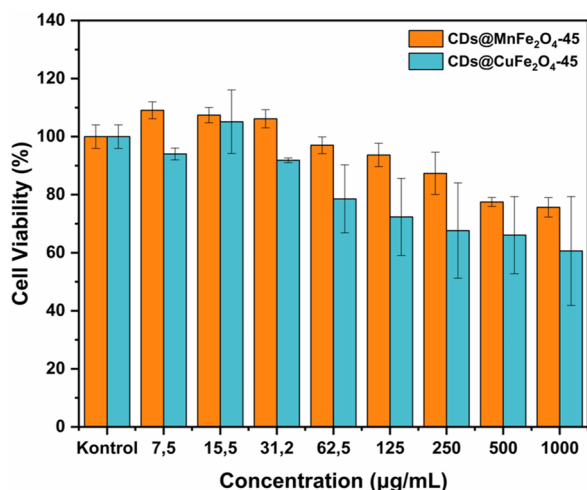


Figure 7: The viability percentage of HeLa cell on varying concentrations (7.50–1000 µg/mL) of CDs@MnFe₂O₄-45 and CDs@CuFe₂O₄-45.

Confocal laser scanning microscopy (CLSM)

CLSM is a method to analyze the internalization of CDs in HeLa cells, expressed by fluorescence intensity. In order to determine the location of the cell nucleus, it was necessary to add 4'6-diamino-2-phenylindol (DAPI) as a marker to produce a blue color [51].

Based on the results of the CLSM analysis, Fig. 8 shows that the NH₂ and -OH groups on CDs produced intracellular uptake through endocytosis of the folate receptors, because they were similar to the folate receptors. The internalization of CDs into the cytoplasm showed green fluorescence, indicating that CDs have entered the cell through endocytosis [50]. In addition, the role of DAPI in PBS (Phosphate Buffer Saline) was a control for determining the number and location of viable cells by staining, thereby showing blue fluorescence [52]. CLSM test results proved that CDs@MnFe₂O₄ and CDs@CuFe₂O₄ had good fluorescence and can be applied as candidates for simultaneous marker. Figure 8 shows the internalization of CDs into the HeLa cytoplasm of cells.

MRI imaging

MRI analysis was performed to assess the ability of the sample CDs@MnFe₂O₄ and CDs@CuFe₂O₄ to serve as a contrast agent. An active ingredient contrast will help in the longitudinal relaxation of water molecules by giving a positive signal effect, increasing the intensity of the T1-weighted image [37]. In this research, the analysis was assigned only to produce a T1-weighted image of nanohybrid samples, the results of which are shown in Fig. 9.

The pictures identify the contrast increase by increasing sample concentration, confirming that positive contrast enhancement depends on the sample concentration analyzed by magnetic nanoparticles [53]. However, at the highest concentration, the contrast in the CDs@MnFe₂O₄ and CDs@CuFe₂O₄ decreased due to the ethanolamine encapsulation covering the

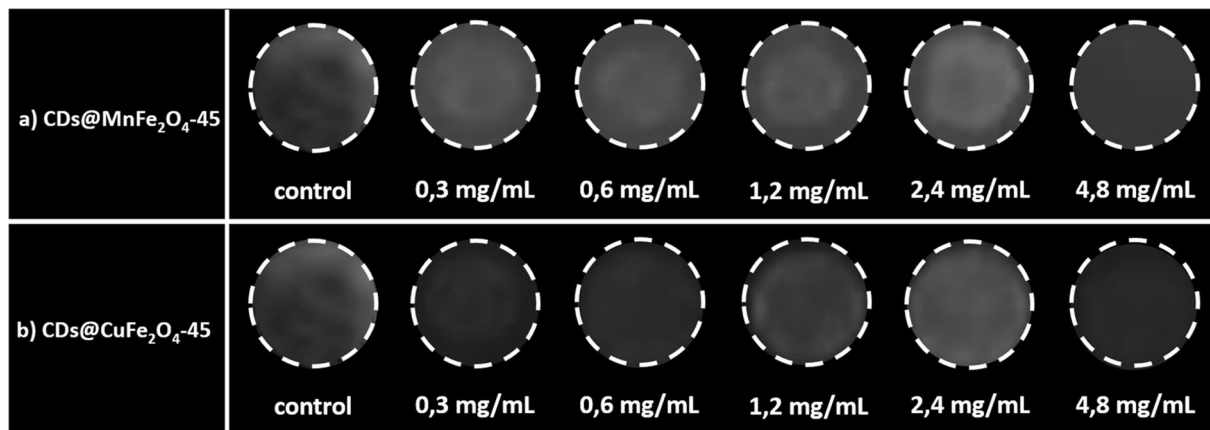


Figure 8: MRI images of (a) CDs@MnFe₂O₄ and (b) CDs@CuFe₂O₄ on varied nanohybrid concentrations.

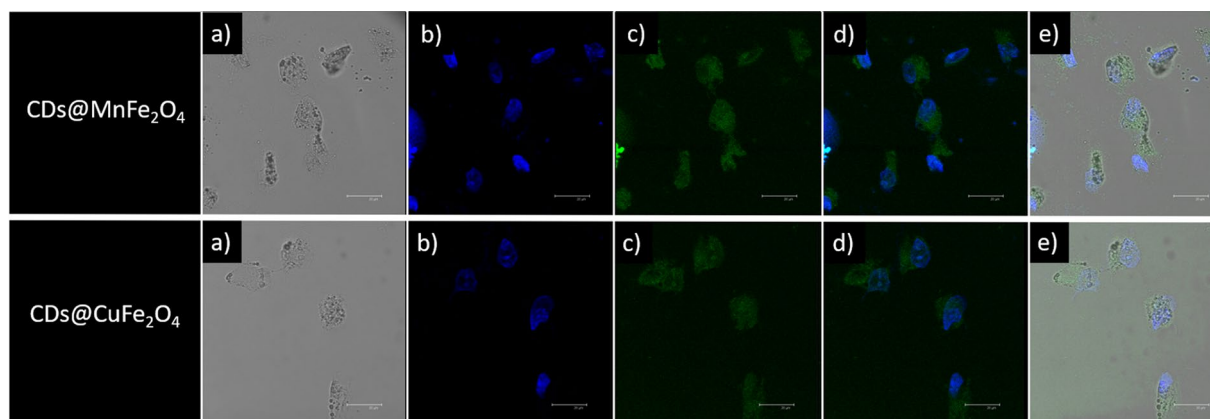


Figure 9: Photograph of CDs@MnFe₂O₄ (a) bright field, (b) DAPI marker emission, (c) CDs@MnFe₂O₄ emission, (d) Combined DAPI and CDs@MnFe₂O₄, and (e) Combined a-d images.

nano-hybrids affecting the particle size increased [54]. The particle size is an essential factor in the contrast agent. The more petite particle size performs dipole–dipole interactions between magnetic nanoparticle ions and protons, H₂O will be maximum. This interaction increases longitudinal relativity and causes positive contrast enhancement in T1-weighted images to be brighter in result [47, 55, 56].

Conclusions

MnFe₂O₄-ethanolamine and CuFe₂O₄-ethanolamine nano-hybrids could be synthesized from Cu(acac)₂, Mn(acac)₂, Fe(acac)₃, oleylamine, benzyl ether, and ethanolamine using the solvothermal method. The characterization results showed that MnFe₂O₄-ethanolamine and CuFe₂O₄-ethanolamine nano-hybrids contained CDs from ethanolamine and had magnetic properties from nanoparticles from MnFe₂O₄ and CuFe₂O₄. The CDs@MnFe₂O₄-45 and CDs@CuFe₂O₄-45 toxicity tests were performed using the MTT Assay method; the percent viability was higher than 80% with a 250 µg/mL concentration that indicated nanoparticles were non-toxic and the contrast of CDs@CuFe₂O₄ gave better images than CDs@MnFe₂O₄ at various sample concentrations in MRI analysis. Thus, CDs@MnFe₂O₄ potentially applies as a candidate for simultaneous contrast and markers.

Experimental method

Materials

Iron(III) acetylacetonate (Fe(acac)₃, 97%, Sigma-Aldrich), manganese(II) acetylacetonate [Mn(acac)₂] copper(II) acetylacetonate [Cu(acac)₂] (97%, Sigma-Aldrich), oleylamine (70%, Sigma-Aldrich), benzyl ether (98%), ethanolamine (98%), and ethanol (90%, Merck).

Synthesis of carbon nanodots-metal ferrite nano-hybrid (CDs@MnFe₂O₄)

The synthesis of CDs-MnFe₂O₄ nano-hybrid was accomplished through a one-pot solvothermal method. Briefly, the total amount of (0.70 g Fe(acac)₃ and 0.25 g Mn(acac)₂) and (0.70 g Fe(acac)₃ and 0.26 g Cu(acac)₂) were obtained in two parts of a two-neck round bottom flask. While mixing with a magnetic stirrer, 15 mL of oleylamine and 15 mL of benzyl ether were added to the flask. In this method, a 220 V electric pressure thermocouple was used. The first temperature was set at 100 °C for 20 min, then raised at 270 °C for 1 h, and lowered to 150 °C. The formulation (0, 15, 30, and 45 mL) of ethanolamine was injected at 150 °C with heating for an hour (Table 1). The temperature was lowered to 60 °C, and the synthesis process was interrupted. The obtained CDs-MnFe₂O₄ were washed with ethanol and centrifugated to accumulate the precipitate. During the solvothermal process, ethanolamine formed CDs by self-assembling, as shown in Scheme 1.

Cell culturing

Culturing the HeLa cell was prepared in Eagle's minimum essential medium (containing 1.5 g L⁻¹ sodium bicarbonate) supplemented with 1% L-glutamine, 1% formulation of antibiotic antimycotic, and 10% fetal bovine serum. The cells were cultured in a humidified 5% CO₂ incubator maintained at 60 °C for inducing cell expansion and senescence. Before CDs-MnFe₂O₄ feeding, HeLa cells were planted in a six-well plate in 2 mL of culturing medium. After 24 h, the HeLa cells were incubated an hour with 300 µL of CDs-MnFe₂O₄, rinsed with PBS three times, and fixed for 10 min with 75% alcohol. The resulting cells were incubated for 20 min with 2 mL DAPI in PBS at room temperature to stain the nucleus. HeLa cells

TABLE 1: Formulation CDs@MFe₂O₄-ethanolamine.

No	Nanohybrid		Ethanolamine Composition (mL)
	MnFe ₂ O ₄	CuFe ₂ O ₄	
1	CDs@MnFe ₂ O ₄	CDs@CuFe ₂ O ₄	0
2	CDs@MnFe ₂ O ₄ -15	CDs@CuFe ₂ O ₄ -15	15
3	CDs@MnFe ₂ O ₄ -30	CDs@CuFe ₂ O ₄ -30	30
4	CDs@MnFe ₂ O ₄ -45	CDs@CuFe ₂ O ₄ -45	45

were visualized using fluorescence using an inverted Confocal Microscope (Leica Microsystems).

Cytotoxicity assessment

The MTT assay was used to quantify cell viability of HeLa. Culturing HeLa cells was prepared in Eagle's minimum essential medium (25,000 cells per well) for 24 h. After rinsing with phosphate-buffered saline (PBS, Uni Region Biotech, Taiwan), the grown cells were incubated with the set samples for 24 h. The plate was rinsed with PBS twice, added with MTT reagent (1 mL, 500 mg m L⁻¹), and incubated for 4 h. Dimethyl sulfoxide (1 mL) was added to dissolve the formazan crystals in each well and the absorbance was measured using an Elisa reader (Biotech Powerwave XS) at 570 nm. The strength of absorption depends on the number of living cells with different formazan.

Other characterizations

Several techniques characterized the yields. Ultraviolet-Visible (UV-Vis) spectra were recorded using a UV-Vis Shimadzu 1800 spectrophotometer (Shimadzu, Japan). Fourier Transform Infra-Red (FTIR) spectra were recorded using an Infrared (IR) Tracer-100 (Shimadzu, Japan). The photoluminescence of CDs@MFe₂O₄ was collected using an LS 55 Fluorescence Spectrometer (Shimadzu, Japan). Dynamic Light Scattering (DLS) analyses were recorded using Analyser Malvern. X-Ray Diffraction (XRD) diffractograms were recorded using an XRD Philips. Vibrating Sample Magnetometry (VSM) curves were recorded using Lake Shore Cryotronic.

Acknowledgments

The authors thank to Universitas Airlangga for SATU joint research scheme (under Contract 1312/UN3.15/PT/2021), and Indonesian Scholar Education Program of Ministry of Education, Culture and Higher Education-LPDP.

Data availability

We declare that all data generated or analyzed during this study are included in this published article; and the data are available from the corresponding author on reasonable request.

Declarations

Conflict of interest Authors declare that there are no conflicts of interest on present study.

References



1. M.J.F. Calvete, S.M.A. Pinto, M.M. Pereira, C.F.G.C. Geraldes, Metal coordinated pyrrole-based macrocycles as contrast agents for magnetic resonance imaging technologies: synthesis and applications. *Coord. Chem. Rev.* **333**, 82 (2017)
2. C. Felton, A. Karmakar, Y. Gartia, P. Ramidi, A.S. Biris, A. Ghosh, Magnetic nanoparticles as contrast agents in biomedical imaging: recent advances in iron-and manganese-based magnetic nanoparticles. *Drug Metab. Rev.* **46**(2), 142 (2014)
3. G.-L. Davies, I. Kramberger, J.J. Davis, Environmentally responsive MRI contrast agents. *Chem. Commun.* **49**(84), 9704 (2013)
4. F. Du, L. Zhang, L. Zhang, M. Zhang, A. Gong, Y. Tan, J. Miao, Y. Gong, M. Sun, H. Ju, Engineered gadolinium-doped carbon dots for magnetic resonance imaging-guided radiotherapy of tumors. *Biomaterials* **121**, 109 (2017)
5. J. Li, C. Wu, P. Hou, M. Zhang, K. Xu, One-pot preparation of hydrophilic manganese oxide nanoparticles as T1 nano-contrast agent for molecular magnetic resonance imaging of renal carcinoma in vitro and in vivo. *Biosens. Bioelectron.* **102**, 1 (2018)
6. V.M. Runge, T. Ai, D. Hao, X. Hu, The developmental history of the gadolinium chelates as intravenous contrast media for magnetic resonance. *Investig. Radiol.* **46**(12), 807 (2011)
7. H.B. Na, I.C. Song, T. Hyeon, Inorganic nanoparticles for MRI contrast agents. *Adv. Mater.* **21**(21), 2133 (2009)
8. Y.-K. Peng, S.C.E. Tsang, P.-T. Chou, Chemical design of nano-probes for T1-weighted magnetic resonance imaging. *Mater. Today* **19**(6), 336 (2016)
9. B.H. McDonagh, G. Singh, S. Hak, S. Bandyopadhyay, I.L. Augestad, D. Peddis, I. Sandvig, A. Sandvig, W.R. Glomm, L-DOPA-coated manganese oxide nanoparticles as dual MRI contrast agents and drug-delivery vehicles. *Small* **12**(3), 301 (2016)
10. P.T. Normann, P. Joffe, I. Martinsen, H.S. Thomsen, Quantification of gadodiamide as Gd in serum, peritoneal dialysate and faeces by inductively coupled plasma atomic emission spectroscopy and comparative analysis by high-performance liquid chromatography. *J. Pharm. Biomed. Anal.* **22**(6), 939 (2000)
11. D. Kim, K.S. Hong, J. Song, The present status of cell tracking methods in animal models using magnetic resonance imaging

- technology. *Mol. Cells* (Springer Science & Business Media BV) **23**(2), 132–7 (2007)
12. A. Barge, G. Cravotto, E. Gianolio, F. Fedeli, How to determine free Gd and free ligand in solution of Gd chelates. A technical note. *Contrast Media Mol. Imaging* **1**(5), 184 (2006)
 13. J. Bennet, R. Tholkappian, K. Vishista, N.V. Jaya, F. Hamed, Attestation in self-propagating combustion approach of spinel AFe_2O_4 ($A = Co, Mg$ and Mn) complexes bearing mixed oxidation states: magnetostructural properties. *Appl. Surf. Sci.* **383**, 113 (2016)
 14. Y. Gao, Carbon nano-allotrope/magnetic nanoparticle hybrid nanomaterials as T2 contrast agents for magnetic resonance imaging applications. *J. Funct. Biomater.* **9**(1), 16 (2018)
 15. J. Cai, P. Yi, Y. Miao, J. Liu, Y. Hu, Q. Liu, Y. Feng, H. Chen, L. Li, Ultrasmall T1–T2 magnetic resonance multimodal imaging nanoprobes for the detection of β -amyloid aggregates in Alzheimer's disease mice. *ACS Appl. Mater. Interfaces* **12**(24), 26812 (2020)
 16. L. Del Bianco, F. Spizzo, P. Sgarbossa, E. Sieni, G. Barucca, M.R. Ruggiero, S. GeninattiCrich, Dipolar magnetic interactions in Mn-doped magnetite nanoparticles loaded into PLGA nanocapsules for nanomedicine applications. *J. Phys. Chem. C* **123**(49), 30007 (2019)
 17. Y. Fu, X. Li, H. Chen, Z. Wang, W. Yang, H. Zhang, CXCR4 chemokine receptor 4 antagonist functionalized renal clearable manganese-doped iron oxide nanoparticles for active-tumor-targeting magnetic resonance imaging-guided bio-photothermal therapy. *ACS Appl. Bio Mater.* **2**(8), 3613 (2019)
 18. S. Kanagesan, M. Hashim, S. AbAziz, I. Ismail, S. Tamilselvan, N.B. Alitheen, M.K. Swamy, B. Purna Chandra Rao, Evaluation of antioxidant and cytotoxicity activities of copper ferrite ($CuFe_2O_4$) and zinc ferrite ($ZnFe_2O_4$) nanoparticles synthesized by sol–gel self-combustion method. *Appl. Sci.* **6**(9), 184 (2016)
 19. M. Arruebo, R. Fernández-Pacheco, M.R. Ibarra, J. Santamaría, Magnetic nanoparticles for drug delivery. *Nano Today* **2**(3), 22 (2007)
 20. M. Zhang, W. Wang, N. Zhou, P. Yuan, Y. Su, M. Shao, C. Chi, F. Pan, Near-infrared light triggered photo-therapy, in combination with chemotherapy using magnetofluorescent carbon quantum dots for effective cancer treating. *Carbon* **118**, 752 (2017)
 21. Z. Zhao, J. Bao, C. Fu, M. Lei, J. Cheng, Controllable synthesis of manganese oxide nanostructures from 0-D to 3-D and mechanistic investigation of internal relation between structure and T1 relaxivity. *Chem. Mater.* **29**(24), 10455 (2017)
 22. Z. Shen, T. Chen, X. Ma, W. Ren, Z. Zhou, G. Zhu, A. Zhang, Y. Liu, J. Song, Z. Li, H. Ruan, W. Fan, L. Lin, J. Munasinghe, X. Chen, A. Wu, Multifunctional theranostic nanoparticles based on exceedingly small magnetic iron oxide nanoparticles for T1-weighted magnetic resonance imaging and chemotherapy. *ACS Nano* **11**(11), 10992 (2017)
 23. I.C. Covaliu, J. Neamtu, G. Georgescu, T. Malaeru, C. Cristea, I. Jitaru, Synthesis and characterization of ferrites ($Fe_3O_4/CuFe_2O_4$)-calcium alginate hybrids for magnetic resonance imaging. *Dig. J. Nanomater. Biostruct.* **6**(1), 245 (2011)
 24. P. Zuo, X. Lu, Z. Sun, Y. Guo, H. He, A review on syntheses, properties, characterization and bioanalytical applications of fluorescent carbon dots. *Microchim Acta* **183**(2), 519 (2016)
 25. X. Xu, R. Ray, Y. Gu, H.J. Ploehn, L. Gearheart, K. Raker, W.A. Scrivens, Electrophoretic analysis and purification of fluorescent single-walled carbon nanotube fragments. *J. Am. Chem. Soc.* **126**(40), 12736 (2004)
 26. X. Sun, Y. Lei, Fluorescent carbon dots and their sensing applications. *TRAC Trends Anal. Chem.* **89**, 163 (2017)
 27. Y. Liu, L. Feng, T. Liu, L. Zhang, Y. Yao, D. Yu, L. Wang, N. Zhang, Multifunctional pH-sensitive polymeric nanoparticles for theranostics evaluated experimentally in cancer. *Nanoscale* **6**(6), 3231 (2014)
 28. L. Cao, X. Wang, M.J. Meziani, F. Lu, H. Wang, P.G. Luo, Y. Lin, B.A. Harruff, L.M. Veca, D. Murray, Carbon dots for multiphoton bioimaging. *J. Am. Chem. Soc.* **129**(37), 11318 (2007)
 29. B. Wang, H. Tan, T. Zhang, W. Duan, Y. Zhu, Hydrothermal synthesis of N-doped carbon dots from an ethanolamine–ionic liquid gel to construct label-free multifunctional fluorescent probes for Hg^{2+} , Cu^{2+} and $S_2O_3^{2-}$. *Analyst* **144**(9), 3013 (2019)
 30. C. Zhang, H. Zhang, Y. Yu, S. Wu, F. Chen, Ratio fluorometric determination of ATP base on the reversion of fluorescence of calcein quenched by Eu(III) ion using carbon dots as reference. *Talanta* **197**, 451 (2019)
 31. X. Dong, Y. Su, H. Geng, Z. Li, C. Yang, X. Li, Y. Zhang, Fast one-step synthesis of N-doped carbon dots by pyrolyzing ethanolamine. *J. Mater. Chem. C* **2**(36), 7477 (2014)
 32. I.Y. Goryacheva, A.V. Sapelkin, G.B. Sukhorukov, Carbon nanodots: mechanisms of photoluminescence and principles of application. *TRAC Trends Anal. Chem.* **90**, 27 (2017)
 33. J. Shen, Y. Zhu, X. Yang, C. Li, Graphene quantum dots: emergent nanolights for bioimaging, sensors, catalysis and photovoltaic devices. *Chem. Commun.* **48**(31), 3686 (2012)
 34. Y.-F. Kang, Y.-W. Fang, Y.-H. Li, W. Li, X.-B. Yin, Nucleus-staining with biomolecule-mimicking nitrogen-doped carbon dots prepared by a fast neutralization heat strategy. *Chem. Commun.* **51**(95), 16956 (2015)
 35. Y. Chen, H. Lian, Y. Wei, X. He, Y. Chen, B. Wang, Q. Zeng, J. Lin, Concentration-induced multi-colored emissions in carbon dots: origination from triple fluorescent centers. *Nanoscale* **10**(14), 6734 (2018)
 36. H. Nagai, Y.H. Kim, Cancer prevention from the perspective of global cancer burden patterns. *J. Thorac. Dis.* **9**(3), 448 (2017)
 37. M.Z. Fahmi, J.-Y. Chang, A facile strategy to enable nanoparticles for simultaneous phase transfer, folate receptor targeting, and cisplatin delivery. *RSC Adv.* **4**(100), 56713 (2014)

38. J. Dulińska-Litewka, A. Łazarczyk, P. Hałubiec, O. Szafranski, K. Karnas, A. Karewicz, Superparamagnetic iron oxide nanoparticles—current and prospective medical applications. *Materials* **12**(4), 617 (2019)
39. H. Li, X. He, Y. Liu, H. Huang, S. Lian, S.-T. Lee, Z. Kang, One-step ultrasonic synthesis of water-soluble carbon nanoparticles with excellent photoluminescent properties. *Carbon* **49**(2), 605 (2011)
40. A. Wibrianto, S.Q. Khairunisa, S.C.W. Sakti, Y.L. Ni'mah, B. Purwanto, M.Z. Fahmi, Comparison of the effects of synthesis methods of B, N, S, and P-doped carbon dots with high photoluminescence properties on HeLa tumor cells. *RSC Adv.* **11**(2), 1098 (2021)
41. S. Kumar, R.R. Nair, P.B. Pillai, S.N. Gupta, M.A.R. Iyengar, A.K. Sood, Graphene oxide–MnFe₂O₄ magnetic nanohybrids for efficient removal of lead and arsenic from water. *ACS Appl. Mater. Interfaces* **6**(20), 17426 (2014)
42. I.O.P. De Berti, M.V. Cagnoli, G. Pecchi, J.L. Alessandrini, S.J. Stewart, J.F. Bengoa, S.G. Marchetti, Alternative low-cost approach to the synthesis of magnetic iron oxide nanoparticles by thermal decomposition of organic precursors. *Nanotechnology* **24**(17), 175601 (2013)
43. Y. Wang, A. Hu, Carbon quantum dots: synthesis, properties and applications. *J. Mater. Chem. C* **2**(34), 6921 (2014)
44. A. Rampino, M. Borgogna, P. Blasi, B. Bellich, A. Cesàro, Chitosan nanoparticles: preparation, size evolution and stability. *Int. J. Pharm.* **455**(1–2), 219 (2013)
45. D.J. McClements, *Food Emulsions: Principles, Practices, and Techniques* (CRC Press, Boca Raton, 2004)
46. A.K. Zak, W.H.A. Majid, M.E. Abrishami, R. Yousefi, X-ray analysis of ZnO nanoparticles by Williamson–Hall and size-strain plot methods. *Solid State Sci.* **13**(1), 251 (2011)
47. M.Z. Fahmi, D.L.N. Wibowo, S.C.W. Sakti, H.V. Lee, Human serum albumin capsulated hydrophobic carbon nanodots as staining agent on HeLa tumor cell. *Mater. Chem. Phys.* **239**, 122266 (2020)
48. D.J. Craik, *Structure and Properties of Magnetic Materials* (Pion, London, 1971)
49. J.C. Stockert, A. Blázquez-Castro, M. Cañete, R.W. Horobin, Á. Villanueva, MTT assay for cell viability: intracellular localization of the formazan product is in lipid droplets. *Acta Histochem.* **114**(8), 785 (2012)
50. M.Z. Fahmi, A. Haris, A.J. Permana, D.L.N. Wibowo, B. Purwanto, Y.L. Nikmah, A. Idris, Bamboo leaf-based carbon dots for efficient tumor imaging and therapy. *RSC Adv.* **8**(67), 38376 (2018)
51. A. Permadi, M.Z. Fahmi, J.-K. Chen, J.-Y. Chang, C.-Y. Cheng, G.-Q. Wang, K.-L. Ou, Preparation of poly (ethylene glycol) methacrylate coated CuInS₂/ZnS quantum dots and their use in cell staining. *RSC Adv.* **2**(14), 6018 (2012)
52. A. Kumar, B. Sahoo, A. Montpetit, S. Behera, R.F. Lockey, S.S. Mohapatra, Development of hyaluronic acid–Fe₂O₃ hybrid magnetic nanoparticles for targeted delivery of peptides. *Nanomed.: Nanotechnol. Biol. Med.* **3**(2), 132 (2007)
53. Y. Pan, J. Yang, Y. Fang, J. Zheng, R. Song, C. Yi, One-pot synthesis of gadolinium-doped carbon quantum dots for high-performance multimodal bioimaging. *J. Mater. Chem. B* **5**(1), 92 (2017)
54. M.Z. Fahmi, J.-K. Chen, C.-C. Huang, Y.-C. Ling, J.-Y. Chang, Phenylboronic acid-modified magnetic nanoparticles as a platform for carbon dot conjugation and doxorubicin delivery. *J. Mater. Chem. B* **3**(27), 5532 (2015)
55. C. Yu, T. Xuan, Y. Chen, Z. Zhao, X. Liu, G. Lian, H. Li, Gadolinium-doped carbon dots with high quantum yield as an effective fluorescence and magnetic resonance bimodal imaging probe. *J. Alloys Compd.* **688**, 611 (2016)
56. C. Zheng, X. An, J. Gong, Novel pH sensitive N-doped carbon dots with both long fluorescence lifetime and high quantum yield. *RSC Adv.* **5**(41), 32319 (2015)



Journal of Materials Research

COUNTRY	SUBJECT AREA AND CATEGORY	PUBLISHER	H-INDEX
<p>Switzerland</p>  <p>Universities and research institutions in Switzerland</p>  <p>Media Ranking in Switzerland</p>	<p>Engineering</p> <ul style="list-style-type: none"> Mechanical Engineering Mechanics of Materials <p>Materials Science</p> <ul style="list-style-type: none"> Materials Science (miscellaneous) <p>Physics and Astronomy</p> <ul style="list-style-type: none"> Condensed Matter Physics 	<p>Springer International Publishing AG</p>	<p>158</p>

PUBLICATION TYPE	ISSN	COVERAGE	INFORMATION
Journals	08842914, 20445326	1986-2022	<p>Homepage</p> <p>How to publish in this journal</p> <p>jmr@mrs.org</p>

SCOPE

Journal of Materials Research (JMR) publishes the latest advances about the creation of new materials and materials with novel functionalities, fundamental understanding of processes that control the response of materials, and development of materials with significant performance improvements relative to state of the art materials. JMR welcomes papers that highlight novel processing techniques, the application and development of new analytical tools, and interpretation of fundamental materials science to achieve enhanced materials properties and uses. Materials research papers in the following topical areas are welcome. • Novel materials discovery • Electronic, photonic and magnetic materials • Energy Conversion and storage materials • New thermal and structural materials • Soft materials • Biomaterials and related topics • Nanoscale science and technology • Advances in materials characterization methods and techniques • Computational materials science, modeling and theory

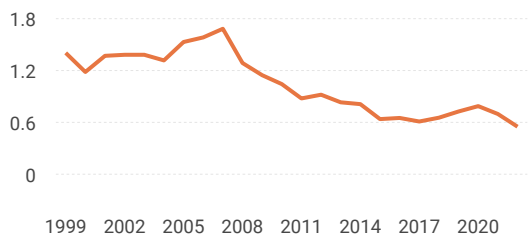
 Join the conversation about this journal



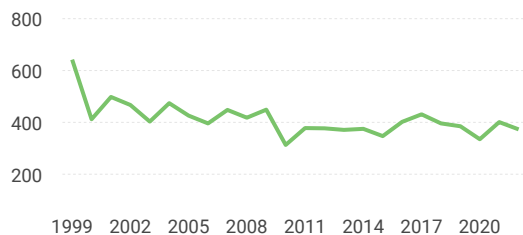
FIND SIMILAR JOURNALS ?

<p>1 Progress in Natural Science: Materials International NLD</p> <p>77% similarity</p>	<p>2 Materials China CHN</p> <p>76% similarity</p>	<p>3 Advanced Engineering Materials DEU</p> <p>75% similarity</p>	<p>4 Progress in Materials Science GBR</p> <p>74% similarity</p>
---	--	---	--

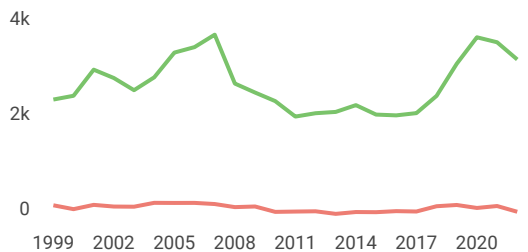
SJR



Total Documents



Total Cites Self-Cites



Citations per document

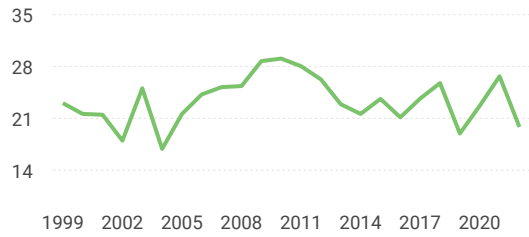


External Cites per Doc Cites per Doc



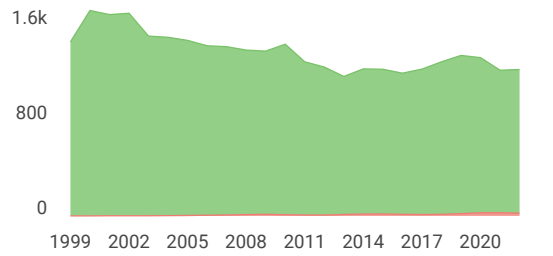


% International Collaboration



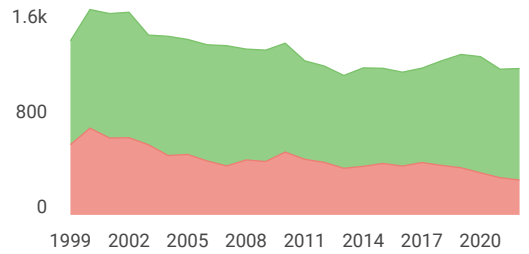
Citable documents

Non-citable documents



Cited documents

Uncited documents



Journal of Materials Research

Q2 Condensed Matter Physics

best quartile

SJR 2022 0.55

powered by scimagojr.com

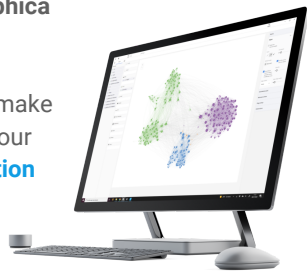
← Show this widget in your own website

Just copy the code below and paste within your html code:

`https://www.scimagojr.com`

SCImago Graphica

Explore, visually communicate and make sense of data with our [new data visualization tool](#).



Metrics based on Scopus® data as of April 2023

A Adams mohat sani 3 years ago

I submitted a paper on 10th December, 2019. I don't have a hint on how to track my submission. Please help

reply



Melanie Ortiz 3 years ago

SCImago Team

Dear Adams,
thank you for contacting us.
Sorry to tell you that SCImago Journal & Country Rank is not a journal. SJR is a portal with scientometric indicators of journals indexed in Elsevier/Scopus.

Unfortunately, we cannot help you with your request, we suggest you to contact the journal's editorial staff , so they could inform you more deeply. Best Regards, SCImago Team

M **Md Shahinoor Alam** 4 years ago

Dear Editors,

Good Day. Is Journal of Materials Research a paid journal. How much I need to pay and how much time is required? Thanks for your cooperation.

Regards

reply

R **Rozana Aina** 5 years ago

How do i publish my work here.I already upload the manuscript but its more than 10 pages. Will you consider or its fix to not more than 10 pages?

reply



Elena Corera 5 years ago

SCImago Team

Dear Rozana,

thank you very much for your comment, unfortunately we cannot help you with your request. We suggest you check author's instructions in journal website. You can find that information in SJR website <https://www.scimagojr.com>

Best Regards,
SCImago Team

D **Dhanalakshmi S** 5 years ago

Dear Editor,

I have a manuscript on the tribological studies of extruded aluminium matrix composites. will it be under the scope of your journal?

Regards

Dhanalakshmi S
Scientist, CVRDE, DRDO
Min. of Defence,AVADI,
Chennai -600 054.

Tamil Nadu. INDIA

reply

**Elena Corera** 5 years ago

SCImago Team

Dear Dhanalakshmi,

thank you very much for your comment. Unfortunately, we cannot help you with your request, we suggest you contact journal's editorial staff so they could inform you more deeply.

Anyway, if there is any user who has already published in the journal, maybe could help us with your request.

Best Regards,
SCImago Team

A **Ain Athirah Rozali** 5 years ago

Dear Editor of JMR,

I would like to ask if there are any payment of page charge if the manuscript is accepted to this journal?

Thank you.

reply

**Elena Corera** 5 years ago

SCImago Team

Dear Ain, in the link below you will find the information corresponding to the author's instructions of this journal. Best regards, SCImago Team

<https://www.cambridge.org/core/services/authors>

Leave a comment

Name

Email

(will not be published)

I'm not a robot reCAPTCHA

Submit

The users of Scimago Journal & Country Rank have the possibility to dialogue through comments linked to a specific journal. The purpose is to have a forum in which general doubts about the processes of publication in the journal, experiences and other issues derived from the publication of papers are resolved. For topics on particular articles, maintain the dialogue through the usual channels with your editor.

Developed by:



Powered by:



Follow us on @ScimagoJR

Scimago Lab, Copyright 2007-2022. Data Source: Scopus®



[Cookie settings](#)

[Cookie policy](#)

Source details

Journal of Materials Research

Scopus coverage years: from 1986 to Present

Publisher: Springer Nature

ISSN: 0884-2914 E-ISSN: 2044-5326

Subject area: Engineering: Mechanical Engineering Engineering: Mechanics of Materials

Physics and Astronomy: Condensed Matter Physics Materials Science: General Materials Science

Source type: Journal

CiteScore 2021 ①
5.2

SJR 2021 ①
0.697

SNIP 2021 ①
0.790

[View all documents >](#)

[Set document alert](#)

[Save to source list](#) [Source Homepage](#)

[CiteScore](#) [CiteScore rank & trend](#) [Scopus content coverage](#)

Improved CiteScore methodology

CiteScore 2021 counts the citations received in 2018-2021 to articles, reviews, conference papers, book chapters and data papers published in 2018-2021, and divides this by the number of publications published in 2018-2021. [Learn more >](#)

CiteScore 2021 ▼

$$5.2 = \frac{7,335 \text{ Citations 2018 - 2021}}{1,406 \text{ Documents 2018 - 2021}}$$

Calculated on 05 May, 2022

CiteScoreTracker 2022 ①

$$4.6 = \frac{6,534 \text{ Citations to date}}{1,410 \text{ Documents to date}}$$

Last updated on 05 April, 2023 • Updated monthly

CiteScore rank 2021 ①

Category	Rank	Percentile
Engineering		
Mechanical Engineering	#128/601	78th
Engineering		
Mechanics of Materials	#92/384	76th
Physics and		

[View CiteScore methodology >](#) [CiteScore FAQ >](#) [Add CiteScore to your site &](#)

About Scopus

[What is Scopus](#)

[Content coverage](#)

[Scopus blog](#)

[Scopus API](#)

[Privacy matters](#)

Language

[日本語版を表示する](#)

[查看简体中文版本](#)

[查看繁體中文版本](#)

[Просмотр версии на русском языке](#)

Customer Service

[Help](#)

[Tutorials](#)

[Contact us](#)

ELSEVIER

[Terms and conditions](#) ↗ [Privacy policy](#) ↗

Copyright © Elsevier B.V. ↗. All rights reserved. Scopus® is a registered trademark of Elsevier B.V.

We use cookies to help provide and enhance our service and tailor content. By continuing, you agree to the use of cookies ↗.



Submission Confirmation

1 message

Journal of Materials Research (JMRS) <em@editorialmanager.com>
Reply-To: "Journal of Materials Research (JMRS)" <ramya.murali.1@springernature.com>
To: Mochamad Zakki Fahmi <m.zakki.fahmi@fst.unair.ac.id>

Wed, Mar 2, 2022 at 5:44 PM

Dear Prof Fahmi,

Thank you for submitting your manuscript, "In Situ Tailoring of Carbon Dots-Metal Ferrite Nanohybrid as Multipurpose Marker Agent of Hela Cancer Cells", to Journal of Materials Research

The submission id is: JMRS-D-22-00260
Please refer to this number in any future correspondence.

During the review process, you can keep track of the status of your manuscript by accessing the journal's web site.

Your username is: m.zakki.fahmi@fst.unair.ac.id
If you forgot your password, you can click the 'Send Login Details' link on the EM Login page at <https://www.editorialmanager.com/jmrs/>.

With kind regards,

Journals Editorial Office
Journal of Materials Research

This letter contains confidential information, is for your own use, and should not be forwarded to third parties.

Recipients of this email are registered users within the Editorial Manager database for this journal. We will keep your information on file to use in the process of submitting, evaluating and publishing a manuscript. For more information on how we use your personal details please see our privacy policy at <https://www.springernature.com/production-privacy-policy>. If you no longer wish to receive messages from this journal or you have questions regarding database management, please contact the Publication Office at the link below.

In compliance with data protection regulations, you may request that we remove your personal registration details at any time. (Use the following URL: <https://www.editorialmanager.com/jmrs/login.asp?a=r>). Please contact the publication office if you have any questions.

Your Submission JMRS-D-22-00260R1 - [EMID:33adb9bf93f3337f]

1 message

Journal of Materials Research (JMRS) <em@editorialmanager.com>

Mon, May 23, 2022 at 7:09 PM

Reply-To: "Journal of Materials Research (JMRS)" <ramya.murali.1@springer.com>

To: Mochamad Zakki Fahmi <m.zakki.fahmi@fst.unair.ac.id>

CC: "Siti Febtria Asrini Sugito" siti.febtria.asrini-2020@fst.unair.ac.id, "Fakhri Firdaus" fakhri.firdaus-2016@fst.unair.ac.id, "Yu-yu Aung" yu.yu.aung-2018@fst.unair.ac.id, "Satya Candra Wibawa Sakti" satya.sakti@fst.unair.ac.id, "Hsien-Tai Chiu" chiuhui@ntnu.edu.tw

Dear Prof Fahmi,

We are pleased to inform you that your manuscript, "In Situ Tailoring of Carbon Dots-Metal Ferrite Nanohybrid as Multipurpose Marker Agent of Hela Cancer Cells", has been accepted for publication in Journal of Materials Research.

You will receive an e-mail in due course regarding the production process.

Please remember to quote the manuscript number, JMRS-D-22-00260R1, whenever inquiring about your manuscript.

With kind regards,

Ramamoorthy Ramesh, Ph.D
Editor in Chief
Journal of Materials Research

Comments to the author (if any):

Reviewer #1: Dear Authors,

Many thanks for responding to all the comments and I'm satisfied with the revised version.

Please note that this journal is a Transformative Journal (TJ). Authors may publish their research with us through the traditional subscription access route or make their paper immediately open access through payment of an article-processing charge (APC). Authors will not be required to make a final decision about access to their article until it has been accepted.

Authors may need to take specific actions to achieve compliance with funder and institutional open access mandates. If your research is supported by a funder that requires immediate open access (e.g. according to Plan S principles) then you should select the gold OA route, and we will direct you to the compliant route where possible. For authors selecting the subscription publication route our standard licensing terms will need to be accepted, including our self-archiving policies. Those standard licensing terms will supersede any other terms that the author or any third party may assert apply to any version of the manuscript.

<a href= <https://www.springernature.com/gp/open-research/funding/policy-compliance-faqs>> Find out more about compliance

This letter contains confidential information, is for your own use, and should not be forwarded to third parties.

Recipients of this email are registered users within the Editorial Manager database for this journal. We will keep your information on file to use in the process of submitting, evaluating and publishing a manuscript. For more information on how we use your personal details please see our privacy policy at <https://www.springernature.com/production-privacy-policy>. If you no longer wish to receive messages from this journal or you have questions regarding database management, please contact the Publication Office at the link below.

In compliance with data protection regulations, you may request that we remove your personal registration details at any time. (Use the following URL: <https://www.editorialmanager.com/jmrs/login.asp?a=r>). Please contact the publication office if you have any questions.

Your Submission JMRS-D-22-00260

2 messages

Journal of Materials Research (JMRS) <em@editorialmanager.com>

Tue, May 10, 2022 at 1:27 AM

Reply-To: "Journal of Materials Research (JMRS)" <ramya.murali.1@springer.com>

To: Mochamad Zakki Fahmi <m.zakki.fahmi@fst.unair.ac.id>

Dear Prof Fahmi,

We have received the reports from our advisors on your manuscript, "In Situ Tailoring of Carbon Dots-Metal Ferrite Nanohybrid as Multipurpose Marker Agent of Hela Cancer Cells", which you submitted to Journal of Materials Research.

Based on the advice received, I have decided that your manuscript could be reconsidered for publication should you be prepared to incorporate minor revisions. When preparing your revised manuscript, you are asked to carefully consider the reviewer comments which can be found below, and submit a list of responses to the comments. You are kindly requested to also check the website for possible reviewer attachment(s).

While submitting, please check the filled in author data carefully and update them if applicable - they need to be complete and correct in order for the revision to be processed further. Please highlight the changes to your manuscript within the document by using the track changes mode in MS Word or by using bold or colored text.

In order to submit your revised manuscript, please access the following web site:

<https://www.editorialmanager.com/jmrs/>

Your username is: m.zakki.fahmi@fst.unair.ac.id

If you forgot your password, you can click the 'Send Login Details' link on the EM Login page.

We look forward to receiving your revised manuscript before 21 May 2022.

In order to add the due date to your electronic calendar, please open the attached file.

With kind regards,
Venu Varanasi
Principal Editor
Journal of Materials Research

Comments to the author (if any):

Reviewer #1: Dear Author,

Thanks for the interesting manuscript.

Minor comments.

Abstract

1)CDs@MnFe2O4-15 has good superparamagnetic properties with a saturation magnetization (Ms) value of 38.485 emu/g; while CDs@MnFe2O4-15 at 9.5245 emu/g. Typo error CDs@CuFe2O4-15 at 9.5245 emu/g right?

2) please add DLS data and relate with the cytotoxicity

Introduction

1)page 2 line 30-31 {Covaliu, 2011 #73;Kanagesan, 2016#18}. Correction needed.

Experimental, result and discussion

1)page 3 line 60 aimed to obtain contrast agents in MRI. suggested to change aimed for potential application as contrast agent.

2)page 5 column2 This study performed CDs synthesis using high temperatures called the solvothermal process shown in Error! Reference source not found.Please correct the sentence.

3) page 6 line 5 reaction of Error! Reference source not found.. occurs, MFe2O4 was covered with CDs is formed in this process as CDs@MFe2O4 nanohybrid. Please correct the sentence.

4) page 6 -Fig 11 and figure 22- please check.

5)page 8 Fig 7 Kontrol-- should be in English

6)page 8 XRD section- significant figure for 2 theta- CDs@MnFe2O4-15 had peaked at 35.1283°, 42.7769°, 56.1394°, and 62.1912°. CDs@MnFe2O4-

30 had a broad peak of 2θ at 17.7477° which CDs@MnFe2O4-15 and CDs@MnFe2O4-45 did not have. The broadest peaks owned by CDs, while the

other peaks were 29.6081°, 34.9985°, 42.4415°, 56.2448°, and 61.7869°. The diffractogram of CDs@MnFe2O4-45 had two peaks at 29.4586° and 35.0188°. these diffractogram was shown in Fig. 5.

29,6081°, 34,9985°- should be 29. 61 and 35.00 degree

7) page 7 FTIR section cm-1 should be superscript.

8) CDs@MnFe2O4-15 was classified as superparamagnetic with coating because the magnetization value of CDs@MnFe2O4-15

was smaller than the raw material. Explain why with coating EMU/G decrease? For clinical application what is the needed emu/ g? 9) related cytotoxicity data with dls data and zeta potential

Conclusion

-ok.

thus, CDs@MFe₂O₄ potentially applies as a candidate for simultaneous markers. Thus not thus. Is it marker or simultaneous contrast and marker?

EDITORIAL OFFICE COMMENTS TO AUTHOR(S)

In addition to the comments raised by the Principal Editor and the reviewers, the author(s) must make the following mandatory formatting corrections prior to re-submission:

1. The abstract is too long. Please rewrite it to be not more than 150 words and not less than 130 words.
2. The written order of your manuscript needs to be rearranged. Please move the Methods section of your manuscript so that it appears after the Conclusion section and before the Acknowledgments (if any) and Reference sections, as described here:

<https://www.springer.com/journal/43578/submission-guidelines?IFA>

Please note that this journal is a Transformative Journal (TJ). Authors may publish their research with us through the traditional subscription access route or make their paper immediately open access through payment of an article-processing charge (APC). Authors will not be required to make a final decision about access to their article until it has been accepted.

Authors may need to take specific actions to achieve compliance with funder and institutional open access mandates. If your research is supported by a funder that requires immediate open access (e.g. according to Plan S principles) then you should select the gold OA route, and we will direct you to the compliant route where possible. For authors selecting the subscription publication route our standard licensing terms will need to be accepted, including our self-archiving policies. Those standard licensing terms will supersede any other terms that the author or any third party may assert apply to any version of the manuscript.

<a href= <https://www.springernature.com/gp/open-research/funding/policy-compliance-faqs>> Find out more about compliance

This letter contains confidential information, is for your own use, and should not be forwarded to third parties.

Recipients of this email are registered users within the Editorial Manager database for this journal. We will keep your information on file to use in the process of submitting, evaluating and publishing a manuscript. For more information on how we use your personal details please see our privacy policy at <https://www.springernature.com/production-privacy-policy>. If you no longer wish to receive messages from this journal or you have questions regarding database management, please contact the Publication Office at the link below.

In compliance with data protection regulations, you may request that we remove your personal registration details at any time. (Use the following URL: <https://www.editorialmanager.com/jmrs/login.asp?a=r>). Please contact the publication office if you have any questions.

 **Revision_Due.ics**
1K

Mochamad Zakki Fahmi <m.zakki.fahmi@fst.unair.ac.id>
To: Siti Febtria Asrini <sitifebtria@gmail.com>

Tue, May 10, 2022 at 6:17 AM

[Quoted text hidden]

--

Best Regards,

Mochamad Zakki Fahmi, Ph.D (張家其)
Assistant Professor, Departement of Chemistry
Airlangga University
Phone : +62-838-32901697
Email : m.zakki.fahmi@fst.unair.ac.id

 **Revision_Due.ics**
1K

Submission Confirmation

1 message

Journal of Materials Research (JMRS) <em@editorialmanager.com>
Reply-To: "Journal of Materials Research (JMRS)" <ramya.murali.1@springer.com>
To: Mochamad Zakki Fahmi <m.zakki.fahmi@fst.unair.ac.id>

Mon, May 16, 2022 at 10:27 PM

Dear Prof Fahmi,

We acknowledge, with thanks, receipt of the revised version of your manuscript, "In Situ Tailoring of Carbon Dots-Metal Ferrite Nanohybrid as Multipurpose Marker Agent of Hela Cancer Cells", submitted to Journal of Materials Research

The manuscript number is JMRS-D-22-00260R1.

You may check the status of your manuscript at any time by accessing the journal's web site.

Your username is: m.zakki.fahmi@fst.unair.ac.id

If you forgot your password, you can click the 'Send Login Details' link on the EM Login page at <https://www.editorialmanager.com/jmrs/>.

We will inform you of the Editor's decision as soon as possible.

With best regards,

Editorial Office
Journal of Materials Research

This letter contains confidential information, is for your own use, and should not be forwarded to third parties.

Recipients of this email are registered users within the Editorial Manager database for this journal. We will keep your information on file to use in the process of submitting, evaluating and publishing a manuscript. For more information on how we use your personal details please see our privacy policy at <https://www.springernature.com/production-privacy-policy>. If you no longer wish to receive messages from this journal or you have questions regarding database management, please contact the Publication Office at the link below.

In compliance with data protection regulations, you may request that we remove your personal registration details at any time. (Use the following URL: <https://www.editorialmanager.com/jmrs/login.asp?a=r>). Please contact the publication office if you have any questions.