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Impacts of New Architectural Materials on Urban Designing

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Abstract

Buildings and live in them over the last two decades has changed. Technological advancements and scientific researches, especially in nanotechnology and smart materials in the latter part of the 20th century, encourage new approaches for the architecture. There have been many studies on Nano-materials smart materials and “searching a new architecture” with the help of architecture and nanotechnology and smart materials. We try to explain Smart and Nano Materials and their impact on architecture. So, Smart and Nano materials can perform like living systems, simulating human skin, the body’s muscles, a leaf’s chlorophyll and self-regeneration. Through the development of materials, products and innovative construction methods, building towards more efficient and more economical and environmentally friendly is essential. We are now at the threshold of the next generation of buildings, buildings with various degrees of Ecological behavior are fully compatible and are capable of using smart materials and functional (Hi-Tech) technology appropriate to the direct and indirect changes around them respond and adapt to the conditions. This article is cooperation between an architect and a materials scientist on the future of materials and their influence in architecture. By explaining that we intend to illustrate and suggest directions ranging from the functional to the expressive, from tectonics to morphology.

Keywords: Smart Materials, Nanotechnology Materials, Architecture.

Introduction

Materials used in the course of human history and the past have undeniable role in shaping the mental space and life. Perhaps that is why a group of thinkers, the ages of human life, according to the format used in its element during the Stone Age, Bronze Age, Iron Age, the era of composite materials (composites) and finally the current era of smart material theories named. Smart and Nano materials are products with the ability to understand and process information, environmental events, and then the appropriate response to the stimuli entered that, unlike traditional materials are static, hard living and very dynamic, reversible and highly reactive. Perhaps that is why, today, intelligent materials and its impacts on various aspects of human life, becoming one of the field's scientific attentions of researchers in all areas including the environment, medicine, engineering and the various trends. Along with these developments, architecture as one of the most important areas of human knowledge that is closely linked to human and how his life is, By the introduction and application of new materials in the body and nature developments and capabilities Dramatic, woven out of the constraints and limitations on the architecture of the past in terms of both substantive and technical until that time there was no idea for it. The following materials which are detailed as follows are raw materials that have potential and special applications in the field of architecture and construction:

- Recycled materials
- Life-biodegradable material
- Biological materials

- Unalterable materials
- Smart materials
- Hybrid materials
- Materials of fossil Index
- Nano-materials

In this article, intelligent and Nano materials that are both new materials and using them is prevalent today, will be discussed.

Smart materials

With the development of material science, many new, high-quality and cost-efficient materials have come into use in various field of engineering. In the last ten decades, the materials became multifunctional and required the optimization of different characterization and properties. With the last evolution, the concept has been driving towards composite materials and recently, the next evolutionary step is being contemplated with the concept of smart materials. Smart materials are new generation materials surpassing the conventional structural and functional materials. These materials possess adaptive capabilities to external stimuli, such as loads or environment, with inherent intelligence. The stimuli could be pressure, temperature, electric and magnetic fields, chemicals, hydrostatic pressure or nuclear radiation. The associated changeable physical properties could be shape, stiffness, viscosity or damping. Smartness describes self-adaptability, self-sensing, memory and multiple functionalities of the materials or structures. These characteristics provide numerous possible applications for these materials and structures in aerospace, manufacturing, civil infrastructure systems, biomechanics and environment. Self-adaptation characteristics of smart structures are a great benefit that utilizes the embedded adaptation of smart materials like shape memory alloys. By changing their properties, smart materials can detect faults and cracks and therefore are useful as a diagnostic tool. This characteristic can be utilized to activate the smart material embedded in the host material in a proper way to compensate for the fault. This phenomenon is called self-repairing effect (Kamila, 2013).

Classification of smart materials

Table 1. The smart and/or intelligent materials have been divided into three groups (Sabry Elattar, 2013).

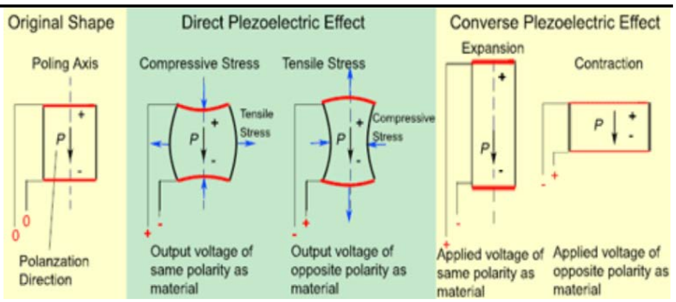
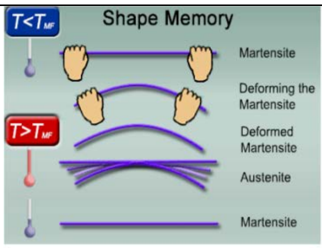
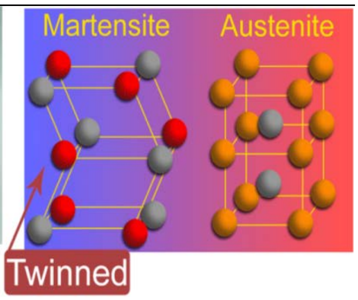
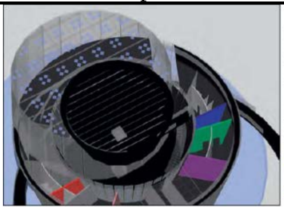
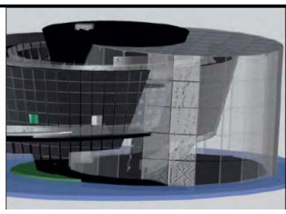
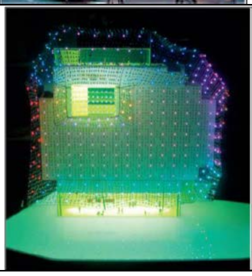
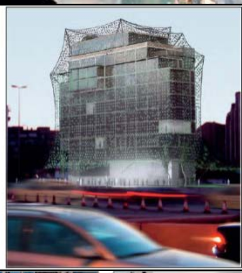
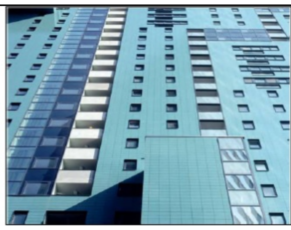
Type	Explanation	Picture
Passive smart materials	Passive smart materials, can only perceive and feel the stimuli of the environment as well as of the own inner and are being acted as sensors. Virtually all shape memory alloy materials fall into this category as they simply respond to temperature change around them by changing shape without analyzing any signal.	
Active smart materials	Active smart materials have the properties of passive ones and additionally react to stimuli and have also the actuator. An example of an actively smart material is the vibration damping made from piezoelectric materials, which utilize a feedback loop enabling them to both recognize the change and initiate an appropriate response through an actuator circuit.	 
Intelligent materials	Intelligent materials are going further and can adapt the behavior to the circumstances.	

Table 2. Other classifications for Smart materials and systems divide it into two classes.

Classification			Example	
Smart materials capable of change Intrinsic properties	1- Change shape Smart materials 2- Change color Smart materials 3- Change linking Smart materials	Change shape	Axel Ritter, Germany Kinetic facade for a documentation and meeting centre on the former, (2004)	 
		Change color	Peter Marino Associates, USA High rise facade | Tokyo, Japan (2004)	 
Smart materials with an exchange Energy	1- emits light Smart materials 2- produce electricity Smart materials 3- energy storage Smart materials	Emits light	CLOUD 9, Spain Light-kinetic curtain-wall facade | Hotel Habitat H&R, Barcelona, Spain (2007)	 
		Energy storage	Dietrich Schwarz, Switzerland Senior citizens' apartments with a latent heat-storing glass facade | Domat/Ems, Switzerland (2004)	  
Smart materials capable of change Internal exchange	Change Internal exchange		Albert Wimmer, AN_architects, Austria High-rise with photocatalytic selfcleaning ceramic facade | Vienna, Austria (2004)	 

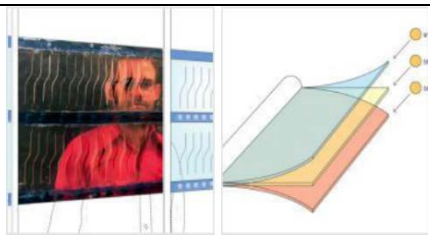
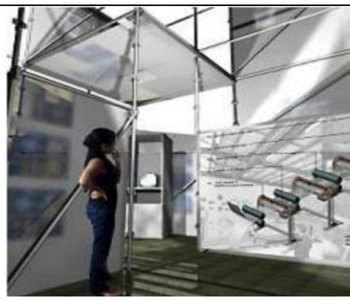
Features smart materials

Smart materials and its production processes may offer a wide range of benefits including:

- Superior strength, toughness, and ductility.
- Enhanced durability/service life.
- Increased resistance to abrasion, corrosion, chemicals, and fatigue.
- Initial and life-cycle cost efficiencies.

- Improved response in extreme events such as natural disasters and fire.
- Ease of manufacture and application or installation.
- Aesthetics and environmental compatibility.
- Ability for self-diagnosis, self- healing, and structural control.

Table 3. Smart materials applications in architecture.

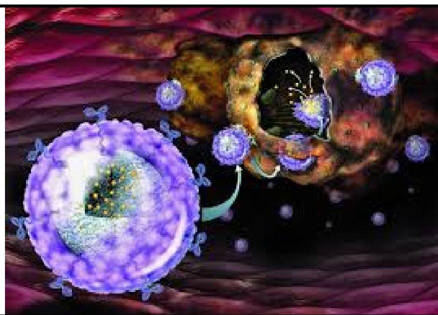
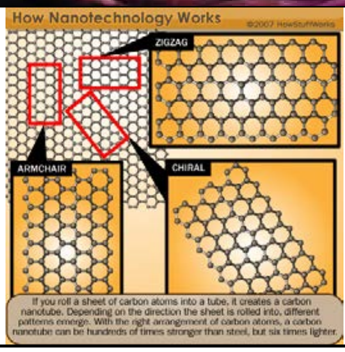
Types	Explanation	Picture
Smart shade	The shown Smart Shade employs the thermodynamics of zinc and steel to control the amount of sunlight passing into a building's interior using elastic shape memory alloy wires to control the level of carbon dioxide in a room. Expansion and contraction of these sandwiched materials in response to temperature cause the blinds to curl up in winter (allowing more sunlight in) and curve down in summer (allowing less).	
Smart windows	Window technologies made up of suspended particle devices (SPD), capable of functioning like a "light valve" in controlling the amount of light able to pass through a window, are now being produced. SPD window technology is both practical and affordable and, through aftermarket vendors, can be retrofitted to existing buildings. In addition to its affordability, these windows offer energy efficient, cost-saving benefits over the life cycle of the building.	
Ceilings	Ceilings with anti-bacterial treatment called the "anti-microbial ceilings" include an intercept coating that destabilizes the cellular membrane of certain microorganisms preventing them from multiplying and surviving. The coating inhibits the growth of odor and stain-causing bacteria on the treated surface of the ceiling tile (Armstrong World Industries).	
Smart bricks	Bricks stuffed with sensors, signal processors and wireless communication links warning about hidden stresses, or damage in the aftermath of natural calamities like earthquakes, storms or hurricanes. Built into a wall, the brick could monitor a building's temperature, vibration and movement. Such information could be vital to firefighters battling a blazing skyscraper, or to rescue workers ascertaining the soundness of an earthquake-damaged structure (Jim, 2007).	
Smart wrap	Smart Wrap as a futuristic building material could replace all existing interior and exterior wall materials. The ultrathin, ultra-light material consists of 6 layers -- an applied layer of carbon nanotubes that gives it rigidity, four organic 'smart' layers that change the appearance of your house, control circuitry, Change Material for thermal regulation, provide environmentally-friendly and inexpensive power to the wall and to the whole building or other application, and a PEN/PET substrate that holds them all together and protects them from the elements.	

Nanotechnology materials

Over 50 years have passed since the Nobel Prize physicist Richard P. Feynman, with the lecture at the California Institute of Technology entitled “There’s plenty of room at the bottom” (Feynman, 1960) has opened the way for innovations related to nanotechnology, prefiguring the possibilities associated with the transformation of matter at the molecular level. Studies conducted by Feynman and his intuitions have laid the basis for a radical transformation of techno-scientific horizon, starting from the possibility of miniaturization of computers to which much of technological innovations produced in the last fifty years is owed. Despite the “intellectual authorship” of Feynman, the term “nanotechnology” was coined in 1974 by Norio Taniguchi of Tokyo Science University, which defines it as a process of reorganization of matter atom-by-atom or molecule-by-molecule (Taniguchi, 1974). After twelve years, in 1986, the potential of this new concept of science and technology was better clarified through the work of Kim Eric Drexler entitled “Engines of creation: the coming era of nanotechnology” (Drexler, 1986), which prefigures many of the goals achieved afterwards in science and production sectors. Drexler defines nanotechnology as the thorough, inexpensive control of the structure of matter based on molecule-by-molecule control of products and by-products; the products and processes of molecular manufacturing, including molecular machinery (Drexler & Peterson, 1991). Since then, nanotechnologies emerged in many industrial sectors, introducing products with new features and benefits, also modifying the way of conceiving the relationship between the matter and its possible transformations.

The study of chemical and physical phenomena at the Nano scale and the application of nanotechnology in the production processes of various materials have produced significant innovations in almost all sectors. The widespread opinion is that the impact of these technologies will have effects comparable to the diffusion of antibiotics and plastics, involving large market sectors, including construction. Through the use of nanotechnology it is possible to develop new materials that can respond to specific functions, creating products and systems with unique properties arising from the particular molecular structure or implementing quality and performances of existing products. The “appearance” of nanotechnology in sectors such as electronics, biomedical and diagnostics is strongly related to the need for an increasing miniaturization of components to improve product performance, ensuring high reliability and control ability. The most delayed research sector is probably the study of possible risk factors related to nanotechnology, since the effects of nanoparticles on humans and environment are still largely unknown to researchers themselves, and only in recent years several countries (including the European Union) have introduced monitoring and protection policies. Such uncertainty is even more surprising if we consider that the main “promises” of nanotechnology are specifically related to the reduction of the environmental impact of production processes.

Table 4. Classification of nano materials.

Types	Explanation	Picture
Nanoparticles	Nanoparticles, also called “zero dimensional Nano materials”, do not possess any dimension outside the 1-100 nm range. Although nanoparticles can have different shapes, crystal structures and compositions, their small scale induces a change in fundamental properties (Dabbousi et al., 1997).	
Nanowires and Nanotubes	Nanowires and nanotubes are materials created with one non-Nano dimension. These materials tend to have one long axis (above 100 nm), and a cross-section that is within the 1-100 nm range. The best examples of these structures are the widely publicized carbon nanotubes.	

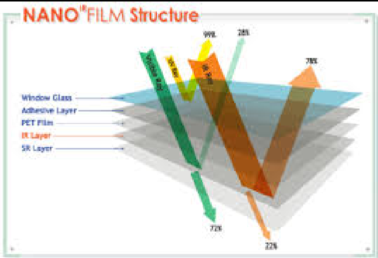
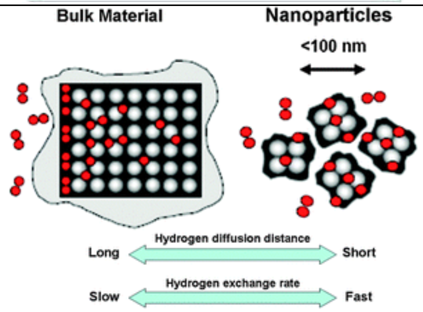
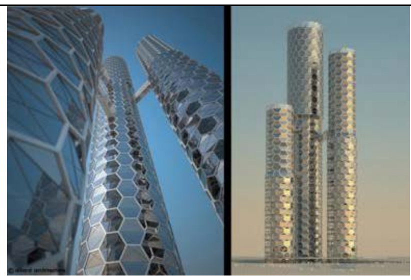
Nano Films	Nano films are materials that have two non-Nano dimensions. Typically, Nano films are used as a surface treatment when composition or/and mechanical properties need to be altered, or as coatings when a different arterial is deposited to create a new surface.	
Bulk Nanomaterial's	Bulk nanomaterial is materials that have macro dimensions in 3-D, but exhibit a Nano scale substructure. Currently, there are two main processes used to achieve bulk nanomaterial production of nanoparticles in powder form, followed by high-pressure compaction and subsequent high temperature sintering to consolidate the powder, and) high angular extrusion or high pressure torsion, where relatively small metal work pieces (of the order of cm) are highly deformed to produce a Nano scale substructure.	

Table 5. Nano materials applications in architecture.

Example	Explanation	Picture
The Nano house Initiative	The Nano house Initiative is a collaborative design between scientists, engineers, architects, designers and builders. It is a new type of ultra-energy-efficient house exploiting the new materials being developed by nanotechnology. The Nano House Initiative was designed in 2002 by Carl Masons at the Institute for Nano scale Technology and was visualized and implemented by architect James Muir. It has the latest technology in which windows clean them, tiles might resist the build-up of soap scum, and timber surfaces resist UV damage.	
The Nano Towers	Were proposed as the new headquarters of the DuBiotech Research Park in Dubai by Allard Architecture. This mixed-use development offers 160.000 square meters of office space, laboratories, a hotel and residential and associated support facilities in a 262 meter-high tower. The canopy at ground level provides sunshade while creating a conceptual ground plane from which the towers grow. The repetitive grid of the exoskeleton structure has non-curved beams of equal length. The structure was inspired by a Nano-scale carbon tube. It has junctions where the geometry shifts from vertical to horizontal, and this creates multiple opportunities for dividing the interior space along mullion lines.	

Nano Vent Skin	Designed by Agustin Otegu, uses Nano-scale wind turbines. This concept wall consists of different kinds of microorganisms that work together to absorb and transform natural energy from the environment. These bio-engineered organisms could convert sunlight and wind power into renewable energy and they could absorb CO_2 from the air. These microorganisms have not been genetically altered. They work as a trained colony where each member has a specific task in this symbiotic process.	
The Shimizu TRY 2004 Mega City Pyramid	Is a proposed project for Tokyo Bay in Japan by the architects Dante Bin and David Dimitric. The structure would be 12 times higher than the Great Pyramid of Giza, and if built, it would be the largest man-made structure on Earth. It is a conceptual city in the air, including wind and sunlight, to serve as a home and workplace for about one million people. A mega truss structure, which also serves as a platform for infrastructure facilities, is designed to meet the needs of residents and the surrounding environment at the same time. The 2000 meter-high structure is based on a combination of regular octahedral units.	

Nanotechnology and architecture

The growing attention in relation to the potential of nanotechnology in architecture is derived from multiple factors that affect both functional and aesthetic aspects of buildings, also involving wider issues related to the possible contribution to the eco-efficiency of industrial processes and products. The potential associated with a complete transformation of the construction logics of the technical elements and the resulting architecture outcomes, including morphology aspects, is now emerging. The possibilities linked with the development of industrial products based on nanotechnology begin to stimulate design researches aimed at exploiting the unique properties of new materials, which allow-for example – the creation of extremely thin, ultra-insulating and self-regulating transparent shells, thin and light structures with a resistance up to a hundred times greater than steel, buildings able to self-repair technical elements or to send “reports” on the functioning of various parts and components (Elvin, 2006).

Nanotech innovations currently available seem therefore not only able to have a significant impact on the characteristics and performance of building components, but also, in perspective, to bring changes in the relationship between the designer and the conventional “palette” of materials used in architectural design. At present, the diffusion of new building materials developed through nanotechnology is mostly due to the efforts made by industries and companies that transformed into products the scientific advances of recent years. However, these are usually products intended to replace conventional technologies that do not cause significant changes in the design and manufacturing approach (e.g., special glass and insulation materials, protective and functionalized coatings, etc.). The “first generation” of nanostructured materials, while introducing additional performance to components and systems in which they are applied, does not seem to have tangible impacts on the possible evolution of the architectural language, which is widely considered the main aspect of the “Nano-architecture” of the future (Johansen, 2002).

According to the architects and designers “pioneers” of nanotech architecture6, new materials will allow the realization of buildings able to create a dynamic relationship with environmental factors and with electrical and electronic impulses activated by man, modifying their performance, their appearance and even their shape in relation to external stimuli, in order to ensure comfort and energy savings, but also to use the architecture itself as a communication “interface”, enhancing the possibilities of information exchange and mutual interaction. One of the main aspects concerning the contribution of nanotechnology to the architectural design is in fact linked to the possibility of creating a new generation of green buildings characterized by the use of innovative materials able to connect the needs of low environmental impact together with aesthetic and communicative aspects of architecture, as in the Marwan Al-Sayed project for the new World Trade Center in New York, characterized by a nanostructured high-energy performance shell, with photo and thermo-chromic properties that allow to modify the color, level of transparency and of heat transmission. The relevance of such changes, already prefigured in some recent pilot projects, is such that some authors claim that in the future «the distinctions between living and inanimate matter are no longer certain; we can no longer distinguish between what is natural and what is artificial and we will do what we want, by assembling the reality a molecule at a time.

Smart Materials and Nano Materials in Architecture

An architect seeking new and better ways of building is often driven by a thirst to develop new forms and express new ideas of space. Architectural history is built of such developments as the 'newest' and the 'boldest' of building forms and construction advancements illustrate. We believe that new smart and Nano materials have the potential to open a new era in architectural design and construction, enabling architects a higher level of intricacy which will span from the smaller scales of a molecule to the larger concepts of society. In this vein, advancing scientific areas are now, as they have often been, the ideal scavenge site for designers eager for new solutions to their technical problems, and looking for better ways to express emerging design concepts. As novel Smart and Nano materials research is no exception, architects must look ahead for the impact these novel cutting edge materials will have in the constructible world. New concepts of materiality emerging from Nano and Smart materials can allow architects to further respond and engage our present – connected, fast paced, organic, plastic, Responsive, consumable, volatile, media-centric, and tech-centric. In response Nano and Smart materials can further point architecture towards the ideal of a systemic organism; wherein a material or construction can respond in action and reaction to its environment. Furthermore, emboldened by these new material technologies architects may find new ways to question Aristotelian notions of separation and causality, expressive necessity and the demands of function. These dichotomies, epitomized in the famous statement by Louis Sullivan that "form follows function" [Sullivan 1934], may dissolve as technological innovation and expression reach toward new unities. Resulting new concepts of materiality can then allow designers to break from 'function or form' into a new cyclic concept, and a new paradigm, that creates one body of 'function and form'. Below we discuss the impact that both Smart and Nano materials can procure in the realms of architecture, construction and design. It is our goal to describe how these materials will not only allow for new and better responses to the performance needs of today's most efficient buildings but will also allow for the shift in architectural thought regarding materiality and the qualities of materials in architecture.

Conclusion

Smart materials are almost endless power; they can change in response to their surroundings so that natural materials (other than our intelligence) are not capable of it. They are capable of positive change in architecture, construction and lifestyle cause, such as a painted wall kept clean and in case of damage to its own building or wall to the gas leak or warns electrical connection at home. Smart materials can change color or as directed generate electricity during the day and at night provided that for us. But the most significant impact is on the energy issue that the most important issues of the coming century, the use of smart materials in the building can be used to optimize energy consumption. Also Nanotechnology is the manipulation of matter at the atomic scale materials and devices, by controlling the level of atoms and molecules. In the construction sector, nanotechnology can be called a technology capable of optimizing the application include conventional materials available. Create new applications for the material and, most importantly, multifunctional materials and create the ability to prevent damage to the material, is highly regarded scientists in the field. In the field of nanotechnology, such as smart materials that appear in the first place friendly to the environment and saving energy is one of the excellent progresses of the human.

References

1. Seyed Mojtaba Mostafavi, A.R., Mina Adibi, Farshid Pashaee, Masoumeh Piryaei, Modification of Glassy Carbon Electrode by a Simple, Inexpensive and Fast Method Using an Ionic Liquid Based on Immidazolium as Working Electrode in Electrochemical Determination of Some Biological Compounds. Asian Journal of Chemistry, 2011. 23(12).

2. Seyed Mojtaba Mostafavi, A.R., Mina Adibi, Farshid Pashaee, Masoumeh Piryaei, Electrochemical Investigation of Thiophene on Glassy Carbon Electrode and Quantitative Determination of it in Simulated Oil

Solution by Differential Pulse Voltammetry and Amperometry Techniques. Asian Journal of Chemistry, 2011. 23(12): p. 5356-5360.

3. Zabihi, O., et al., The effect of zinc oxide nanoparticles on thermo-physical properties of diglycidyl ether of bisphenol A/2, 2′-Diamino-1, 1′-binaphthalene nanocomposites. Thermochimica acta, 2011. 521(1-2): p. 49-58.

4. Shamsipur, M., et al., Biotransformation of methyl tert-butyl ether by human cytochrome P450 2A6. Biodegradation, 2012. 23(2): p. 311-318.

5. Zabihi, O., A. Khodabandeh, and S.M. Mostafavi, Preparation, optimization and thermal characterization of a novel conductive thermoset nanocomposite containing polythiophene nanoparticles using dynamic thermal analysis. Polymer degradation and stability, 2012. 97(1): p. 3-13.

6. Seyed Mojtaba Mostafavi, M.P., Ahmad Rouhollahi and A. Mohajeri, Separation and Quantification of Hydrocarbons of LPG Using Novel MWCNT-Silica Gel Nanocomposite as Packed Column Adsorbent of Gas Chromatography. Journal of NanoAnalysis, 2014. 1(01): p. 01.

7. Seyed Mojtaba Mostafavi, M.P., Ahmad Rouhollahi and A. Mohajeri, Separation of Aromatic and Alcoholic Mixtures using Novel MWCNT-Silica Gel Nanocomposite as an Adsorbent in Gas Chromatography. Journal of NanoAnalysis, 2014. 1(01): p. 11.

8. Mostafavi, S.M., 3D Graphene Biocatalysts for Development of Enzymatic Biofuel Cells: A Short Review. Journal of Nanoanalysis, 2015. 2(2): p. 57-62.

9. Kargarfard, M., et al., Hemodynamic physiological response to acute exposure to air pollution in young adults according to the fitness level. ARYA Atherosclerosis, 2009. 5(3).

10. Aye Rizvandi, s.A.Z., Mehdi Namazi zadeh, The relationship between emotional Intelligence And Entrepreneurial Rate among sport clubs Mangers in Esfahan City. 2012, from Islamic Azad University, Khorasgan Branch(Isfahan).

11. Aye, R. The Relationship between Entrepreneurial and Five major personality traits Among sport management graduate students in Esfahan. in International Sport Science Student Conference2013 (ISSSC2013) -UNIVERSITY OF MALAYA -Kuala Lumpur- Malaysia. 2013.

12. Aye Rizvandi1 , E.M., Mohammad Soltan Hosseini3, Gholam Reza Sharifi2. Relationship of Emotional Intelligence and the Level of Swim Skills in Women in Isfahan City. in International Sport Science Student Conference(2013) ISSSC 2013 -UNIVERSITY OF MALAYA -Kuala Lumpur- Malaysia. 2013.

13. , M.S.H.P.Z., Hamid Reza Ahmadi Bazdi, Ayeh Rizvandi, The relationship between emotional intelligence and mental health of Iranian football referees(in Persian). Applied research in sports physiology, 2015. 6(1): p. 107-117.

14. Rizvandi, A. "Emotional Intelligence of Isfahan's Sport Club Managers Regarding Demographic Characteristics, Isfahan, Iran". in International Sport Science Student Conference 2015 (ISSSC 2015), at the University of Malaya, Kuala Lumpur, Malaysia. 2015.

15. Rizvandi Aye , M.a., Hossein aghaee Nia. Study of Knowledge Level of Soccer Players of Premier League in Sports Rights in Iran. in International Sport Science Student Conference 2015 (ISSSC 2015),at the University of Malaya, Kuala Lumpur, Malaysia. 2015.

16. Bahman Gh. Goudarzi, M.A., Mohammd Abdigoudarzi, Masoumeh Piryaei, Roya Bagherian, Proteases Detection of in vitro culture of midgut cells from Hyalomma anatolicum anatolicum (Acari: Ixodidae). Archives of Razi Institute, 2008. 64(1): p. 23-28.

17. Anbia, M., et al., Employing a new modified nanoporous carbon for extraction and determination of 1, 10-phenanthroline and 2, 2′-bipyridine by SPE and use of the Taguchi optimization method. Analytical Methods, 2012. 4(12): p. 4220-4229.

18. Kim, Y., et al., Hydrolytic transformation of microporous metal–organic frameworks to hierarchical micro-and mesoporous MOFs. Angewandte Chemie, 2015. 127(45): p. 13471-13476.