Annual Methodological Archive Research Review
http://amresearchreview.com/index.php/Journal/about
Volume 4, Issue 6 (2026)

Online ISSN 3007-3197
Print ISSN 3007-3189

http://amresearchreview.com/index.php/Journal/about

A Comprehensive Review on the Importance of Different Magnetic Nanoparticles in Nanoburning, Hyperthermia and MRI Devices

Tahir Shahzad

Faculty of Sciences, The Superior University Lahore, Lahore 54000, Pakistan

Zia Ullah*

Center of Turbulence Control, Harbin Institute of Technology (Shenzhen), Shenzhen 518055, China. Department of Mathematics and Statistics, The University of Lahore, Sargodha Campus, 40100 Sargodha, Pakistan. Corresponding Author Email: ziakhan.uos.72@gmail.com

Tasadduq Niaz

Faculty of Sciences, The Superior University Lahore, Lahore 54000, Pakistan

Uzma Tariq

Department of Mathematics and Statistics, The University of Lahore, Sargodha Campus, 40100 Sargodha, Pakistan

Muhammad Haroon Khaliq

Department of Mathematics and Statistics, The University of Lahore, Sargodha Campus, 40100 Sargodha, Pakistan

Muhammad Waqar Shah

Department of Mathematics and Statistics, The University of Lahore, Sargodha Campus, 40100 Sargodha, Pakistan

ABSTRACT

Magnetic nanoparticles (MNPs) have emerged as a transformative component in modern biomedical science, particularly in diagnostic imaging and therapeutic applications. This review presents a comprehensive analysis of the role of various magnetic nanoparticles in nanoburning, hyperthermia, and magnetic resonance imaging (MRI) devices. Recent advancements in nanotechnology have significantly enhanced the functionality of imaging techniques, enabling precise diagnosis of complex diseases such as cancer, neurological disorders, and cardiovascular conditions. Among these techniques, MRI stands out due to its superior soft tissue

Annual Methodological Archive Research Review
http://amresearchreview.com/index.php/Journal/about
Volume 4, Issue 6 (2026)

Online ISSN 3007-3197
Print ISSN 3007-3189
http://amresearchreview.com/index.php/Journal/about

contrast and non-invasive nature. The incorporation of MNPs, especially super paramagnetic iron oxide nanoparticles (SPIONs), has further improved MRI sensitivity and specificity through enhanced contrast mechanisms. In therapeutic domains, magnetic hyperthermia has gained considerable attention as an effective cancer treatment strategy, where MNPs generate localized heat under an alternating magnetic field to selectively destroy malignant cells while minimizing damage to healthy tissues. Additionally, nanoburning and magnetically controlled drug delivery systems provide innovative pathways for targeted therapy and controlled drug release. The physicochemical properties of MNPs including size, shape, surface coating, and magnetic behavior, play a crucial role in determining their biomedical efficacy and biocompatibility. Furthermore, this review highlights different types of magnetic nanoparticles such as ferrites, cobalt ferrite, and manganese ferrite, emphasizing their distinct advantages in medical applications. Despite significant progress, challenges related to toxicity, stability, and targeted delivery remain. Future research should focus on optimizing nanoparticle design and integrating multifunctional capabilities to advance clinical translation. Overall, MNPs hold immense potential to revolutionize diagnostic and therapeutic approaches in modern medicine.

Keywords: Magnetic nanoparticles; medical treatment; nanoburning; hyperthermia; MRI devices; comprehensive review

1. Introduction

In recent medical field, we find ourselves amid the nexus of modern science and therapeutic art. The significant advancements in advanced technology have made imaging in medicine a vital component of both ailment identification and treatment. Numerous multifunctional imaging procedures that probe deeply inside human beings and offer a thorough understanding regarding both conventional and anomalous physiological functions are used throughout the field of medical diagnosis. We discover adaptable instruments that serve a wide range of testing needs in the field of cutting-edge healthcare imaging strategies, from recognizing and assessment of coronary artery disease conditions, various kinds of cancer, brain diseases, and gastrointestinal ailments and various other crucial health issues. Although MRI uses

Annual Methodological Archive Research Review
http://amresearchreview.com/index.php/Journal/about
Volume 4, Issue 6 (2026)

Online ISSN 3007-3197
Print ISSN 3007-3189
http://amresearchreview.com/index.php/Journal/about

electromagnetic irradiation it stands out from CT and is therefore the preferable option for numerous healthcare environments. MRI, a painless neuroimaging method, is essential for evaluating the physiological and anatomical structure of the body of an individual in both healthy and diseased conditions. The broad-ranging effects of MRI include its widespread use as a biological technique to get pictures of soft tissues in the body which includes fluid. This is accomplished by subjecting the specimen to an ambient electromagnetic field, which forces the magnetized poles of the fluid molecule to align towards the field. It is crucial to recognize the fact there is still a great deal of space for improvement in the face of these developments. Health has been transformed by our present variety of methods for imaging, but there is still room for advancement. Significant promise exists for the incorporation of innovative contrast substances derived from nanotechnologies providing opportunities to enhance the practice of medicine.

1.1 Overview of magnetic nanoparticles

Moskvin et al. [1] discussed as instruments for heating, administering medications, and diagnostics, inorganic nanoparticles including silicon dioxide, ferrous oxide, and gold are being utilized more and more in nanostructures. Shi et al. [2] observed the structure of these particles allows them to be classified as either inanimate (metallic substances, graphite tiny particles, and metallic oxide nanostructures) or biological (fatty acids, polymer chains, liposomes, viscoelastic microorganisms dendrimers, modified peptides, and nucleic acids).

The mechanical properties of the different substances are thought to be enhanced by combining them into an identical nanoplatform. Luo et al. [3] described the mechanism of action underlying medication administration can be enhanced and systemic damage can be decreased by using nanotechnology as carriers for drugs. Persano et al. [4] showed certain imaging approaches that take advantage of the chemical, biological, and photonic characteristics of nanostructures can be used to produce heating and photo controlled release of drugs or retrieve imaging data regarding unobtrusive drug distribution to the intended region. Ullah et al. [5] investigated an effective method to enhance the thermodynamic properties of polymerization is the evaluation of activated energy in relation to the heat

Annual Methodological Archive Research Review
http://amresearchreview.com/index.php/Journal/about
Volume 4, Issue 6 (2026)

Online ISSN 3007-3197
Print ISSN 3007-3189
http://amresearchreview.com/index.php/Journal/about

transfer of a permeable polyethylene film. Al Arni et al. [6] examined the sequential dynamics and equilibrium condition of a Darcy Forchheimer magnetized tiny liquids traversing a perforated sloped substrate involving a vacuum, MHD, electromagnetic waves, electron warmth, and various slip impacts. Wust et al. [7] explored an exponential growth in the discipline of infrared psychotherapy. In fact, there are numerous investigations that are currently published that use classic hydrotherapy in conjunction with radiotherapy and medication to eradicate a variety of malignant forms.

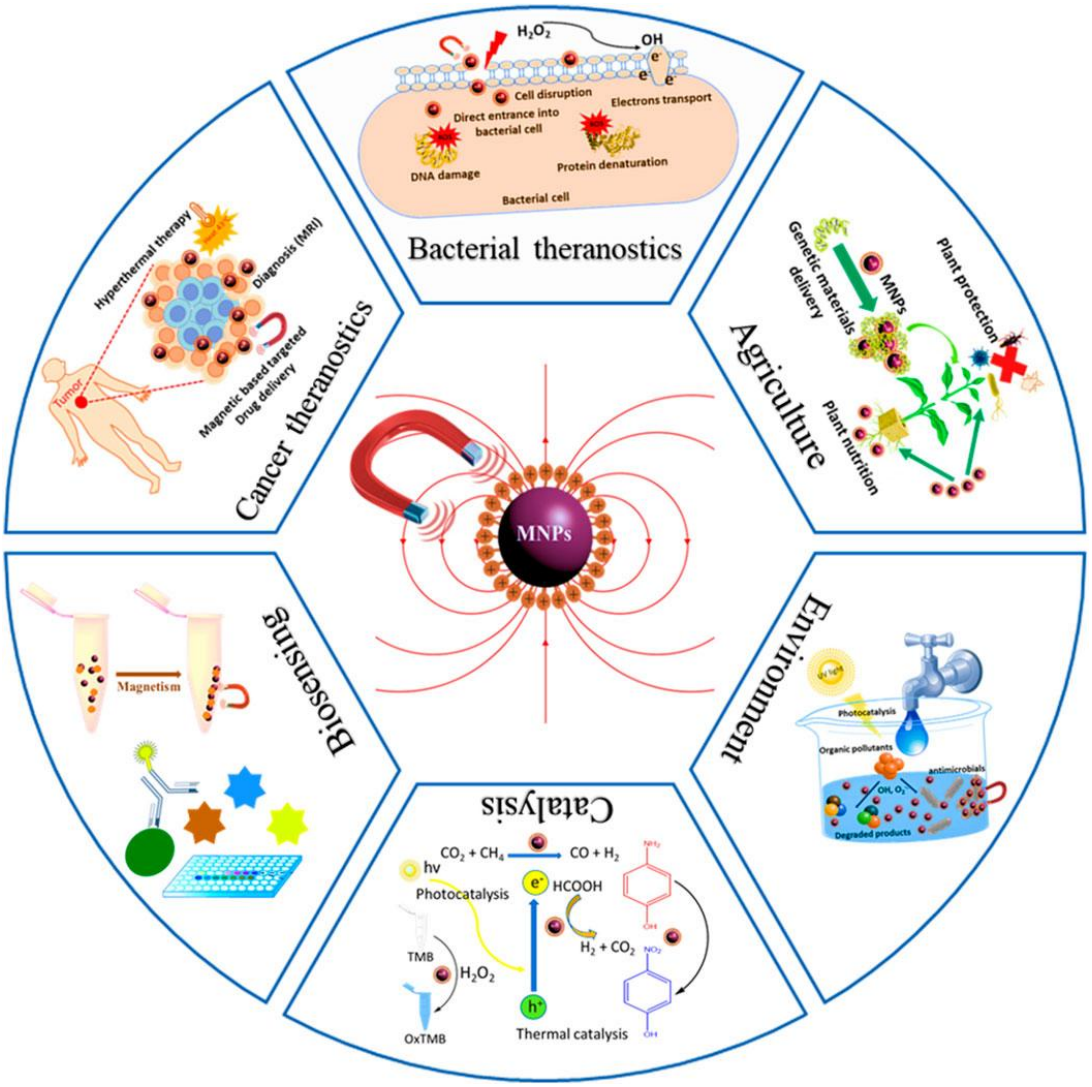

Fig. 1 Magnetic Nanoparticles applications in various fields by following Ali et al. [8]

Zhang et al. [9] observed a variety of particles with magnetic properties are

Annual Methodological Archive Research Review
http://amresearchreview.com/index.php/Journal/about
Volume 4, Issue 6 (2026)

Online ISSN 3007-3197
Print ISSN 3007-3189
http://amresearchreview.com/index.php/Journal/about

currently employed, microscopic iron oxide-based nanomaterials known as ultra-electromagnetic ferrous oxide nanoparticles have received special attention. Stafford et al. [10] interrogated a route to innovative versatile nanotechnology with bidirectional capabilities can be paved by combining magnets and additional capabilities into an individual molecule. Kandasamy et al. [11] studied magnetic iron oxide (Fe_3O_4) as well as magma (Fe_2O_3) fragments, which are often wrapped with various exterior coating monomers such citrate, the latter plastics, and silicon dioxide, are the USPIOs. Ullah et al. [12] noted the rhythmic electromagnetic flux along with heat exchange in an atmosphere of fluctuating surface temperatures are investigated by conducting electricity a fluid through a warmed concentric barrel. Boukholda et al. [13] showed a sizable amount of thermal energy is continuously generated; materials have a greater capacity to transmit infrared versus atmosphere of comparable volume

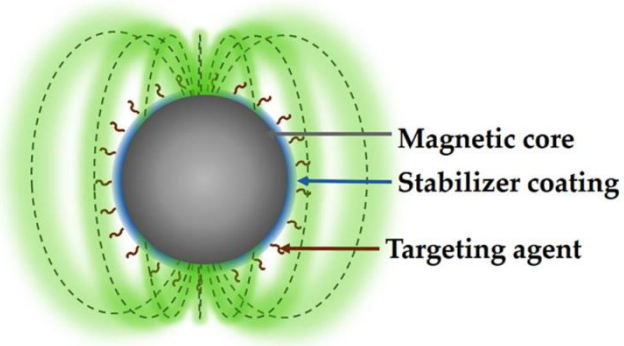

Fig. 2 Structure of functionalized MNP in medical field by following Flores-Rojas et al. [14]

1.2. Nanoburning and MRI Devices

Jin et al. [15] investigated a potent non-intrusive technique for physiological scans, medical evaluation, and treatment is a form of magnetic resonance imaging (MRI) employing super paramagnetic ferrous oxide nanomaterials (SPION). Lam et al. [16] discussed new and extremely effective contrast agents are being invented as a result of the necessity to isolate, perform, and then assess the effectiveness of medicines in the therapy of a medical condition. Matsuura and Rowlands [17] noted the diagnostic techniques such as computational tomography (CT), MR imaging (magnetic resonance imaging), ultrasound scans and X-ray have expanded their

Annual Methodological Archive Research Review
http://amresearchreview.com/index.php/Journal/about
Volume 4, Issue 6 (2026)

Online ISSN 3007-3197
Print ISSN 3007-3189
http://amresearchreview.com/index.php/Journal/about

usage of biochemical distinction tiny needles that were first studied utilizing PET and laser. Ullah et al. [18] showed significant uses of flowing nanofluid through an inclined interface involving infrared and concentrate slips include heat pumps, geophysical technology, energy conservation, and petroleum extractor. Khedher et al. [19] determined a magneto-thermal assessment of an electrical oscillation inside a ferromagnetic sphere that is warming longitudinally while taking absorbing material and thermal producing effects into account. Ullah et al. [20] examined the effects of the electromagnetic flux characteristics of dissipative streams and viscoelastic dissipations, Joule temperatures, and the field of magneto (MHD) on the transient movements of convective heat transmission across a polarized and preheated barrel at appropriate locations.

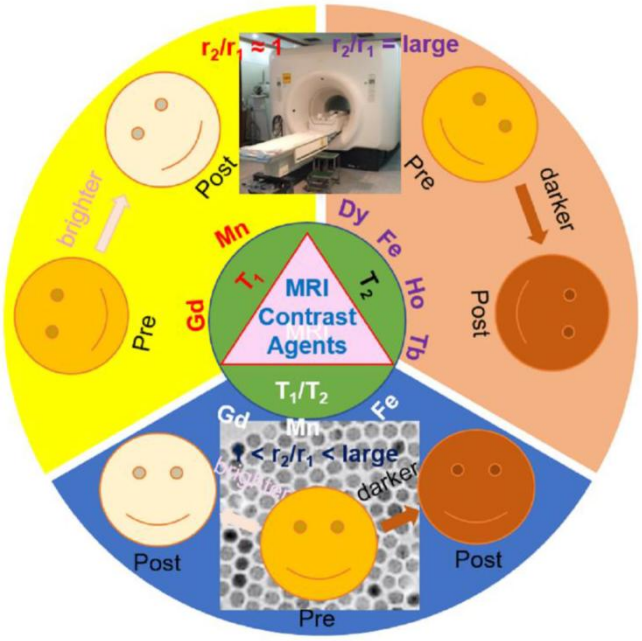

Fig. 3 Magnetic nanoparticle and MRI contrast agents by following Tegafaw et al. [21]

2. Importance of Magnetic Nanoparticles in Hyperthermia

The method of combating malignancy by applying warmth to cancerous cells through the use of nanoparticles with magnets (MNPs) with a magnetic field that alternates is known as hyperthermia using magnets. This strategy may show promise in treating fundamental or tiny cancers. Jordan et al. [22] examined the decrease in the quantity of MNPs, which are capable of being utilized in living tissue

Annual Methodological Archive Research Review
http://amresearchreview.com/index.php/Journal/about
Volume 4, Issue 6 (2026)

Online ISSN 3007-3197
Print ISSN 3007-3189
http://amresearchreview.com/index.php/Journal/about

constitutes one of the main problems being studied in electromagnetic hyperthermia. Ullah et al. [23] noticed magnetic effects around solid sphere in fusion reactors for heat transfer performance. Grüttner et al. [24] investigated to avoid any negative effects associated with elevated magnet intensities on the individual being treated, the fragments must be made to accumulate and distribute sufficiently in the intended region to enable the administration of moderate magnetic fields that alternating (AMF). Ullah et al. [25] discussed the forward motion of supersonic boundaries flow on an expanding sheet of paper, in addition to the transmission of heat and mass, is significant in both theory and practice because of its extensive use in polymeric manufacturing.

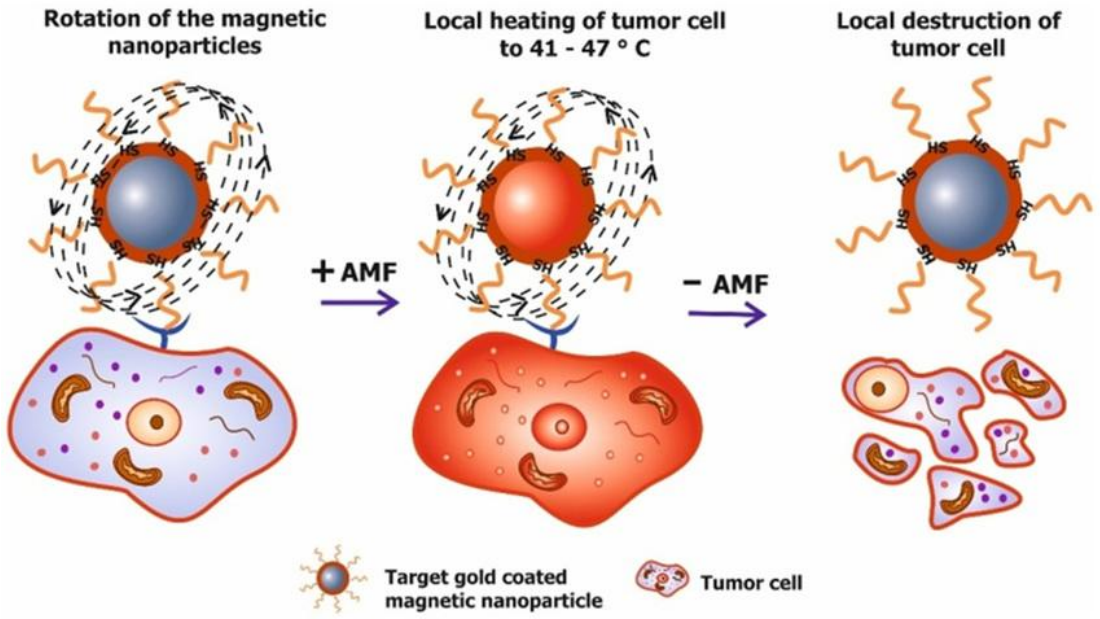

Fig. 4 Principle of magnetic mediated hyperthermia by following Belyanina et al. [26]

Grazu et al. [27] demonstrated the cytoplasmic overheating is an effective technique for killing parasites from protozoa that carry MNPs. These results increase the potential for innovative methods to treat parasite infections. Van Landeghem [28] suggested the biological acceptability and longevity of neodymium or magnesium oxide nanoparticles (NPs) as contrast mediums for MRI (magnetic resonance imaging) and as tiny carriers in therapeutic radiofrequency treatments. Carrey et al. [29] observed giant ferrous, NPs that had little asymmetry were found to have the

Annual Methodological Archive Research Review
http://amresearchreview.com/index.php/Journal/about
Volume 4, Issue 6 (2026)

Online ISSN 3007-3197
Print ISSN 3007-3189
http://amresearchreview.com/index.php/Journal/about

highest scorching capacity. Salih et al. [30] showed heat energy and mass flow performance of magnetic fluid. Baronzio and Hager [31] investigated cavitation warming of water, extra corporal plasma being heated, and radiofrequency catheters are examples of thermal insulation methods. Ullah et al. [32] developed many commercial uses in the producing goods, power, aviation, and semiconductor industries; there has been an abundance of interest in the study of hydraulic thermal transfer and movement over frontiers of stagnant stream powered by an extensible film.

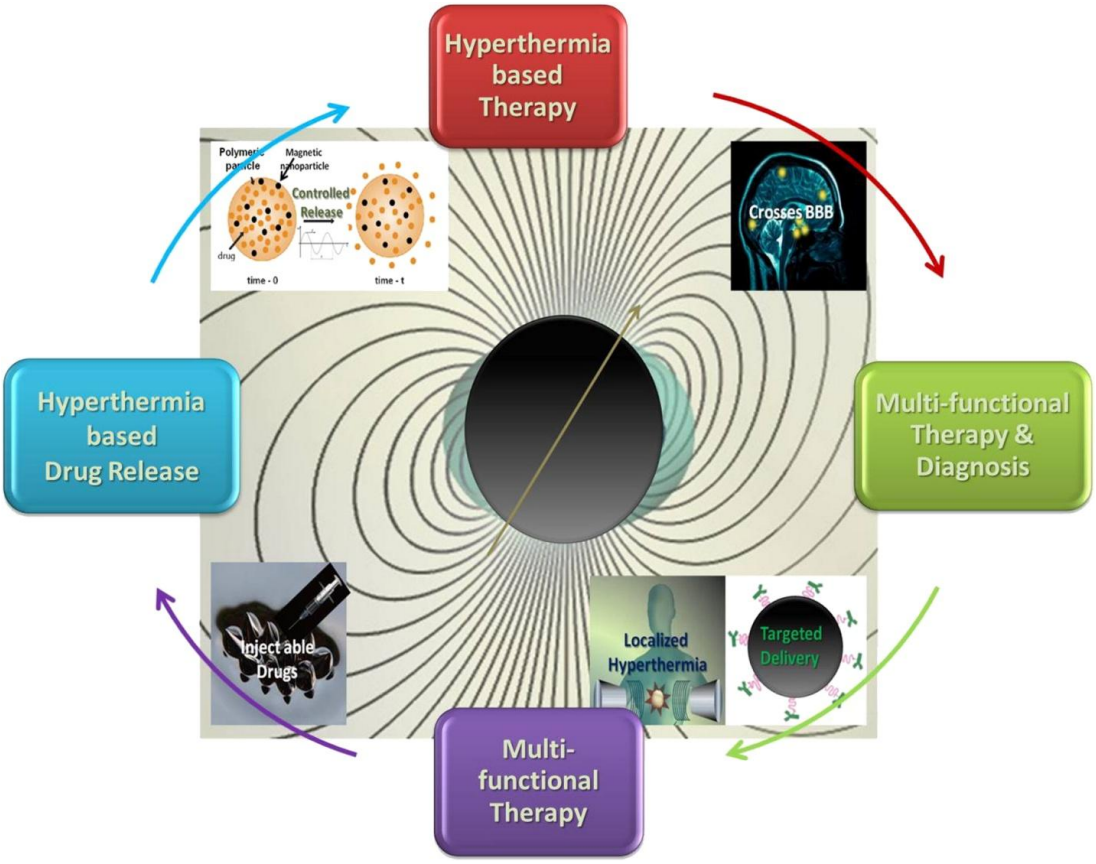

Fig. 5 Magnetic nanomaterials for hyperthermia-based therapy by following [33]

3. Types of Magnetic Nanoparticles

Krishnan et al. [34] discussed new research in the field indicates that nanoparticles with magnets may be utilized to control warmth at an ongoing pace and enhance the effectiveness of hydrotherapy. Jin et al. [35] showed in laboratory and in real life, 5-bromotetrandrine (5-BrTet) may build up chemotherapy drugs, reduce antiapoptosis,

Annual Methodological Archive Research Review
http://amresearchreview.com/index.php/Journal/about
Volume 4, Issue 6 (2026)

Online ISSN 3007-3197
Print ISSN 3007-3189
http://amresearchreview.com/index.php/Journal/about

and partially block the protein P-g functionality. Chen et al. [36] interrogated at both in vivo as well as in experimental tumor scenarios, iron oxide nanoparticles with magnetization (MNP) improve the effectiveness of 5-BrTet and a chemotherapy drug such (DNR) in reversing drug resistance. Ullah et al. [37] provided oscillatory magnetic properties of magnetic based fluid around magnetized cylinder. Laurent et al. [38] acquired the Ferromagnetic tiny particles, particularly super paramagnetic ferrous oxide small particles, have emerged as a very desirable alternative amid the several nanotechnology kinds being investigated for cancer diagnostics and treatment. Ullah et al. [39] noted the volatility development, thermal radiation, and fluctuating thermal conductivity are used for evaluating the development of second-grade nanofluid material.

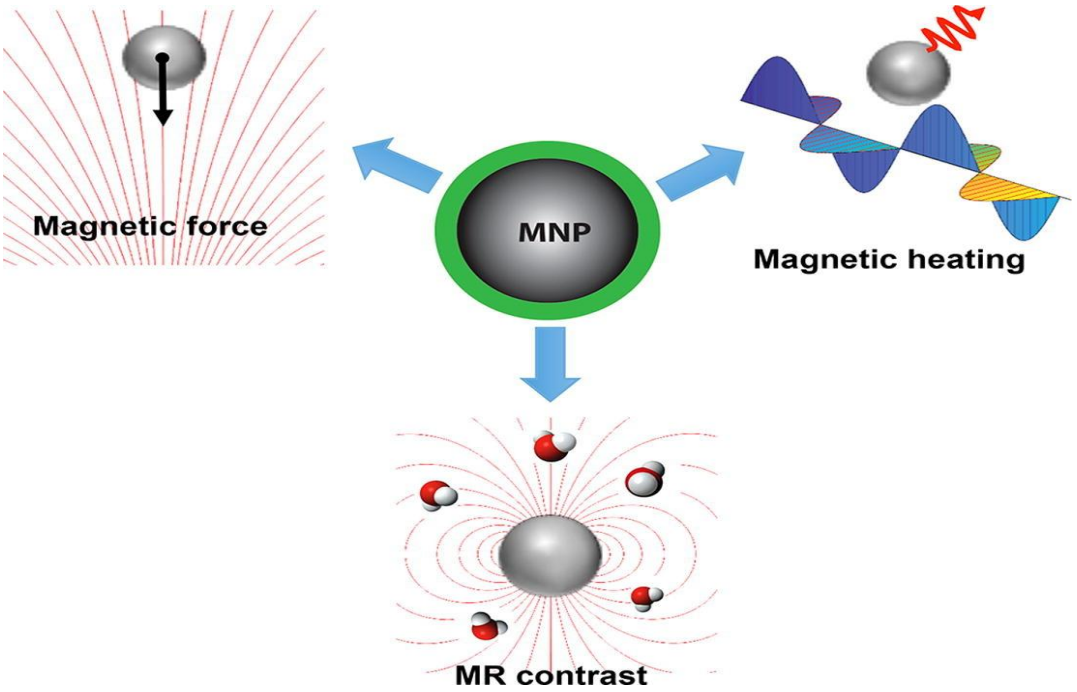

Fig. 6 Magnetic iron oxide nanoparticles for illness diagnosis and treatment by following Tong et al. [40]

Lee et al. [41] discovered potential uses of ferrites were discovered, particularly for ferrite made from cobalt in the medical field. Due to certain characteristics, cobalt-ferrite (CF) has emerged as a viable option for a variety of uses, including, lately, medical research. Co-ferrite is used mostly for therapeutic uses because to its strong magneto-crystalline distortion, which results through the spin orbit (L–S) resonance

Annual Methodological Archive Research Review
http://amresearchreview.com/index.php/Journal/about
Volume 4, Issue 6 (2026)

Online ISSN 3007-3197
Print ISSN 3007-3189
http://amresearchreview.com/index.php/Journal/about

at the lattices of crystals. Kim et al. [42] studied the material nanoparticles made from ferrite that have extremely powerful and adjustable magnetizations have improved MRI susceptibility. The magnetic boundary layers along vertical plate and magnetic Prandt effects on magnetic flux were evaluated in [43-44]. Yuan et al. [45] investigated the two primary kinds of polymeric substances are synthetic as well as natural polymers. Among them, organic ones are biodegradable and appropriate for use in applications in medicine, such encapsulating nanomaterials.

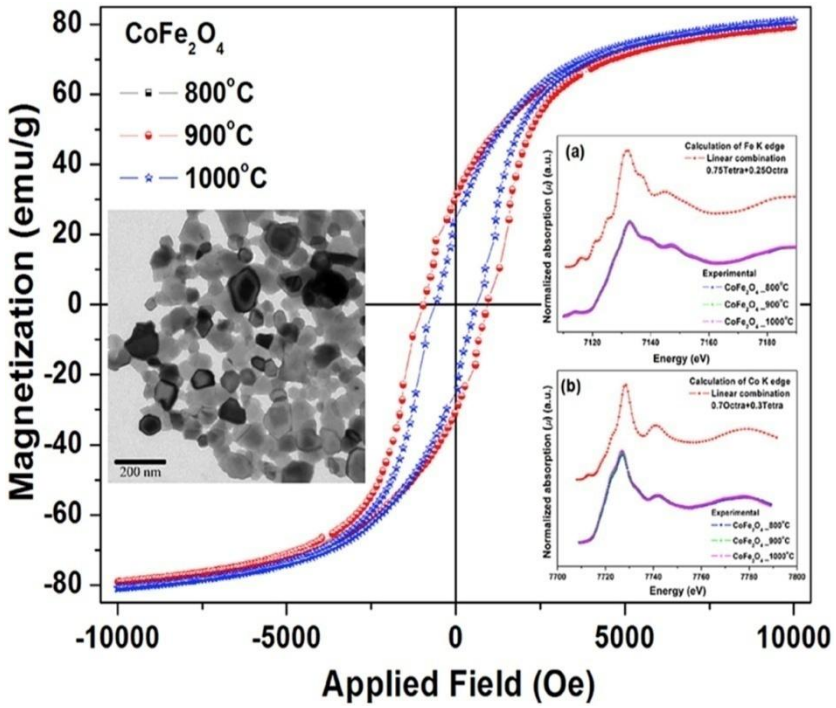

Fig. 7 Cobalt Ferrite nanoparticles for magnetization efficiency by following Swatsitang et al. [46]

There are many different uses in technology for composites made of magnesium ferrite. Franco et al. [47] noticed whenever it comes to producing acute heat exhaustion, magnesium ferromagnetic is better than other iron oxides. Maehara et al. [48] analyzed majority of these biological traits necessitate elevations above the ambient level; for instance, for healthcare applications, magneto caloric features can produce localized heatstroke, such as in cancerous areas. Ullah et al. [49] provided numerous physical characteristics of heat and mass transfer using magnetic based fluid. Asab et al. [50] acquired the responsiveness, heat, arbitrary, ophthalmic, electronic, and electromagnetic attributes of nanostructures are different or

Annual Methodological Archive Research Review
http://amresearchreview.com/index.php/Journal/about
Volume 4, Issue 6 (2026)

Online ISSN 3007-3197
Print ISSN 3007-3189
http://amresearchreview.com/index.php/Journal/about

improved from those of their analogs in bulk due to their high ratio of surface to volume and particulate dimensions up to 100 nm. Zuo et al. [51] demonstrated the magnetized qualities, strong electrical conductivity, and mass performance in rotating water. Hu et al. [52] presented vital function in advancing the comprehension of magnetization broadly and ferrous ions in specific, magnetically serpentine ferrite compounds have garnered an abundance of interest lately. Ullah et al. [53] considered magnetic based polymer surface for the mass flow performance of drug eluting polymer stents. Borade et al. [54] observed ferrous nanoscale manufacturing is currently attracting more interest due to its large area relative to volume ratio, chemical composition of the surface, and significant number of flaws.

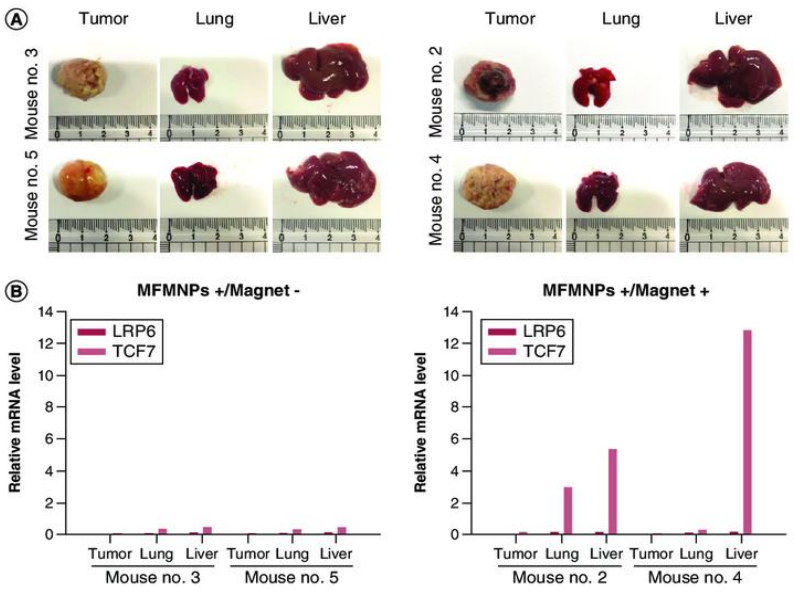

Fig. 8 Manganese ferrite magnetic nanoparticles for tumor, lung and liver treatment by following Yang et al. [55]

4. Applications of Magnetic Nanoparticles in Nanoburning

Koksharov et al. [56] studied restricted dimensions and interface impacts that arise from harmony breakdown of the crystal shell at the particle's terrain, deterioration, hanging securities, contact varnish, etc., are the two main elements that influence the magnetism of nanomaterials (NPs). Issa et al. [57] observed the optimum dimension of nanomaterials for the majority of healthcare uses is usually between 10 and 50 nm. Obaidat et al. [58] showed significant saturation magnetization ratings

Annual Methodological Archive Research Review
http://amresearchreview.com/index.php/Journal/about
Volume 4, Issue 6 (2026)

Online ISSN 3007-3197
Print ISSN 3007-3189
http://amresearchreview.com/index.php/Journal/about

are required for nanoparticles with magnetism used in therapeutic technologies. Ullah et al. [59] investigated the magnetic field properties on elastic surface for heat performance. Ullah et al. [60] examined the interactions of slip temperature in magnetic based fluid around horizontal sheet. Jones et al. [61] discovered thermal strengthens the cancer-fighting abilities of ionizing rayon and other cancer prevention therapies, frequently resulting in an integrated morbidity that is noticeably higher compared to that from either therapy separately. Riedinger et al. [62] discussed the techniques for treating tumors that use warmth brought on by a magnetic field that changes periodically are also becoming more popular. Scientists suggest releasing molecules of medicine into their immediate surroundings by warming them at the microscopic level. Ullah et al. [63] provided magnetic nanofluid properties for mass flow and heat transfer in gravitational conditions. Diamond [64] discussed one of the primary goals of biomedicine diagnostics is the detection of infectious diseases and disorders.

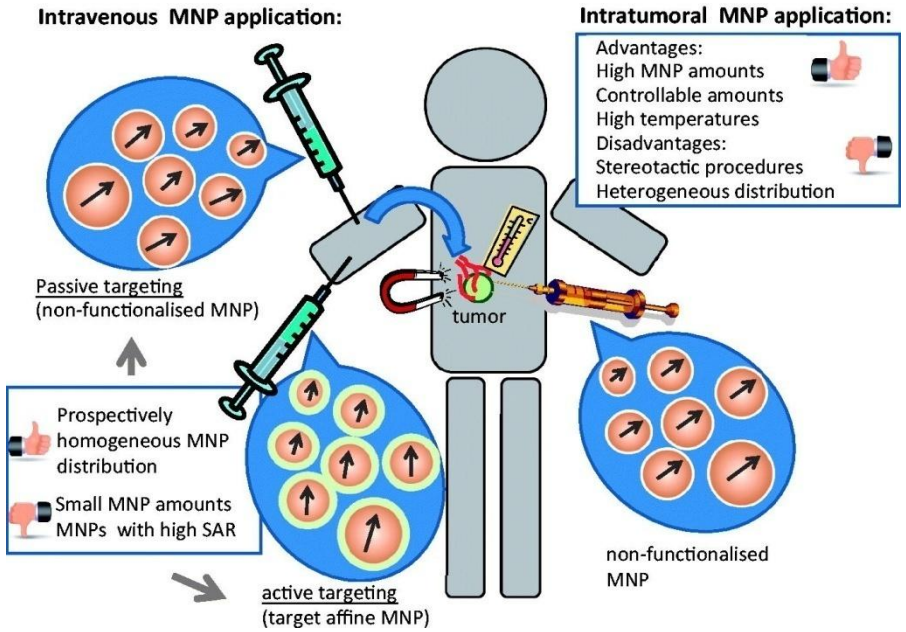

Fig. 9 Magnetic nanoparticle applications in hyperthermia by following Hilger [65]

Bareford and Swaan [66] interrogated the capacity of nanotechnology to pass across cellular barriers, including the endothelium and epithelium that are present in intestinal, placental, and vascular structures, is the primary factor influencing their

Annual Methodological Archive Research Review
http://amresearchreview.com/index.php/Journal/about
Volume 4, Issue 6 (2026)

Online ISSN 3007-3197
Print ISSN 3007-3189
http://amresearchreview.com/index.php/Journal/about

dissemination. Sanhai et al. [67] observed the cellular wall and organelles, enzyme breakdown, phagocyte adoption, aberrant circulation, aberrant water pressure at targeted locations, and biochemical and electrical drainage pumps that remove medications from cells of interest are further hurdles. Hu et al. [68] demonstrated particulate dimensions, forms, and exterior chemistry (which includes charged surfaces, hydrophilicity, and biochemical functionalities) should all influence how nanomaterials and cellular engage. Sardari and Verg [69] showed modern methods of treating hyperthyroidism include the use of radio signals, microwaves, ultrasound scans steam circulation, resistive wire encases, and thermal heaters, which can be applied wherever needed or throughout the body. Thiesen and Jordan [70] explained the idea behind overheating is that elevating cancerous cells to between 40 and 44 degrees Celsius can cause them to necrotize, undergo cell death, or become more vulnerable to chemotherapy and radiation treatment. Ullah et al. [71] discovered energy transportation in magnetic based nanofluid for thermal boundary layers. Al-Shammari et al. [72] presented gravity and magnetic fluid properties for the improvement of heat transfer. Zhao et al. [73] developed need for study in numerous other fields that use electromagnetic warmth, such as magnetism driven pharmaceutical or biopharmaceutical discharge, high-SAR MNPs might be helpful.

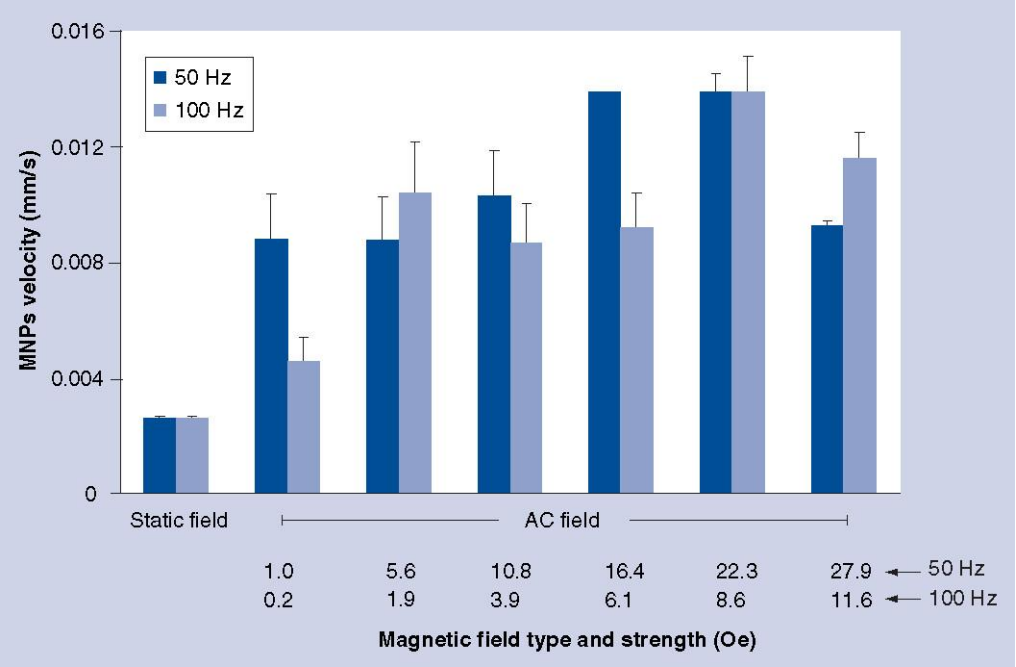

Fig. 10 Time varied magnetic field enhances transport of magnetic

Annual Methodological Archive Research Review
http://amresearchreview.com/index.php/Journal/about
Volume 4, Issue 6 (2026)

Online ISSN 3007-3197
Print ISSN 3007-3189
http://amresearchreview.com/index.php/Journal/about

nanoparticles. Zhang et al. [74]

Kobayashi [75] observed a different option is heat exhaustion, which involves warming the cancerous area while seriously harming healthy cells. Otte [76] explained thermal transporters like Fe, Co, and Ni nanoparticles from metals with oxides of them, which function as heating agents, are more frequently utilized to induce localized heatstroke, which kills tumor cells in a specific confined region with higher precision. Islam et al. [77] examined an oscillating exterior electromagnetic field is applied after MNPs are administered to induce magneto overheating, which produces heat inside the site of the cancer. Ullah et al. [78] investigated the internal environment of magnetic field in nanofluid flow for energy transportation. Pankhurst et al. [79] discovered MNPs can be connected with the molecules of life, including plasmids (10-100 nm long), infectious agents (20–450 nm), and peptides (5–50 nm) to enable specific treatments. Teran et al. [80] showed a number of variables, including MNP focusing, authorization, and thermal effectiveness, affect how well MNPs work in magnetized hyperthermia.

5. Applications of Magnetic Nanoparticles in MRI Devices

Bonnemain [81] studied when designing microscopic particles, the covering of the antagonist has to be taken into account, even if the contrary reagent's magnitude of signal is an essential component for the identification of tiny cancers. Yuan and Kerwin [82] explained utilizing anatomical electromagnetic resonance phenomena, Magnetic Resonance Imaging (MRi) offers the potential to identify aggressive tumors promptly in the course of diagnosis with the use of suitable contrast medications. David et al. [83] investigated the application of particles with magnetic properties in pharmaceuticals for curing oncology and other illnesses is still in the demonstrations of concept phase. Nabwey et al. [84] noted magnetic properties and gravity effects on flow rate of magnetic fluid. Levy et al. [85] explored when exposed to an AMF of kHz radio waves range (100-300 kHz) and an adequate field extent, nanoparticles of super paramagnetic iron oxide that are deposited right at the site of cancer function as a sensor to transform radiation into warmth. Thomas et al. [86] observed the establishment of MNPs-based frameworks aiming at enhancing synergies in order to enhance melanoma treatment effectiveness with no side effects

Annual Methodological Archive Research Review
http://amresearchreview.com/index.php/Journal/about
Volume 4, Issue 6 (2026)

Online ISSN 3007-3197
Print ISSN 3007-3189
http://amresearchreview.com/index.php/Journal/about

has become necessary due to the use of MHT alongside additional therapies such photothermal, photodynamic, the airwaves, vaccinations, and chemotherapy treatments. Blasiak et al. [87] found malignancies tend to be identified by standard structural scans after they are barely millimeters (MRI) or centimeters (PET) in size by which point they usually contain over a million cells.

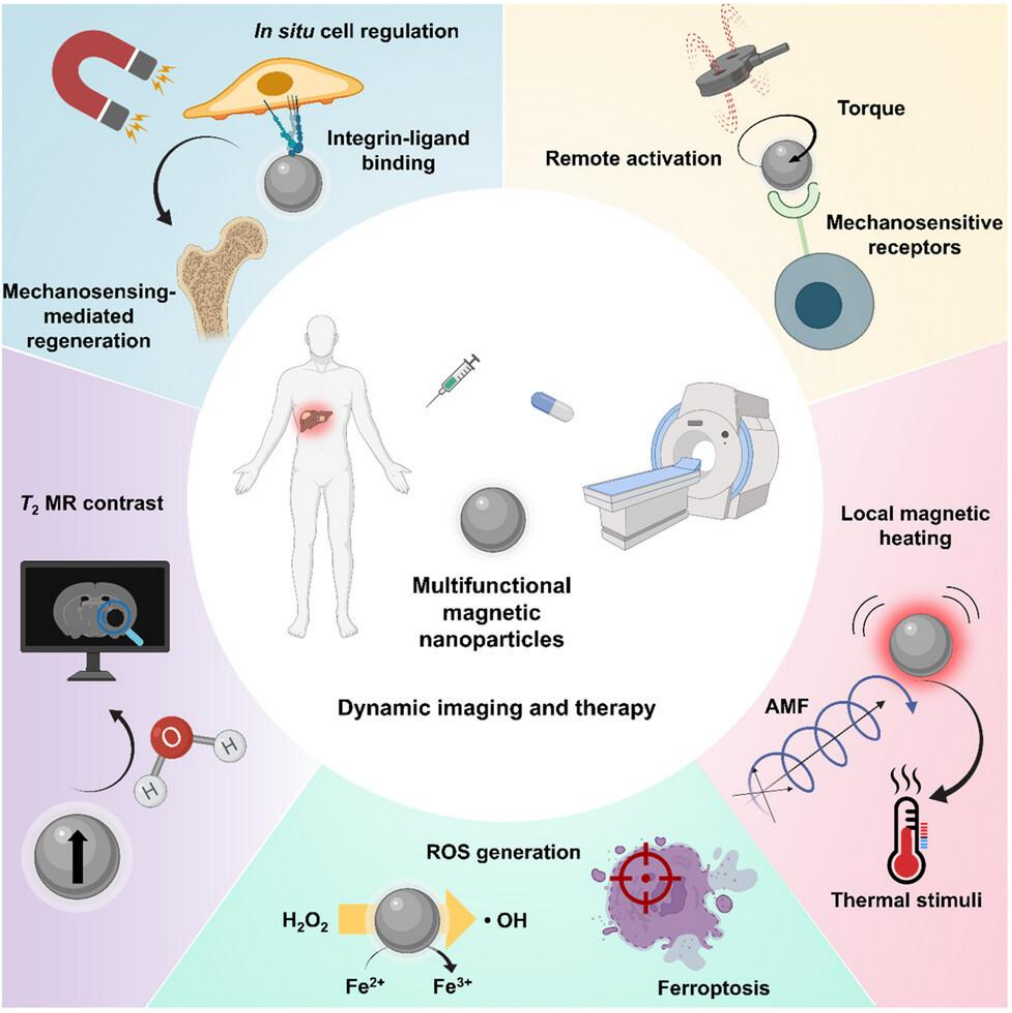

Fig. 11 Uses of multimodal MNPs with exterior magnetic fields for interactive imaging and treatment by following Ko et al. [88]

Parkes et al. [89] noted MRI limited precision (a 10% erroneous probability for carcinoma of the breast) has prevented it from being used to its fullest likelihood of diagnosing cancer. Meyers et al. [90] discussed a variety of substances, including metallic substances (nickel, metallic silver and platinum) or oxides of metal, make up nanomaterials with possible MRI-related health benefits. Ramchand et al. [91]

Annual Methodological Archive Research Review
http://amresearchreview.com/index.php/Journal/about
Volume 4, Issue 6 (2026)

Online ISSN 3007-3197
Print ISSN 3007-3189
http://amresearchreview.com/index.php/Journal/about

explained under the perspective of MRI technology, two kinds of contrasting agents which provide either favorable or adverse imaging distinction to boost MRI accuracy. Werner et al. [92] investigated the formation of these contrasting substances is only caused by variations in the endothelium across neoplasm and healthy tissues, certain cancer forms cannot be recognized by MRI. Weissleder [93] developed nanotechnology can be coupled with different biological carriers to enhance MR precision, such as individual region antigens that are unique for enzymes that accumulate in the microenvironment of tumors and on the outermost layers of cancerous cells. Firouznia et al. [94] acquired MRI can be used for precisely identifying lymph nodes involved in ailments, track the effectiveness of medication, and stage carcinoma, especially when paired with the utilization of nanotechnology. Liu et al. [95] delivered the chemotherapy drug epirubicin and provided an MRI contrast medium for brain tumors using polymer covered nanoparticles with magnetic attraction.

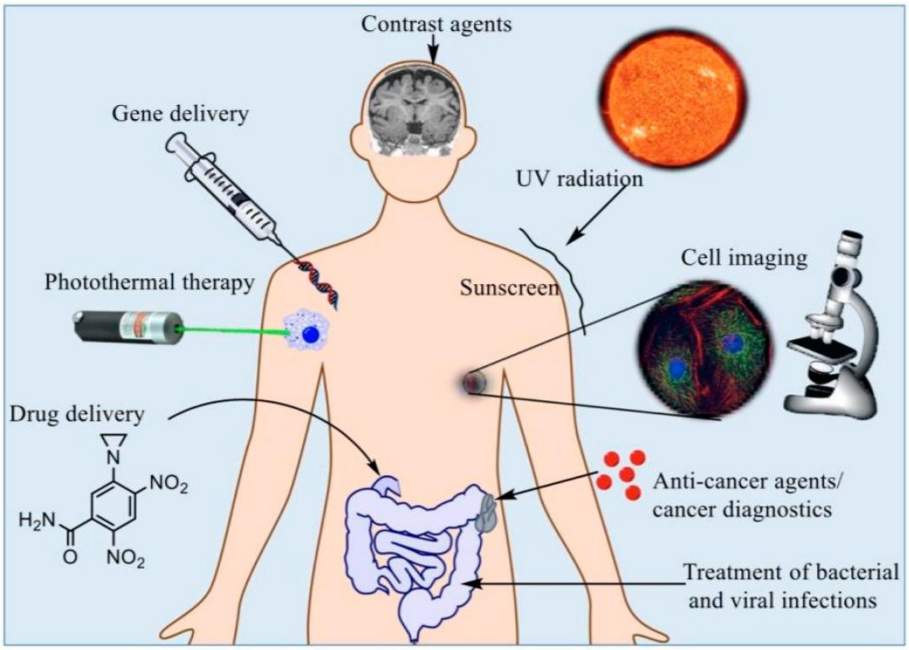

Fig. 12 Nanoparticles and magnetic resonance imaging (MRI) by following Anderson et al. [96]

Thorek et al. [97] provided magnetism pursuing, choices for heat exhaustion, and transparency with MRI (magnetic resonance imaging), are among the other benefits that come with using SPIO nanomaterials as a delivery transport. Lauffer et al. [98]

Annual Methodological Archive Research Review
http://amresearchreview.com/index.php/Journal/about
Volume 4, Issue 6 (2026)

Online ISSN 3007-3197
Print ISSN 3007-3189
http://amresearchreview.com/index.php/Journal/about

observed for harmless medical evaluation, MRI has become as one of the most common and efficient techniques because of its excellent cellular comparison, multidimensional image quality, and deep penetration. Wickline et al. [99] defined MNPs are a significant kind of microscopic technology that is presently being extensively developed for better detection of illnesses involving psychological, coronary, and oncology conditions. Filippousi [100] et al. showed several polymer chains, including polycaprolactone (PCL), polyethylene glycol, or PET , lactic acid, dextran are made, chitin, and others, have been previously approved by the FDA and used in conjunction with iron dioxide. Wang et al. [101] explained with potential uses for both MRI with heat exhaustion, the magnetized fluid (MF) produced with this approach demonstrated exceptional consistency and a quick magneto temperature interaction. Li et al. [102] interrogated among numerous additional advantages, hydrothermal synthesizing offers excellent precipitation and simple management of final form, making it one of the most promising methods for producing nanomaterials.

6. Conclusion

Magnetic nanoparticles (MNPs) have established themselves as versatile tools at the intersection of diagnostics and therapy, offering integrated solutions for complex biomedical challenges. Their unique magnetic behavior, tunable surface chemistry, and nanoscale dimensions enable precise interaction with biological systems, making them highly suitable for advanced medical applications. In imaging, particularly magnetic resonance imaging (MRI), MNPs significantly enhance contrast and improve the early detection of pathological conditions by providing clearer visualization of soft tissues and abnormal structures. In the therapeutic domain, the use of MNPs in magnetic hyperthermia and nanoburning introduces a targeted approach to disease treatment, especially in oncology. By converting electromagnetic energy into localized heat under an alternating magnetic field, these nanoparticles enable selective destruction of malignant cells while preserving surrounding healthy tissues. Additionally, their ability to act as drug carriers allows controlled and site-specific delivery, improving treatment efficiency and reducing systemic side effects.

Annual Methodological Archive Research Review
http://amresearchreview.com/index.php/Journal/about
Volume 4, Issue 6 (2026)

Online ISSN 3007-3197
Print ISSN 3007-3189
http://amresearchreview.com/index.php/Journal/about

Different classes of magnetic nanoparticles, including iron oxide-based particles, ferrites, and coated nanostructures, demonstrate distinct advantages depending on their composition and functionalization. Surface modification further enhances their stability, biocompatibility, and targeting capability, which are essential for clinical applications. Despite these promising features, several limitations remain, such as potential cytotoxicity, aggregation issues, and challenges in large-scale production and standardization. Addressing these concerns requires continued interdisciplinary research focusing on material optimization, safety assessment, and clinical validation. In summary, magnetic nanoparticles represent a powerful platform for next-generation medical technologies. Their integration into imaging and therapeutic systems is expected to advance personalized medicine, offering more accurate diagnosis and efficient treatment strategies in the near future.

References

[1] Moskvin, M.; Babiˇc, M.; Reis, S.; Cruz, M.M.; Ferreira, L.P.; Carvalho, M.D.; Lima, S.A.C.; Horák, D. Biological evaluation of surface-modified magnetic nanoparticles as a platform for colon cancer cell theranostics. Colloids Surf. B Biointerfaces 2018, 161, 35–41

[2] Shi, X.; Yang, W.; Ma, Q.; Lu, Y.; Xu, Y.; Bian, K.; Liu, F.; Shi, C.; Wang, H.; Shi, Y.; et al. Hemoglobin-mediated biomimetic synthesis of paramagnetic O2-evolving theranostic nanoprobes for MR imaging-guided enhanced photodynamic therapy of tumor. Theranostics 2020, 10, 11607–11621.

[3] Luo,D.; Wang, X.; Burda, C.; Basilion, J. Recent Development of Gold Nanoparticles as Contrast Agents for Cancer Diagnosis. Cancers 2021, 13, 1825.

[4] Persano, S.; Das, P.; Pellegrino, T. Magnetic Nanostructures as Emerging Therapeutic Tools to Boost Anti-Tumour Immunity. Cancers 2021, 13, 2735.

[5] Ullah, Z., Alotaibi, H., Akhter, A., Khan, I., & Niazai, S. (2024). Computational analysis of thermal performance of temperature dependent density and Arrhenius-activation energy of chemically reacting nanofluid along polymer porous sheet in high temperature differences. *AIP Advances*, *14*(6).

[6] Al Arni, S., El Jery, A., Ullah, Z., Alsulami, M. D., El-Zahar, E. R., Seddek, L. F.,

Annual Methodological Archive Research Review
http://amresearchreview.com/index.php/Journal/about
Volume 4, Issue 6 (2026)

Online ISSN 3007-3197
Print ISSN 3007-3189
http://amresearchreview.com/index.php/Journal/about

& Khedher, N. B. (2024). Oscillatory and non-oscillatory analysis of heat and mass transfer of Darcian MHD flow of nanofluid along inclined radiating plate with Joule heating and multiple slip effects: microgravity analysis. *Case Studies in Thermal Engineering*, *60*, 104681.

[7] Wust, P.; Hildebrandt, B.; Sreenivasa, G.; Rau, B.; Gellermann, J.; Riess, H.; Schlag, P.M. Hyperthermia in combined treatment of cancer. Lancet 2002, *3*, 487–497.

[8] Ali, A., Shah, T., Ullah, R., Zhou, P., Guo, M., Ovais, M., ... & Rui, Y. (2021). Review on recent progress in magnetic nanoparticles: Synthesis, characterization, and diverse applications. *Frontiers in chemistry*, *9*, 629054.

[9] Zhang,Y.; Li, M.; Gao, X.; Chen, Y.; Liu, T. Nanotechnology in cancer diagnosis: Progress, challenges and opportunities. J. Hematol. Oncol. 2019, 12, 137.

[10] Stafford, S.; Serrano Garcia, R.; Gun'ko, Y.K. Multimodal magnetic-plasmonic nanoparticles for biomedical applications. Appl. Sci. 2018, 8, 97.

[11] Kandasamy, G.; Sudame, A.; Luthra, T.; Saini, K.; Maity, D. Functionalized hydrophilic superparamagnetic iron oxide nanoparticles for magnetic fluid hyperthermia application in liver cancer treatment. ACS Omega 2018, *3*, 3991–4005.

[12] Ullah, Z., Altaweel, N. H., Aldhabani, M. S., Ghachem, K., Alhadri, M., & Kolsi, L. (2023). Oscillatory Behavior of Heat Transfer and Magnetic Flux of Electrically Conductive Fluid Flow along Magnetized Cylinder with Variable Surface Temperature. *Mathematics*, *11*(14), 3045.

[13] Boukholda, I., Ullah, Z., Mahrous, Y. M., Alamer, A., Amara, M. B., Alsulami, M. D., ... & Khedher, N. B. (2024). Analysis of thermal density and heat sink on dissipative nanofluid along magnetized sheet and applications in microelectronic cooling systems. *Case Studies in Thermal Engineering*, *55*, 104185.

[14] Flores-Rojas, G. G., López-Saucedo, F., Vera-Graziano, R., Mendizabal, E., & Bucio, E. (2022). Magnetic Nanoparticles for Medical Applications: Updated Review. *Macromol*, *2*(3), 374-390.

[15] Jin, R., Lin, B., Li, D., & Ai, H. (2014). Superparamagnetic iron oxide

Online ISSN 3007-3197
Print ISSN 3007-3189
http://amresearchreview.com/index.php/Journal/about

nanoparticles for MR imaging and therapy: design considerations and clinical applications. *Current opinion in pharmacology*, *18*, 18-27.

[16] Lam, T., Pouliot, P., Avti, P. K., Lesage, F., & Kakkar, A. K. (2013). Superparamagnetic iron oxide based nanoprobes for imaging and theranostics. *Advances in colloid and Interface Science*, *199*, 95-113.

[17] Matsuura, N., & Rowlands, J. A. (2008). Towards new functional nanostructures for medical imaging. *Medical physics*, *35*(10), 4474-4487.

[18] Ullah, Z., Alam, M. M., Elhag, S. H., Merga, F. E., Haider, I., & Malik, A. (2024). Evaluation of thermal and concentration slip effects on heat and mass transmission of nanofluid over a moving wedge surface using Keller box scheme. *AIP Advances*, *14*(10).

[19] Khedher, N. B., El-Zahar, E. R., Seddek, L. F., Ullah, Z., & Eldin, S. M. (2023). Amplitude and oscillating assessment of thermal and magnetic boundary layer flow across circular heated cylinder with heat source/sink. *Case Studies in Thermal Engineering*, *49*, 103216.

[20] Ullah, Z., Aldhabani, M. S., & Qaiser, M. A. (2023). Oscillatory and Periodical Behavior of Heat Transfer and Magnetic Flux along Magnetic-Driven Cylinder with Viscous Dissipation and Joule Heating Effects. *Mathematics*, *11*(18), 3917.

[21] Tegafaw, T., Liu, S., Ahmad, M. Y., Saidi, A. K. A. A., Zhao, D., Liu, Y., Nam, S.-W., Chang, Y., & Lee, G. H. (2023). Magnetic Nanoparticle-Based High-Performance Positive and Negative Magnetic Resonance Imaging Contrast Agents. *Pharmaceutics*, *15*(6), 1745.

[22] Jordan, A.; Scholz, R.; Wust, P.; Schirra, H.; Schiestel, T.; Schmidt, H.; Felix, R. Endocytosis of dextran and silan-coated magnetite nanoparticles and the effect of intracellular hyperthermia on human mammary carcinoma cells in vitro. J. Magn. Magn. Mater. 1999, 194, 185–196.

[23] Ullah, Z., Alam, M., El-Zahar, E. R., Shahab, S., Abu-Zinadah, H., Mahrous, Y. M., & Seddek, L. F. (2026). Magnetic confinement on fluctuating waves of heat radiations using ohmic heating around oscillatory fuel-sphere in fusion reactors: Energy dissipation model. *Thermal Science and Engineering Progress*,

Online ISSN 3007-3197
Print ISSN 3007-3189
http://amresearchreview.com/index.php/Journal/about

104513.

[24] Grüttner, C., Müller, K., Teller, J., & Westphal, F. (2013). Synthesis and functionalisation of magnetic nanoparticles for hyperthermia applications. *International Journal of Hyperthermia*, *29*(8), 777-789.

[25] Ullah, Z., Yasmin, S., Younis, J., Abdullah, A., Abbas, S., & Shah, A. (2022). Dynamics of Unsteady Flow of Chemically Reactive Upper-Convected Maxwell Fluid with Temperature-Dependent Viscosity: Keller Box Analysis. *Mathematical Problems in Engineering*, *2022*(1), 5344759.

[26] Belyanina, I., Kolovskaya, O., Zamay, S., Gargaun, A., Zamay, T., & Kichkailo, A. (2017). Targeted magnetic nanotheranostics of cancer. *Molecules*, *22*(6), 975.

[27] Grazu V, Silber A, Moros M, Asin L, Torres T, Marquina C, et al. Application of magnetically induced hyperthermia in the model protozoan Crithidia fasciculata as a potential therapy against parasitic infections. Int J Nanomedicine 2012;7:5351–60.

[28] van Landeghem FKH, Maier-Hauff K, Jordan A, Hoffmann K-T, Gneveckow U, Scholz R, et al. Post-mortem studies in glioblastoma patients treated with thermotherapy using magnetic nanoparticles. Biomaterials 2009;30:52–7.

[29] Carrey, J.; Mehdaoui, B.; Respaud, M. Simple models for dynamic hysteresis loop calculations of magnetic single-domain nanoparticles: Application to magnetic hyperthermia optimization. J. Appl. Phys. 2011, 109, doi:10.1063/1.3551582.

[30] Salih, A. A., Ullah, Z., Alam, M. M., Mahrous, Y. M., Alsulami, M. D., Benaissa, M., ... & Khedher, N. B. (2026). Turbulent heat and mass transfer in Williamson nanofluid flow over gasketed-plate heat exchanger: Influence of exothermic catalytic-reaction and radiative-heat source. *Engineering Science and Technology, an International Journal*, *76*, 102305.

[31] Baronzio, G. F., & Hager, E. D. (Eds.). (2008). Hyperthermia in Cancer Treatment: A Primer. Springer Science & Business Media.

[32] Ullah, Z., Alam, M. M., Tariq, U., Mahrous, Y. M., Merga, F. E., Albouchi, F., ... & Faqihi, A. A. (2024). Variable density and heat generation impact on

Online ISSN 3007-3197
Print ISSN 3007-3189
http://amresearchreview.com/index.php/Journal/about

chemically reactive carreau nanofluid heat-mass transfer over stretching sheet with convective heat condition. *Case Studies in Thermal Engineering*, *63*, 105260.

[33] Kumar, C. S., & Mohammad, F. (2011). Magnetic nanomaterials for hyperthermia-based therapy and controlled drug delivery. *Advanced drug delivery reviews*, *63*(9), 789-808.

[34] Krishnan S, Diagaradjane P, Cho SH. Nanoparticle-mediated thermal therapy: evolving strategies for prostate cancer therapy. Int J Hyperthermia. 2010;26:775–789.

[35] Jin J, Wang FP, Wei H, et al. Reversal of multidrug resistance of cancer through inhibition of P-glycoprotein by 5-bromotertrandrine. Cancer Chemother Pharmacol. 2005;55:179–188.

[36] Chen BA, Cheng J, Wu YN, et al. Reversal of multidrug resistance by magnetic Fe3 O4 nanoparticle copolymerizating daunorubicin and 5-bromotetrandrine in xenograft nude-mice. Int J Nanomedicine. 2009;4:73–78.

[37] Ullah, Z., Makinde, O. D., & Hussanan, A. (2024). Temperature-dependent density effects on oscillatory mixed convective flow across a non-conducting horizontal circular cylinder embedded in a porous medium. *International Journal of Ambient Energy*, *45*(1), 2423226.

[38] Laurent, S.; Dutz, S.; Häfeli, U.O.; Mahmoudi, M.; Magnetic fluid hyperthermia: Focus on superparamagnetic iron oxide NPs. Adv Colloid Interface Sci 2011, 166, 8-23.

[39] Ullah, Z., Alam, M. M., Khan, A. A., Alkarni, S., & Merga, F. E. (2025). Radiative heat and mass transfer of second-grade nanofluid slip flow with variable thermal properties. *AIP Advances*, *15*(3).

[40] Tong, S., Zhu, H., & Bao, G. (2019). Magnetic iron oxide nanoparticles for disease detection and therapy. *Materials Today*, *31*, 86-99.

[41] Lee, S. W., Bae, S., Takemura, Y., Shim, I. B., Kim, T. M., Kim, J., ... & Kim, C. S. (2007). Self-heating characteristics of cobalt ferrite nanoparticles for hyperthermia application. *Journal of Magnetism and Magnetic Materials*, *310*(2), 2868-2870.

Annual Methodological Archive Research Review
http://amresearchreview.com/index.php/Journal/about
Volume 4, Issue 6 (2026)

Online ISSN 3007-3197
Print ISSN 3007-3189
http://amresearchreview.com/index.php/Journal/about

[42] Kim, D. H., Nikles, D. E., Johnson, D. T., & Brazel, C. S. (2008). Heat generation of aqueously dispersed CoFe2O4 nanoparticles as heating agents for magnetically activated drug delivery and hyperthermia. *Journal of Magnetism and Magnetic Materials*, *320*(19), 2390-2396.

[43] Ullah, Z., Abbas, A., Tariq, U., Haq, M. I. U., Kaynat, A., Bibi, A., ... & Ashraf, M. (2025). Gravity modulation analysis of heat transfer and magnetic boundary layer of MHD fluid along vertical plate with variable viscosity and porous medium effects. *Computational Environmental Heat Transfer*, *1*(2), 51-64.

[44] Nabwey, H. A., Ashraf, M., Ullah, Z., Rashad, A. M., & Chamkha, A. J. (2024). Reviewing the impact of magnetic Prandtl number and magnetic force parameter on convective heat transfer in boundary layers. *Special Topics & Reviews in Porous Media: An International Journal*, *15*(5).

[45] Yuan, X. B., Li, H., Zhu, X. X., & Woo, H. G. (2006). Self-aggregated nanoparticles composed of periodate-oxidized dextran and cholic acid: preparation, stabilization and in-vitro drug release. *Journal of Chemical Technology & Biotechnology: International Research in Process, Environmental & Clean Technology*, *81*(5), 746-754.

[46] Swatsitang, E., Phokha, S., Hunpratub, S., Usher, B., Bootchanont, A., Maensiri, S., & Chindaprasirt, P. (2016). Characterization and magnetic properties of cobalt ferrite nanoparticles. *Journal of Alloys and Compounds*, *664*, 792-797.

[47] Franco, A., Pereira Alves, T. E., de Oliveira Lima, E. C., da Silva Nunes, E., & Zapf, V. (2009). Enhanced magnetization of nanoparticles of Mg x Fe (3− x) O 4 (0.5≤ x≤ 1.5) synthesized by combustion reaction. *Applied Physics A*, *94*, 131-137.

[48] Maehara, T., Konishi, K., Kamimori, T., Aono, H., Naohara, T., Kikkawa, H., ... & Kawachi, K. (2002). Heating of ferrite powder by an AC magnetic field for local hyperthermia. *Japanese journal of applied physics*, *41*(3R), 1620.

[49] Ullah, Z., Alam, M. M., Younis, J., Elhag, S. H., Hussain, A., & Haider, I. (2024). Computational study of heat and mass transfer with Soret/Dufour effects on power-law magneto nanofluid flow along stretching surface. *AIP Advances*, *14*(9).

Annual Methodological Archive Research Review
http://amresearchreview.com/index.php/Journal/about
Volume 4, Issue 6 (2026)

Online ISSN 3007-3197
Print ISSN 3007-3189
http://amresearchreview.com/index.php/Journal/about

[50] Asab, G., Zereffa, E. A., & Abdo Seghne, T. (2020). Synthesis of silica-coated Fe3O4 nanoparticles by microemulsion method: characterization and evaluation of antimicrobial activity. *International journal of biomaterials*, *2020*(1), 4783612.

[51] Zuo, Z., Majeed, S., Ali, B., Shah, N. A., Ullah, Z., & Riaz, S. (2025). Insight into oscillation of wall temperature and horizontal Lorentz force in rotating water conveying solid aluminum oxide tiny particles nanolayer via simulation of finite element computation. *Chaos, Solitons & Fractals*, *194*, 116141.

[52] Hu, P., Chang, T., Chen, W. J., Deng, J., Li, S. L., Zuo, Y. G., ... & Volinsky, A. A. (2019). Temperature effects on magnetic properties of Fe3O4 nanoparticles synthesized by the sol-gel explosion-assisted method. *Journal of Alloys and Compounds*, *773*, 605-611.

[53] Ullah, Z., Alam, M. M., El-Zahar, E. R., Shahab, S., Abu-Zinadah, H., Mahrous, Y. M., ... & Faqihi, A. A. (2025). Turbulent and steady boundary layers and radiative heat transfer over magnetic coated elastic-polymer surface in drug-eluting polymeric stents: Powell-Eyring turbulence model. *Chaos, Solitons & Fractals*, *200*, 117054.

[54] Borade, R. M., Somvanshi, S. B., Kale, S. B., Pawar, R. P., & Jadhav, K. M. (2020). Spinel zinc ferrite nanoparticles: an active nanocatalyst for microwave irradiated solvent free synthesis of chalcones. *Materials Research Express*, *7*(1), 016116.

[55] Yang, S. H., Kang, B., Choi, Y., Rho, H. W., Son, H. Y., & Huh, Y. M. (2021). Genetic changes and growth promotion of glioblastoma by magnetic nanoparticles and a magnetic field. *Nanomedicine*, *16*(10), 787-800.

[56] Koksharov, Y.A. Magnetism of Nanoparticles: Effects of Size, Shape, and Interactions. In Magnetic Nanoparticles, 1st ed.; Gubin, S.P., Ed.; Wiley-VCH: Berlin, Germany, 2009; pp. 228–229.

[57] Issa, B.; Obaidat, I.M.; Albiss, B.A.; Haik, Y. Magnetic nanoparticles: Surface effects and properties related to biomedicine applications. Int. J. Mol. Sci. 2013, 14, 21266–21305.

Annual Methodological Archive Research Review
http://amresearchreview.com/index.php/Journal/about
Volume 4, Issue 6 (2026)

Online ISSN 3007-3197
Print ISSN 3007-3189
http://amresearchreview.com/index.php/Journal/about

[58] Obaidat, I. M., Issa, B., & Haik, Y. (2015). Magnetic properties of magnetic nanoparticles for efficient hyperthermia. *Nanomaterials*, *5*(1), 63-89.

[59] Ullah, Z., Alam, M. M., Younis, J., Haider, I., Alqurashi, M. S., Abu-Zinadah, H., ... & Faqihi, A. A. (2024). Entropy optimization of MHD second-grade nanofluid thermal transmission along stretched sheet with variable density and thermal-concentration slip effects. *Case Studies in Thermal Engineering*, *63*, 105288.

[60] Ullah, Z., Alam, M. M., Ilyas, A., Said, M. A., Abu-Zinadah, H., Alsulami, M. D., ... & Faqihi, A. A. (2025). Slip temperature oscillation, turbulent magnetic-radiation and heat frequency effects on unsteady nanofluid along horizontal stretching circular cylinder: Darcy-Forchheimer nonlinear model. *Chaos, Solitons & Fractals*, *196*, 116432.

[61] Jones EL, Prosnitz LR, Dewhirst MW, Marcom PK, Hardenbergh PH, Marks LB, et al. Thermochemoradiotherapy improves oxygenation in locally advanced breast cancer. Clin Cancer Res 2004;10:4287–93.

[62] Riedinger, A.; Guardia, P.; Curcio, A.; Garcia, M. A.; Cingolani, R.; Manna, L.; Pellegrino, T. Subnanometer Local Temperature Probing and Remotely Controlled Drug Release Based on Azo Functionalized Iron Oxide Nanoparticles. Nano Lett. 2013, 13 (6), 2399–2406.

[63] Ullah, Z., Alam, M. M., Ilyas, A., El-Zahar, E. R., Shahab, S., Seddek, L. F., ... & Merga, F. E. (2025). Turbulent magnetic flux and heat transfer amplitude of unsteady MHD fluid using solar energy and joule heating with thermally stratified medium and gravitational conditions. *Case Studies in Thermal Engineering*, 106935.

[64] Diamond d. overview. in: Wiley N, editor. Principles of Chemical and Biological Sensors; 1998: p. 1-18.

[65] Hilger, I. (2013). *In vivo* applications of magnetic nanoparticle hyperthermia. *International Journal of Hyperthermia*, *29*(8), 828–834.

[66] Bareford LM, Swaan PW. endocytic mechanisms for targeted drug delivery. adv drug deliv Rev 2007;59:748-758.

[67] Sanhai WR, Sakamoto JH, Canady R, et al. Seven challenges for nanomedicine.

Online ISSN 3007-3197
Print ISSN 3007-3189
http://amresearchreview.com/index.php/Journal/about

Nat Nanotechnol 2008;3:242-244.

[68] Hu L, Mao Z, gao C. Colloidal particles for cellular uptake and delivery. J Mater Chem 2009;19:3108-3115.

[69] Sardari D, Verg N. Cancer treatment with hyperthermia. In: Ozdemir O, editor. Current cancer treatment– novel beyond con ventional approaches. Rijeka, Croatia: InTech; 2011. p. 454–474.

[70] Thiesen B, Jordan A. Clinical applications of magnetic nanopar ticles for hyperthermia. Int J Hyperthermia. 2008;24:467–474.

[71] Ullah, Z. (2024). Thermal and concentration slip analysis on heat and mass transfer in magnetic-driven dissipative nanofluid across stretched sheet for high temperature difference. *Arabian Journal for Science and Engineering*, *49*(11), 14773-14785.

[72] Al-Shammari, H., Ullah, Z., Albouchi, F., Ilyas, A., Aldhabani, M. S., Alrihieli, H. F., ... & Hassan, A. M. (2024). Primitive and gravity modulation of periodical heat transfer along magnetic-driven porous cone with thermal conductivity and surface heat flux. *Case Studies in Thermal Engineering*, *53*, 103866.

[73] Zhao X, Kim J, Cezar CA, et al. Active scaffolds for on-demand drug and cell delivery. Proc Natl Acad Sci U S A. 2011;108:67–72.

[74] Zhang, L., Li, Q., Liu, J., Deng, Z., Zhang, X., Alifu, N., ... & Sun, K. (2024). Recent advances in functionalized ferrite nanoparticles: from fundamentals to magnetic hyperthermia cancer therapy. *Colloids and Surfaces B: Biointerfaces*, *234*, 113754.

[75] Kobayashi, T. Cancer hyperthermia using magnetic nanoparticles. Biotechnol. J. 2011, 6, 1342–1347.

[76] Otte, J. (1988). Hyperthermia in cancer therapy. *European journal of pediatrics*, *147*, 560-569.

[77] Islam, K.; Haque, M.; Kumar, A.; Hoq, A.; Hyder, F.; Hoque, S.M.J.N. Manganese ferrite nanoparticles (MnFe2O4): Size dependence for hyperthermia and negative/positive contrast enhancement in MRI. Nanomaterials 2020, 10, 2297.

Annual Methodological Archive Research Review
http://amresearchreview.com/index.php/Journal/about
Volume 4, Issue 6 (2026)

Online ISSN 3007-3197
Print ISSN 3007-3189
http://amresearchreview.com/index.php/Journal/about

[78] Ullah, Z., Alotaibi, H., & Usman, A. *Thermal slip and variable viscosity analysis on heat rate and magnetic flux through accelerating non-conducting wedge in the presence of induced magnetic field. Sci Rep 2024; 14.*

[79] Pankhurst, Q.A.; Connolly, J.; Jones, S.K.; Dobson, J. Applications of magnetic nanoparticles in biomedicine. J. Phys. D Appl. Phys. 2003, 36, R167–R181.

[80] Teran, F.J.; Casado, C.; Mikuszeit, N.; Salas, G.; Bollero, A.; Morales, M.; Camarero, J.; Miranda, R. Accurate determination of the specific absorption rate in superparamagnetic nanoparticles under non-adiabatic conditions. Appl. Phys. Lett. 2012, 101, 062413.

[81] Bonnemain B. Superparamagnetic agents in magnetic resonance imaging: physicochemical characteristics and clinical applica tions. a review. J drug target 1998;6:167-174.

[82] Yuan C, Kerwin WS. MRi of atherosclerosis. J Magn Reson imag ing 2004;19:710-719.

[83] David R, Groebner M, Franz WM. Magnetic cell sorting purifica tion of differentiated embryonic stem cells stably expressing trun cated human Cd4 as surface marker. Stem Cells 2005;23:477-482.

[84] Nabwey, H. A., Ullah, Z., Ilyas, A., Ashraf, M., Rashad, A. M., Alshber, S. I., & Abu Hawsah, M. (2023). Reduced gravity and magnetohydrodynamic effects on transient mixed convection flow past a magnetized heated cone embedded in porous medium. *Journal of Mathematics*, *2023*(1), 9618432.

[85] Levy, M., Quarta, A., Espinosa, A., Figuerola, A., Wilhelm, C., García-Hernández, M., ... & Pellegrino, T. (2011). Correlating magneto-structural properties to hyperthermia performance of highly monodisperse iron oxide nanoparticles prepared by a seeded-growth route. *Chemistry of Materials*, *23*(18), 4170-4180.

[86] Thomas, R., Park, I. K., & Jeong, Y. Y. (2013). Magnetic iron oxide nanoparticles for multimodal imaging and therapy of cancer. *International journal of molecular sciences*, *14*(8), 15910-15930.

[87] Blasiak, B., Van Veggel, F. C., & Tomanek, B. (2013). Applications of nanoparticles for MRI cancer diagnosis and therapy. *Journal of*

Online ISSN 3007-3197
Print ISSN 3007-3189
http://amresearchreview.com/index.php/Journal/about

Nanomaterials, *2013*(1), 148578.

[88] Ko, M. J., Hong, H., Choi, H., Kang, H., & Kim, D. H. (2022). Multifunctional magnetic nanoparticles for dynamic imaging and therapy. *Advanced NanoBiomed Research*, *2*(11), 2200053.

[89] Parkes, L. M., Hodgson, R., Lu, L. T., Tung, L. D., Robinson, I., Fernig, D. G., & Thanh, N. T. (2008). Cobalt nanoparticles as a novel magnetic resonance contrast agent—relaxivities at 1.5 and 3 Tesla. *Contrast media & molecular imaging*, *3*(4), 150-156.

[90] Meyers, J. D., Doane, T., Burda, C., & Basilion, J. P. (2013). Nanoparticles for imaging and treating brain cancer. *Nanomedicine*, *8*(1), 123-143.

[91] Ramchand, C. N., Pande, P., Kopcansky, P., & Mehta, R. V. (2001). Application of magnetic fluids in medicine and biotechnology.

[92] Werner, E. J., Datta, A., Jocher, C. J., & Raymond, K. N. (2008). High-relaxivity MRI contrast agents: where coordination chemistry meets medical imaging. *Angewandte Chemie International Edition*, *47*(45), 8568-8580.

[93] Weissleder, R. (2006). Molecular imaging in cancer. *Science*, *312*(5777), 1168-1171.

[94] Firouznia, K., Amirmohseni, S., Guiti, M., Amanpour, S., Baitollahi, A., Kharadmand, A. A., ... & Oghabian, M. A. (2008). MR relaxivity measurement of iron oxide nano-particles for MR lymphography applications. *Pakistan Journal of Biological Sciences: PJBS*, *11*(4), 607-612.

[95] Liu, H. L., Hua, M. Y., Yang, H. W., Huang, C. Y., Chu, P. C., Wu, J. S., ... & Wei, K. C. (2010). Magnetic resonance monitoring of focused ultrasound/magnetic nanoparticle targeting delivery of therapeutic agents to the brain. *Proceedings of the National Academy of Sciences*, *107*(34), 15205-15210.

[96] Anderson, S.; Gwenin, V.V.; Gwenin, C.D. Magnetic Functionalized Nanoparticles for Biomedical, Drug Delivery and Imaging Applications. *Nanoscale Res. Lett.* **2019**, *14*, 1–16.

[97] Thorek DL, Chen AK, Czupryna J, Tsourkas A. Superparamagnetic iron oxide nanoparticle probes for molecular imaging. Ann Biomed Eng 2006; 34: 23-38

Annual Methodological Archive Research Review
http://amresearchreview.com/index.php/Journal/about
Volume 4, Issue 6 (2026)

Online ISSN 3007-3197
Print ISSN 3007-3189
http://amresearchreview.com/index.php/Journal/about

[98] Lauffer R, Edelman R, Zlatkin M, Hesselink J, Saunders W. 1996. MRI Clinical Magnetic Resonance Imaging. Philadelphia (PA): WB Saunders Co.

[99] Wickline SA, Neubauer AM, Winter PM, Caruthers SD, Lanza GM. 2007. Molecular imaging and therapy of atherosclerosis with targeted nano particles. J Magn Reson Imaging. 25:667–680.

[100] Filippousi M, Papadimitriou SA, Bikiaris DN, Pavlidou E, Angelakeris M, Zamboulis D, et al. 2013. Novel core–shell magnetic nanoparticles for Taxol encapsulation in biodegradable and biocompatible block copolymers: preparation, characterization and release properties. Int J Pharm. 448:221–230.

[101] Wang YM, Cao X, Liu GH, Hong RY, Chen YM, Chen XF, et al. 2011. Synthesis of Fe3O4 magnetic fluid used for magnetic resonance imag ing and hyperthermia. J Magnet Magn Mater. 323:2953–2959.

[102] Li J, Zheng L, Cai H, Sun W, Shen M, Zhang G, et al. 2013. Polyethyleneimine-mediated synthesis of folic acid-targeted iron oxide nanoparticles for in vivo tumor MR imaging. Biomaterials. 34: 8382–8392.