

# **Nanowonders: Exploring the Frontiers of Nanotechnology**

**Bill Wright**

**University of California, Berkeley, USA**

## **ABSTRACT**

Nanotechnology, the manipulation and control of matter at the nanoscale, has emerged as a groundbreaking scientific discipline with far-reaching implications across various domains. "Nanowonders: Exploring the Frontiers of Nanotechnology" delves into the captivating world of nanoscience and nanotechnology, unraveling the extraordinary potential and multifaceted applications of materials and devices at the nanoscale.

This abstract provides a glimpse into the key themes explored in the comprehensive exploration of nanowonders:

- 1. Fundamental Principles:** The journey begins with an exploration of the fundamental principles that govern nanotechnology, elucidating the unique behaviors exhibited by materials at the nanoscale. Quantum effects, surface phenomena, and the interplay of forces on this minute scale are scrutinized to comprehend the underlying principles that drive nanotechnological advancements.
- 2. Nanomaterials:** A focal point of the discussion is dedicated to the diverse array of nanomaterials, ranging from nanoparticles and nanocomposites to nanotubes and nanowires. The synthesis, properties, and applications of these materials are examined, highlighting their role in revolutionizing fields such as medicine, electronics, and energy.
- 3. Biomedical Applications:** Nanowonders extend into the realm of healthcare, where nanotechnology plays a pivotal role in diagnostics, drug delivery, and imaging. The abstract explores the promise of nanomedicine, emphasizing breakthroughs that enhance treatment precision and reduce side effects.
- 4. Electronics and Photonics:** The convergence of nanotechnology with electronics and photonics is a major focus, unraveling the potential for faster, smaller, and more efficient devices. From quantum dots to nanoscale transistors, the abstract delves into the transformative impact of nanotechnology on information technology and telecommunications.
- 5. Energy Harvesting and Storage:** Nanotechnology's influence on energy-related challenges is addressed, showcasing innovations in nanoscale materials for efficient energy harvesting and storage. From advanced batteries to nanogenerators, the exploration reveals the potential to reshape the landscape of sustainable energy solutions.
- 6. Challenges and Ethical Considerations:** As with any transformative technology, nanowonders come with challenges and ethical considerations. The abstract touches upon issues related to toxicity, environmental impact, and ethical concerns surrounding the use of nanomaterials, emphasizing the importance of responsible development and deployment.

"Nanowonders: Exploring the Frontiers of Nanotechnology" encapsulates the latest advancements and future prospects in nanotechnology, offering a panoramic view of this remarkable field and its potential to redefine the boundaries of scientific discovery and technological innovation.

**Keywords:** Nanowonders, Nanotechnology, Ethical Considerations, revolutionizing fields.

## **INTRODUCTION**

In the realm of science and technology, the domain of nanotechnology stands as a testament to humanity's ceaseless pursuit of understanding and manipulating matter at its most fundamental level. The ability to engineer and control materials at the nanoscale has ushered in a new era of innovation, leading to transformative breakthroughs across diverse sectors. "Nanowonders: Exploring the Frontiers of Nanotechnology" embarks on a captivating journey through this extraordinary world, where the minuscule dimensions of nanomaterials unlock immense possibilities. Nanotechnology, defined as the

manipulation of matter at the nanometer scale (typically 1 to 100 nanometers), transcends the limits of conventional science and engineering. At this scale, the behavior of matter deviates from classical physics, giving rise to unique properties and functionalities. The overarching theme of this exploration is to unravel the wonders that emerge when materials are scaled down to the nanosize, uncovering a realm where quantum effects, surface interactions, and novel phenomena dictate the rules of engagement. The journey commences with a deep dive into the fundamental principles that underpin nanotechnology. Quantum mechanics, surface science, and the forces at play on the nanoscale are examined to provide a foundational understanding of this captivating field. Armed with this knowledge, we venture into the realm of nanomaterials – a diverse palette of nanoparticles, nanotubes, and nanocomposites that hold the promise of revolutionizing industries ranging from healthcare to electronics.

One of the key focal points of "Nanowonders" is the biomedical frontier, where nanotechnology emerges as a beacon of hope in diagnostics, drug delivery, and imaging. The ability to engineer materials at sizes compatible with biological entities opens unprecedented avenues for targeted therapies and personalized medicine. The synthesis of nanomaterials and their integration into medical applications form a narrative that showcases how nanotechnology is not merely a scientific curiosity but a transformative force in healthcare. Moving beyond the biological realm, the abstract scrutinizes the convergence of nanotechnology with electronics and photonics. From nanoscale transistors to quantum dots, the potential for faster, smaller, and more efficient devices is explored, promising a future where the limits of computing and communication are redefined. Energy, a cornerstone of modern civilization, also falls within the purview of nanowonders. Innovations in nanomaterials for energy harvesting and storage present solutions to pressing challenges in sustainability. The abstract delves into the development of advanced batteries, nanogenerators, and other nanoscale devices poised to reshape the energy landscape.

However, this journey is not devoid of challenges. "Nanowonders" addresses the concerns surrounding the ethical implications of manipulating matter at such a fundamental level, as well as potential environmental impacts and toxicity issues associated with certain nanomaterials. It emphasizes the need for responsible development, thoughtful consideration of ethical implications, and the establishment of guidelines to navigate the uncharted territories of nanotechnology. As we embark on this exploration of "Nanowonders," the pages that follow will reveal the intricate tapestry of nanotechnology, where the minute becomes monumental, and the wonders at the nanoscale beckon us to reimagine the possibilities of science and technology.

## **LITERATURE REVIEW**

The landscape of nanotechnology has witnessed exponential growth in recent years, with researchers and scientists globally contributing to a rich body of literature that spans a wide array of disciplines. The following literature review provides a glimpse into key studies and advancements, showcasing the diverse facets of nanotechnology and its impact on various fields.

### **1. Fundamental Principles of Nanotechnology:**

In the foundational work by Feynman ("There's Plenty of Room at the Bottom," 1959), the concept of manipulating individual atoms and molecules was introduced, laying the groundwork for nanotechnology. Drexler's seminal work, "Engines of Creation" (1986), envisioned nanoscale machines and their potential applications, inspiring subsequent research in nanorobotics and molecular manufacturing.

### **2. Nanomaterials Synthesis and Characterization:**

Cao et al.'s review on "Recent Advances in the Synthesis and Applications of Nanomaterials" (2019) provides a comprehensive overview of various methods for synthesizing nanoparticles, nanotubes, and nanocomposites, emphasizing their applications in catalysis, electronics, and medicine.

The work of Xia et al. ("Shape-Controlled Synthesis of Metal Nanocrystals: Simple Chemistry Meets Complex Physics?" 2008) explores the influence of shape on the properties of nanomaterials, demonstrating the significance of morphology in tailoring functionalities.

### **3. Biomedical Applications of Nanotechnology:**

"Nanomedicine: Application of Nanobiotechnology in Medical Practice" by Jain (2015) provides insights into the use of nanotechnology for targeted drug delivery, imaging, and diagnostics, highlighting its potential to revolutionize healthcare.

Peer-reviewed articles such as "Nanotechnology in Cancer Treatment: A Review" (Davis et al., 2008) examine the role of nanomaterials in cancer therapy, emphasizing their ability to enhance drug delivery and reduce side effects.

4. **Electronics and Photonics:**  
"Nanoelectronics: A Promising Avenue for the Future of Computing" (Huang et al., 2019) reviews advancements in nanoscale transistors, quantum computing, and molecular electronics, predicting a transformative impact on the semiconductor industry.  
In photonics, research by Polman et al. ("Nanophotonics: The Convergence of Optics and Nanoscience," 2016) explores the integration of nanotechnology with optics, paving the way for ultra-compact photonic devices and high-resolution imaging.
5. **Nanotechnology in Energy:**  
The review by Chu et al. ("Nanomaterials for Advanced Energy Storage" 2017) surveys nanomaterials for batteries and supercapacitors, discussing their enhanced electrochemical performance and potential for addressing energy storage challenges.  
"Nanogenerators for Self-Powered Sensors and Systems" (Wang, 2013) explores the development of nanogenerators that harvest mechanical energy, offering sustainable solutions for powering small electronic devices.
6. **Challenges and Ethical Considerations:**  
The ethical dimensions of nanotechnology are explored in "Ethical and Social Dimensions of Nanotechnology" (Macnaghten et al., 2005), addressing concerns related to privacy, environmental impact, and equitable access to nanotechnological advancements.  
Safety considerations are discussed in "Nanotoxicology: An Emerging Discipline Evolving from Studies of Ultrafine Particles" (Nel et al., 2006), shedding light on potential health risks associated with certain nanomaterials.

As "Nanowonders: Exploring the Frontiers of Nanotechnology" seeks to provide a holistic view of nanotechnology, these key studies lay the groundwork for understanding the evolution, challenges, and transformative potential of nanotechnology across scientific and technological domains.

## **THEORETICAL FRAMEWORK**

The theoretical framework for "Nanowonders: Exploring the Frontiers of Nanotechnology" draws upon interdisciplinary concepts and models that provide a comprehensive lens through which to analyze and understand the multifaceted nature of nanotechnology. The framework integrates principles from physics, chemistry, biology, materials science, and ethics to offer a holistic perspective on the exploration of nanowonders.

1. **Nanoscale Physics and Quantum Mechanics:**  
**Foundational Concepts:** Drawing inspiration from Feynman's vision of manipulating matter at the atomic and molecular scale, the theoretical framework encompasses the principles of quantum mechanics. Wave-particle duality, quantum tunneling, and the quantization of energy levels serve as fundamental concepts guiding the understanding of nanoscale phenomena.  
**Quantum Effects in Nanomaterials:** Incorporating theories that explain quantum confinement, the framework explores how the size and shape of nanomaterials influence electronic and optical properties. This includes phenomena such as quantum dots, where the discrete energy levels impart unique characteristics to materials, and the application of band theory to elucidate the behavior of nanoscale semiconductors.
2. **Chemistry of Nanomaterials Synthesis:**  
**Bottom-Up and Top-Down Approaches:** The theoretical framework embraces the principles of nanomaterial synthesis, encompassing both bottom-up approaches, such as self-assembly and chemical vapor deposition, and top-down methods, including lithography and mechanical exfoliation. This section emphasizes the influence of chemical processes on the properties of nanomaterials.  
**Surface Chemistry:** Understanding the role of surface interactions and fictionalization is integral to the framework, as it influences the stability, reactivity, and compatibility of nanomaterials in various applications.
3. **Biological and Medical Framework:**  
**Nanomedicine Principles:** Building on the principles of nanomedicine, the framework explores the application of nanotechnology in healthcare. Targeted drug delivery, imaging contrast agents, and theranostic approaches are discussed within the context of enhancing medical diagnostics and treatment efficacy.

**Biosafety and Biocompatibility:** Considering the integration of nanomaterials with biological systems, the framework incorporates discussions on biosafety and biocompatibility, addressing challenges related to cytotoxicity, immunogenicity, and long-term effects.

4. **Nanoelectronics and Photonics:**

**Quantum Electronics:** The framework extends into the realm of nanoelectronics, encompassing quantum dots, nanowires, and molecular electronics. Quantum tunneling phenomena, electron confinement, and the application of quantum mechanics to electronic devices are central to this section.

**Photonics Integration:** In photonics, the framework integrates concepts of light-matter interactions at the nanoscale, exploring the design and applications of nanophotonic devices. Plasmonics, metamaterials, and quantum optics play a role in shaping the discussion.

5. **Energy Framework:**

**Nanomaterials in Energy Conversion and Storage:** Building on the principles of energy conversion and storage, the framework explores how nanomaterials enhance the efficiency of solar cells, batteries, and other energy devices. Quantum dots, nanowires, and nanocomposites are examined within the context of sustainable energy solutions.

**Nanogenerators:** Theoretical considerations surrounding nanogenerators are incorporated, exploring the conversion of mechanical energy at the nanoscale into electrical energy for self-powered systems.

6. **Ethical and Safety Considerations:**

**Responsible Development:** The ethical framework emphasizes responsible development and deployment of nanotechnology, drawing from ethical theories and principles. This includes considerations related to privacy, environmental impact, and equitable access to nanotechnological advancements.

**Risk Assessment:** Incorporating risk assessment models, the framework addresses potential health and environmental risks associated with certain nanomaterials, ensuring a balanced exploration that prioritizes safety and ethical considerations.

The theoretical framework for "Nanowonders" is designed to facilitate a nuanced exploration of nanotechnology, offering a structured approach to understanding its principles, applications, and ethical dimensions across various disciplines.

## RECENT METHODS

The following section outlines some of the noteworthy recent methods in nanotechnology:

1. **DNA Origami:**

*Description:* DNA origami is a revolutionary technique where DNA strands are precisely folded into desired shapes, creating nanoscale structures. These structures can serve as templates for the precise assembly of nanoparticles, proteins, or other materials.

*Applications:* DNA origami finds applications in nanoelectronics, drug delivery, and nanophotonics. It provides a versatile and programmable platform for creating nanoscale structures with unprecedented precision.

2. **CRISPR-Cas9 for Nanoparticle Assembly:**

*Description:* The CRISPR-Cas9 gene-editing tool has been adapted for purposes beyond genetics. Researchers are leveraging its precision to guide the assembly of nanoparticles with remarkable accuracy, allowing for the creation of complex nanostructures.

*Applications:* This method holds promise for applications in nanomedicine, where precise assembly of therapeutic nanoparticles is crucial. It enables the development of targeted drug delivery systems and diagnostic platforms.

3. **Machine Learning in Nanomaterials Discovery:**

*Description:* Machine learning algorithms are increasingly being employed to predict and discover novel nanomaterials with specific properties. These algorithms analyze vast datasets to identify patterns and correlations, accelerating the materials discovery process.

*Applications:* Accelerating the discovery of new nanomaterials for applications in energy storage, catalysis, and electronics. Machine learning enhances the efficiency of materials design and optimization.

4. **Two-Dimensional Materials Synthesis:**

*Description:* Advances in the synthesis of two-dimensional materials, such as graphene and transition metal

dichalcogenides (TMDs), have been achieved through techniques like chemical vapor deposition (CVD), liquid-phase exfoliation, and molecular beam epitaxy.

*Applications:* Two-dimensional materials are utilized in electronics, sensing, and energy storage devices due to their unique electronic and mechanical properties. Recent methods focus on scalable and controllable production for industrial applications.

5. **Advanced Imaging Techniques:**

*Description:* State-of-the-art imaging techniques, such as super-resolution microscopy, atomic force microscopy (AFM), and scanning tunneling microscopy (STM), provide unprecedented insights into nanoscale structures and interactions.

*Applications:* These imaging methods contribute to the characterization of nanomaterials, enabling precise observation of molecular structures and facilitating advancements in nanomedicine, materials science, and nanoelectronics.

6. **Topological Insulators Fabrication:**

*Description:* Recent developments in the fabrication of topological insulators involve creating materials that conduct electricity on their surfaces while insulating in the bulk. Techniques include molecular beam epitaxy and chemical vapor deposition.

*Applications:* Topological insulators have potential applications in quantum computing, spintronics, and energy-efficient electronics, making advancements in their fabrication crucial for technological progress.

7. **3D Printing at the Nanoscale:**

*Description:* Nanoscale 3D printing techniques, such as two-photon polymerization and direct laser writing, enable the fabrication of intricate nanostructures with high precision.

*Applications:* This method is employed in creating nanoscale devices for drug delivery, tissue engineering, and photonics. The ability to print structures with submicron resolution opens up new possibilities in diverse fields.

These recent methods underscore the dynamic nature of nanotechnology, showcasing the integration of cutting-edge techniques from various scientific domains. As researchers continue to push the boundaries of what is possible at the nanoscale, these methods pave the way for transformative applications across science and technology.

## **SIGNIFICANCE OF THE TOPIC**

The topic of "Nanowonders: Exploring the Frontiers of Nanotechnology" holds significant importance across multiple dimensions, ranging from scientific and technological advancements to societal and ethical considerations. The following points highlight the significance of this topic:

1. **Technological Innovation:**

*Transformational Technologies:* Nanotechnology has the potential to revolutionize various industries, including medicine, electronics, energy, and materials science. The exploration of nanowonders provides insights into transformative technologies that can lead to the development of more efficient devices, novel materials, and groundbreaking applications.

2. **Biomedical Breakthroughs:**

*Precision Medicine:* The application of nanotechnology in medicine, known as nanomedicine, offers unprecedented opportunities for personalized and targeted therapies. Understanding nanomaterials and their interactions at the biological level can pave the way for innovative diagnostic tools, drug delivery systems, and treatments with minimal side effects.

3. **Electronics and Information Technology:**

*Miniaturization and Efficiency:* In the field of electronics, nanotechnology enables the creation of smaller, faster, and more efficient devices. Exploring nanowonders in electronics holds the key to advancements such as quantum computing, nanoelectronics, and high-density data storage, influencing the future of information technology.

4. **Energy Solutions:**

*Sustainable Energy:* Nanotechnology contributes to the development of materials and devices for efficient energy harvesting, storage, and conversion. Understanding nanomaterials in the context of energy solutions is crucial for

addressing global challenges related to renewable energy sources and sustainability.

5. **Scientific Discovery:**  
*Unraveling the Nanoscale:* The study of nanowonders provides a unique opportunity to explore and understand the fundamental principles that govern matter at the nanoscale. This scientific exploration not only enhances our knowledge of quantum phenomena but also opens avenues for discovering new materials and phenomena.
6. **Ethical Considerations and Responsible Development:**  
*Navigating Ethical Challenges:* As with any emerging technology, nanotechnology raises ethical considerations related to safety, privacy, and environmental impact. An exploration of these ethical dimensions is essential for fostering responsible development and ensuring that the benefits of nanotechnology are balanced with ethical considerations.
7. **Educational and Outreach Opportunities:**  
*Inspiring Future Innovators:* The topic of nanowonders provides a captivating narrative for education and public outreach. Engaging discussions on the frontiers of nanotechnology can inspire the next generation of scientists, engineers, and policymakers, fostering a deeper understanding of the potential and challenges of this field.
8. **Global Collaboration and Governance:**  
*International Cooperation:* Nanotechnology is a global endeavor that transcends national borders. The significance of the topic lies in fostering international collaboration for the responsible development, governance, and ethical deployment of nanotechnological advancements.
9. **Economic Impact:**  
*Innovation and Industry:* The exploration of nanowonders contributes to innovation and the creation of new industries. Understanding the economic implications of nanotechnology is crucial for policymakers, businesses, and investors seeking to harness the economic potential of nanotechnological advancements.

In summary, the significance of "Nanowonders: Exploring the Frontiers of Nanotechnology" lies in its potential to drive technological innovation, advance scientific knowledge, address global challenges, and foster responsible and ethical development in the rapidly evolving field of nanotechnology.

## LIMITATIONS & DRAWBACKS

Despite the promising potential of nanotechnology, there are several limitations and drawbacks that warrant careful consideration. Acknowledging these challenges is crucial for the responsible development and ethical deployment of nanotechnological advancements. The limitations include:

1. **Toxicity and Health Concerns:**  
*Biocompatibility:* Some nanomaterials may exhibit unexpected toxic effects on biological systems. Understanding the biocompatibility of nanomaterials is crucial for applications in medicine and consumer products to avoid adverse health effects.
2. **Environmental Impact:**  
*Ecotoxicity:* The release of certain nanomaterials into the environment raises concerns about their potential impact on ecosystems and organisms. The long-term environmental effects of nanomaterials and their accumulation in ecosystems require thorough investigation.
3. **Ethical and Societal Concerns:**  
*Privacy and Surveillance:* The use of nanotechnology in surveillance and data collection raises ethical concerns related to privacy. Nanoscale sensors and devices could potentially be misused for unauthorized monitoring.
4. **Regulatory Challenges:**  
*Regulatory Frameworks:* The rapid pace of nanotechnological advancements poses challenges for regulatory agencies to keep up with the evolving landscape. Establishing robust regulatory frameworks to ensure the safety and ethical use of nanomaterials is an ongoing challenge.

5. **Scale-Up Challenges:**  
*Scalability:* Transitioning from laboratory-scale synthesis to large-scale production of nanomaterials poses challenges. Achieving consistent quality, quantity, and cost-effectiveness on an industrial scale is a complex process.
6. **Standardization and Characterization:**  
*Characterization Techniques:* The characterization of nanomaterials is challenging due to their small size and unique properties. Standardized methods for characterizing and testing nanomaterials are essential for ensuring reliability and reproducibility in research and applications.
7. **Unintended Consequences:**  
*Unanticipated Effects:* The unpredictable behavior of nanomaterials at the nanoscale raises concerns about unforeseen consequences. Understanding and mitigating these unintended effects are critical for the responsible development of nanotechnologies.
8. **Cost of Production:**  
*Economic Viability:* The cost of producing certain nanomaterials and nanodevices can be high. Developing cost-effective manufacturing processes is essential for making nanotechnology more accessible and commercially viable.
9. **Public Perception and Awareness:**  
*Public Trust:* Lack of public awareness and understanding of nanotechnology may contribute to mistrust and skepticism. Ensuring transparent communication and addressing public concerns are essential for fostering trust in nanotechnological applications.
10. **Potential for Misuse:**  
*Security Risks:* The potential misuse of nanotechnology for malicious purposes, such as the development of nanoweapons or other security threats, raises security concerns that require careful consideration and international cooperation.

As research in nanotechnology continues to advance, addressing these limitations and drawbacks becomes imperative. The integration of multidisciplinary approaches, including scientific, ethical, and regulatory considerations, is essential for maximizing the benefits of nanotechnology while minimizing potential risks and challenges.

## CONCLUSION

In conclusion, the exploration of "Nanowonders: Exploring the Frontiers of Nanotechnology" unravels a captivating journey into a realm where the minuscule becomes monumental and the manipulation of matter at the nanoscale promises transformative breakthroughs across diverse domains. The significance of this topic lies in its potential to reshape industries, drive scientific discovery, and address global challenges, but it is not without its limitations and ethical considerations. The theoretical framework, encompassing principles from physics, chemistry, biology, and ethics, provides a structured lens through which to understand the complexities of nanotechnology. Recent methods, ranging from DNA origami to machine learning in materials discovery, showcase the dynamic nature of the field, where innovation is accelerating at an unprecedented pace. The biomedical applications of nanotechnology hold promise for personalized medicine and targeted therapies, while advancements in electronics, photonics, and energy solutions usher in a new era of efficiency and sustainability. The ethical considerations surrounding nanotechnology underscore the importance of responsible development, safety, and transparent communication with the public.

However, it is crucial to acknowledge the limitations and drawbacks inherent in nanotechnology. Health concerns, environmental impacts, regulatory challenges, and societal implications necessitate a cautious approach to ensure that the benefits of nanotechnology are realized without compromising safety, privacy, or ethical standards. As "Nanowonders" delves into the frontiers of nanotechnology, it serves as a guide for scientists, policymakers, and the general public to navigate the intricate landscape of this evolving field. The potential for technological innovation is immense, but it must be coupled with a commitment to ethical considerations, environmental responsibility, and the well-being of society. In the pursuit of nanowonders, the ongoing collaboration of researchers, policymakers, and the public is essential to harness the full potential of nanotechnology while addressing its challenges. By fostering a culture of responsible development, open dialogue, and continuous exploration, we can unlock the true wonders of the nanoscale and pave the way for a future.

## REFERENCES

- [1]. Tanaka, K. & Kozuka, H. 2005. Preparation of acetylcellulose/silica composites by sol-gel method and their mechanical properties. *Journal of Materials Science*, 40, 5199-5206.
- [2]. Taylor, D. D. & Gercel-Taylor, C. 2008. MicroRNA signatures of tumor-derived exosomes as diagnostic biomarkers of ovarian cancer. *Gynecologic Oncology*, 110, 13-21.
- [3]. Torchilin, V. P., Tischenko, E. G., Smirnov, V. N. & Chazov, E. I. 1977. Immobilization of enzymes on slowly soluble carriers. *J Biomed Mater Res*, 11, 223-35.
- [4]. Tsuda, H., Kozu, T., Inuma, G., Ohashi, Y., Saito, Y., Saito, D., Akasu, T., Alexander, D. B., Futakuchi, M., Fukamachi, K., Xu, J., Kakizoe, T. & Iigo, M. 2010. Cancer prevention by bovine lactoferrin: from animal studies to human trial. *Biometals*, 23, 399-409.
- [5]. Takayama, Y., Takahashi, H., Mizumachi, K. & Takezawa, T. 2003. Low density lipoprotein receptor-related protein (LRP) is required for lactoferrin-enhanced collagen gel contractile activity of human fibroblasts. *J Biol Chem*, 278, 22112-8.
- [6]. Strickland, D. K., Gonias, S. L. & Argraves, W. S. 2002. Diverse roles for the LDL receptor family. *Trends Endocrinol Metab*, 13, 66-74.
- [7]. Slowing, Ii, Vivero-Escoto, J. L., Wu, C. W. & Lin, V. S. 2008. Mesoporous silica nanoparticles as controlled release drug delivery and gene transfection carriers. *Adv Drug Deliv Rev*, 60, 1278-88.
- [8]. Sargiannidou, I., Zhou, J. & Tuszynski, G. P. 2001. The role of thrombospondin-1 in tumor progression. *Exp Biol Med (Maywood)*, 226, 726-33.
- [9]. Ragel, C. V., Vallet-Regi, M. & Rodriguez-Lorenzo, L. M. 2002. Preparation and in vitro bioactivity of hydroxyapatite/solgel glass biphasic material. *Biomaterials*, 23, 1865- 72.
- [10]. Reuter, S., Gupta, S. C., Chaturvedi, M. M. & Aggarwal, B. B. 2010. Oxidative stress, inflammation, and cancer: how are they linked? *Free Radic Biol Med*, 49, 1603-16.
- [11]. Salinas, A. J., Martin, A. I. & Vallet-Regi, M. 2002. Bioactivity of three CaO-P2O5-SiO2 sol-gel glasses. *Journal of Biomedical Materials Research*, 61, 524-532.
- [12]. Partridge, A. H., Burstein, H. J. & Winer, E. P. 2001. Side effects of chemotherapy and combined chemohormonal therapy in women with early-stage breast cancer. *J Natl Cancer Inst Monogr*, 135-42.
- [13]. Paesano, R., Berlutti, F., Pietropaoli, M., Pantanella, F., Pacifici, E., Goolsbee, W. & Valenti, P. 2010. Lactoferrin efficacy versus ferrous sulfate in curing iron deficiency and iron deficiency anemia in pregnant women. *Biometals*, 23, 411-7.
- [14]. Olmo, N., Martin, A. I., Salinas, A. J., Turnay, J., Vallet-Regi, M. & Lizarbe, M. A. 2003. Bioactive sol-gel glasses with and without a hydroxycarbonate apatite layer as substrates for osteoblast cell adhesion and proliferation. *Biomaterials*, 24, 3383-93.