J. Basic. Appl. Sci. Res., 3(8)509-519, 2013
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ISSN 2090-4304
Journal of Basic and Applied Scientific Research
www.textroad.com

Application of Nanotechnology in Construction Industry

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ABSTRACT

Today, different technologies are widely used to provide comfort and safety and save costs especially in using energy sources. Nanotechnology is one of the new technologies with a bright future predicted for it. The range of the effect of this technology has been so extended that one can say this technology is able to influence most aspects of future human life; hence, adopting a suitable approach to this phenomenon and sufficient knowledge of the different fields of its application is very important. This science promises discovering the secrets of the nature in all fields from engineering to medicine through controlling materials on a molecular scale. Moreover, nanotechnology plays an important role in providing suitable building materials, improving quality and their efficiency in different parts of a building, installations, cooling and heating equipment and reducing the consumption of raw materials and energy in direct or indirect ways.
KEYWORDS: new technologies, future buildings, new materials, energy consumption, environment.

1. INTRODUCTION

Unlike the past world which totally focused on industries like oil and energy, today's world is inclined towards information technology[1], new materials, biotechnology[2], nanotechnology and electronics. Since industries like oil vanish someday, investing in science and technology would be justifiable. Nanotechnology and an understanding the great potentials of this evolutionary technology, causes the organization and formulation of numerous national plans in many countries of the world. Formulating such programs is mainly due to utilizing the potentials of nanotechnology more and preventing from lagging behind the route of quick changes and the increasing achievements of this technology [1]. This science promises discovering the secrets of the nature in all fields from engineering to medicine through controlling materials on a molecular scale. Nanotechnology is controlled in a very small world and aims to creating things atom by atom or molecule by molecule which is the way the nature has been taking for millions of years. Many properties of materials like color, strength and brittleness are made controllable. Given the increasing population and construction rate as well as the limited resources and consumer materials, the demand for new materials has gone up in construction industry [1]. Attempts to find solutions to improve quality, to increase the efficiency of materials and to reduce the consumption of raw materials and energy caused the utilization of this technology. In addition to preventing from wasting energy in different parts of a building, nanotechnology can considerably help with the optimum use of energy in buildings, maintaining buildings for a long time and strengthening them even against unpredictable phenomena (in an economical way).

2. NANOTECHNOLOGY INTRODUCTION

Nano is a Greek term meaning small and is used to determine an amount of one billionth or 10^{-9}. One nanometer equals one thousandth of a micron[3] or about 100,000 times smaller than a human hair and since an atom is almost 10 nanometers in size, the term “nanotechnology” is used to refer to the general studies on atomic and molecular particles. Nano materials generally refer to materials at least one whose dimensions (length, width, thickness) is below 100 nm (Figure 1).

[1] Information and communications technology or information and communication technology, usually called ICT, is often used as an extended synonym for information technology (IT) but is usually a more general term that stresses the role of unified communications and the integration of telecommunications (telephone lines and wireless signals), intelligent building management systems and audio-visual systems in modern information technology.
[2] Biotechnology is a field of applied biology that involves the use of living organisms and bioprocesses in engineering, technology, medicine and other fields requiring bio products.
[3] A micrometer is one-millionth of a meter (1/1000 of a millimeter, or 0.001mm). Its unit symbol in the International System of Units (SI) is µm.

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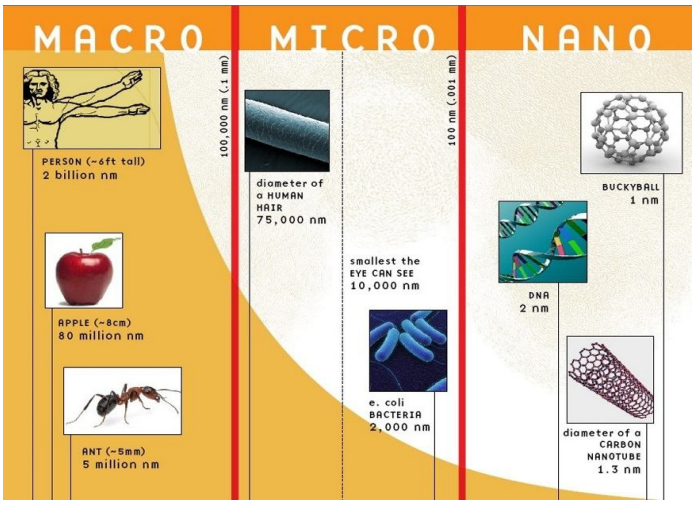

Figure 1: Nanotechnology Diagram [9]

Nanotechnology is able to make, control and use substances on a Nano scale. This technology is used in electronics, biology, genetics[4] and aeronautics and even in studying energies. This simple definition itself has many meanings. For example, nanotechnology with its infra-disciplinary nature will cover all modern technologies and will lead their progress instead of competing them and will integrate all as a branch of science.

It is been for millions of years that very complicated structures with Nano metric (molecular) daintiness like a tree or a microbe are produced in nature [2]. Human science is, however, is on the verge of dominating this field in order to create unique structures not even found in nature. Nanotechnology provides functions human is completely unable to perform and produce such results in a society human has never imagined. For instance:

- Very light and strong material structures for common or new uses
- The bankruptcy of old industries like steel with the commercial emergence of new materials
- Serious reduction in demands for fossil fuels
- Pervasiveness of very powerful, small and low-energy consuming supercomputers
- Missiles that are lighter, smaller, smarter, longer-range, cheaper and more invisible for radars
- Quick identification of all genetic, behavioral and disease vulnerability
- Precise medicine dispatch to far target addresses inside the body and increasing the life span
- Complete elimination of the dangerous factors in chemical or microbial wars
- Complete elimination of the smallest amounts of urban or industrial pollutants
- Ever-clean and smart surfaces and clothes
- Mass production of materials and tools never been practical and economical before

And many other unpredictable cases.

The main goal of most Nano technological researches is to form new compounds or making changes in existing ones. The size of particles is very important in nanotechnology since the dimensions of a material is very influential in its properties on a Nano scale, and the physical, chemical and biological properties of each single atom or molecule are different from the those of the whole material. The high ratio of surface to Nano volume is one of the most important properties of materials produced on a Nano scale. The behavior of surfaces dominates the behavior of the material mass.

Quantum physics[5] allows the changes in materials' properties like boiling point, magnetic properties and color on a Nano scale. Nano material creation methods can be divided into two general categories:

- Top-down method: it includes shrinking the size of structures from micrometer to nanometer. In fact, it is possible to decompose materials until they reach nanometer sizes. Today, it is done by physical and chemical breaks.
- Bottom-up method: it is based on joining atomic and molecular masses in a controlled were in order to produce bigger systems.

The bottom-up production methods can be only used to create materials on a nanometer scale while top-down methods are used to produce both Nano and micro materials [2].

Generally, Nano products can be mentioned as follows in a general classification:

[4] Genetics a discipline of biology, is the science of genes, heredity, and variation in living organisms.

[5] Quantum mechanics, also known as quantum physics or quantum theory, is a branch of physics providing a mathematical description of the dual particle-like and wave-like behavior and interaction of matter and energy.

- Nano layer thin films for electronic applications mainly
- Protective Nano coatings to increase strength against erosion and protection against destructive environmental factors
- Nanoparticles as the precursors or modifiers of chemical and physical phenomena
- Nanotubes which means a Nano structure materials or simply a Nano structure body
- Nanostructure which is a solid in which the atomic configuration, the size of constituent crystals and the chemical compound is extended all over the body on a scale of few nanometer

3. THE APPLICATION OF NANOTECHNOLOGY IN CONSTRUCTION INDUSTRY

Future buildings should be able to increase efficiency, improve safety and prevent wasting energy through the utilization of nanotechnology and creation of a healthier environment. In spite of the existing problems (the rise in construction costs and polluting cities, etc.) in the realm of urbanization and architecture and their direct effect on buildings, it is more necessary no than ever before to consider new technologies and their roles in buildings.

Nanotechnology activities are quickly increasing in the world and now have very important infra-disciplinary aspects whose harmony would be difficult to achieve without a strategic research and development plan. Given the novelty of this technology, some its new applications in industries are introduces every year. The Ultimate goal of studying materials on a Nano scale is to find a new class of building materials with high performance which can be regarded as high-performance or multipurpose materials [3].

By multipurpose performance, we mean the emergence of properties that are new and different from those of usual materials in a way that materials be able to provide various applications. Controlling Nano structures and the combination and configuration of new materials to reach modern ways used in buildings promise much hope for future buildings and cities. Regarding the properties this technology provides for us, we can meet the needs of buildings through producing new, modern, highly efficient and multipurpose materials. The needs which can be met include:

- Creating higher durability against the effect of environmental and climatic factors
- Reaching long lifespan, increased shock absorption, low fragility and slight deformations concerning building materials and installations
- Producing highly-strong materials against leakage which can be used in making the installations required for buildings
- Increasing the electric and mechanical productivity of building installations (like improving the performance of water transfer pipes)
- Limiting heat conduction to allowed quantities
- Providing necessary water-resistance and moisture-resistance
- Sufficient durability against fire (heating insulation and making the different parts of the membrane heat-resistant) along with tolerance and resistance to exerted stresses
- Providing and maintaining the heating comfort conditions of the controlled spaces easily and with saving energy in case of the heating insulation of the members of a building
- Decreasing the thickness of the layers forming the heating resistance of a membrane [3]

There are some of the factors directly or indirectly effective in reducing energy consumption in a building (the guide of the 19th chapter of Iranian National Construction Regulations).

Other general or specific applied potentials of this technology in building materials are studied by Iranian National Research Council Institute for further research on some building materials (like cement and glass). They include:

- Extraordinary durability and strength
- Very high stiffness
- Retrofitted glass (retrofitting strength without interference in light transfer)
- Self-cleaning glasses (which eliminated the problem of cleaning windows especially in tall buildings)
- Higher strength in building suspension bridges
- Possibility to design arches and bridges with wider mouths

Concerning the main applications of this technology in construction industry, the following items can be mentioned:

I. IMPROVING THE PROPERTIES OF CEMENT AND CONCRETE

The properties, behavior and performance of concrete depend on the nanostructure of the fundamental substance of the concrete and cement to create cohesion, coherence and consistency. Therefore, studies on concrete and cement pastry on a Nano scale is very important for the development of building materials and their applications. Using Nano particles causes the improvement of mechanical properties and increase in the quality of cement and concrete. Also, Nano particles and Nano coating prevent the penetration of destructive external factors into concrete that cause reduction in durability and stability and increase in destruction speed.

An example application of these structures in concrete is the use of them in “high-performance concrete” (HPC) and “self-compacting concrete” (SCC). HPC is a kind of composite, multiphase and complex materials in terms of durability and type [3].

The common way to develop HPC often includes different parameters like the usual and reinforced concrete mixture designs with different binders. In addition to HPC, another type of concrete can be produced with this technology which has other properties besides the properties of HPC. This type of concrete is called “multi high performance concrete” (MHCP). Some of the properties of this concrete are electromagnetism, applicability in atomic structures (protection against radiation) and rise in its effectiveness in maintaining the energies in a building [3].

Silica[6] is one of the most famous materials in concrete industry which play an important role in the cohesion in filler of HPC. Adding Nano silica improves the compression of particles, increases the strength of the concrete and prevents the penetration of water into the concrete. The Nano silica product is composed of particles of bullet shape and a diameter of less than 100 nm which are dry (powder) or suspended particles diffusible in the solution liquid which is the most common type of Nano silica solution. This type of solution has been used in certain experiments on SCC.

Suspended Nano silica has shown multipurpose applications like:

- Antifriction
- Anti-slide
- Anti-fire
- Anti-surface reflection

Experiments have shown that the reaction between Nano silica materials and colloidal silica is much quicker than micro silica[7]; a small amount of these materials have the same pozzolan effect of a large amount of micro silica in primary ages. All previous studies on the applications of colloidal Nano silica materials were related to the modification of rheological, functional and mechanical properties of the cement pastry. What is posed here includes the primary results of Nano silica products with a diameter of 5 to 100 nm.

Titanium dioxide[8] is another material able to be used in increasing the capabilities of concrete. Using Titanium dioxide causes self-cleaning and self-disinfecting properties of concrete and gives a white and bright color to concrete. Hematite[9] Nano particles also increase the strength of concrete.

❖ CARBON NANOTUBES: A REVOLUTION IN CONSTRUCTION INDUSTRY

Binders are usually used to reinforce or modify the mechanical performance of concrete. Today, metal, glass, polypropylene[10] and carbon binders are used to reinforce concrete. Hence, researches on the concrete reinforced with carbon nanotubes (CNT) are not issued in order to use their results to reinforce with nanotubes.

❖ An INTRODUCTION TO CARBON NANOTUBES

Carbon nanotube was discovered by a Japanese physicist, Sumio Lijma[11], in 1991. Carbon nanotube is a new generation of carbon made of Nano carbonic materials. This substance which is stronger than steel (the density of carbon nanotubes is of the density of steel, their Young's module ¼ and strength are 5 and 8 times more than those of steel). They are lighter than aluminum and more conductive than copper and have many applications as the key ones include electronics, sensors, building materials, fillers etc. (figure 2).

[6] The chemical compound silicon dioxide, also known as silica, is an oxide of silicon with the chemical formula SiO_2. It has been known for its hardness since antiquity. Silica is most commonly found in nature as sand or quartz, as well as in the cell walls of diatoms.

[7] Micro silica is a product of nanometer size in the range of high performance composite materials to increase cement is used.

[8] Titanium dioxide, also known as titanium (IV) oxide or Titania, is the naturally occurring oxide of titanium with chemical formula TiO_2.

[9] Hematite, also spelled as hematite, is the mineral form of iron (III) oxide (Fe_2O_3), one of several iron oxides.

[10] Polypropylene (PP), also known as polypropene, is a thermoplastic polymer used in a wide variety of applications including packaging, textiles (e.g. ropes, thermal underwear and carpets), stationery, plastic parts and reusable containers of various types, laboratory equipment, loudspeakers, automotive components, and polymer banknotes and its molecular formula is $[C_2H_2]_n$.

[11] Sumio Lijima (born May 2, 1939) is a Japanese physicist, often cited as the discoverer of carbon nanotubes. Although carbon nanotubes had been observed prior to his "discovery", Lijima's 1991 paper generated unprecedented interest in the carbon nanostructures and has since fueled intense research in the area of nanotechnology. For this and other work Sumio Lijima was awarded, together with Louis Brus, the inaugural Kavli Prize for Nanoscience in 2008.

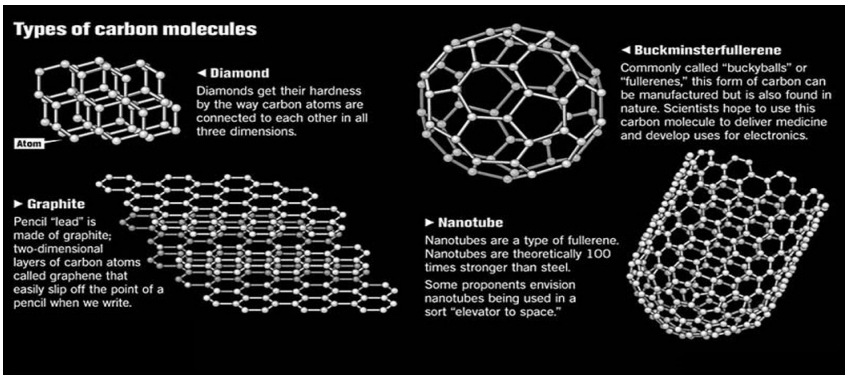

Figure 2: Type of Carbon Molecules [10]

One of its common uses for example is its application as a filler in plastic and color industry as a replacement for black carbon. Carbon nanotubes can tolerate bending and tension without cracking and will be a replacement for carbon binders in composites [4].

Regarding the researches carried out in Concrete Research Center (related to ACI, Iran branch), nanotubes have tension strength of more than any other known concrete binder and show considerable thermal and electric properties as they are twice more thermally conductive than diamond and 1000 times more electrically conductive than copper.

The metal and quasi-metal properties of carbon nanotubes are achieved through changes in structure instead of changes in composition. These properties create many applications in Nano electronics [4]. From the mechanical viewpoint, carbon Nano material is the strongest material known so far. This very strong substance is highly flexible too as its can be bent in the form of a circle or tied in a knot (figure 3, 4).

This special mechanical behavior has created much interest in using it in building materials. The potentials of carbon nanotubes can be still taken into account. Carbon nanotubes thus has key role in achieving building materials with multipurpose high performance.

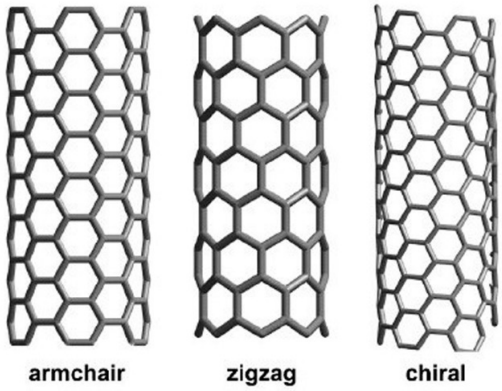

Figure 3: Types of Carbon Nanotube [11]

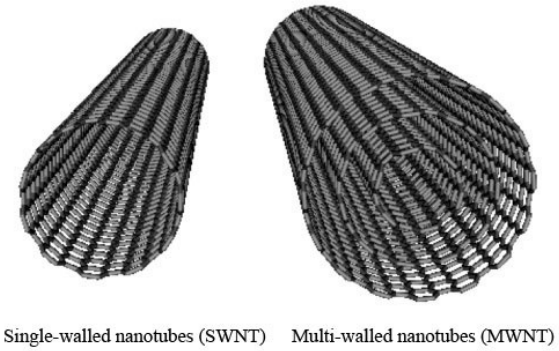

Figure 4: Forms of Single-Walled Nanotubes [12]

❖ THE APPLICATION OF CARBON NANOTUBES IN CONSTRUCTION INDUSTRY

As many applications of carbon nanotubes are extended over most industries, it will have some uses in construction industry as well. There are some vast areas of research leading to the production of product uniquely and specifically needed for buildings. Their research areas include:

- Carbon nanotubes can be used as a suitable reinforcing tool with an ability to bridge between cracks and reduce the sizes and deformation of cracks.
- Due to their great mechanical properties, the use carbon nanotubes in glass polymer and building can be considered.
- Carbon nanotubes are considered as the parts of making heat conduction systems because of their durability, extraordinary strength, very high stiffness, great retrofitting and its special heat conduction properties.
- Long carbon nanotubes are used in suspension bridges in the form of a rope. In concrete for instance, steel fibers (reinforced concrete) were used from the past until now. Hence, concrete is apt to use carbon nanotubes. It is expected to reach better properties in concrete through these materials.[5]

- Carbon nanotubes are discussed and studied as materials to build superstructures like space-based lifts. These cable systems are theoretically able to reach geo synchronous orbits. The rooms of the lift move up and down at the same time and the cable makes load transport from space to the ground and vice versa possible with lowest energy consumed. We should see whether such structures can be designed or built. It seems that carbon nanotubes are the only materials able to be used for this purpose.
- The heat conduction of carbon nanotubes provides other applications too. Since carbon nanotubes have proper density[12], they are able to conduct heat from the surface into heat sinks quickly. Here, the possibility of realizing the composite of materials modified in terms of strength is posed. Moreover, the development of insulators and heating tubes may realize the utilization of heat conduction difference in the widths and lengths of tubes in future. One of the applications can be to heat buildings which can replace systems based on existing liquids to heat different floors.[5]

The special properties of carbon nanotubes cover a wide spectrum including their very high strength to their unusual electronic behavior, high heat conduction, and ability to save and maintain Nano particles inside the tubes. Given the potential application of carbon nanotubes, the need to this material is felt in home industries. The application of carbon nanotubes in construction industry covers a wide range from material composites to compounds and parts with high structural strength and heat conduction technology. Given the high frequency of earthquakes in Iran, the construction industry in which we can observe the necessity to optimize construction and building materials. Iran is rich in providing the primary resources of producing carbon nanotubes on one hand and many researchers have been carried out in this field in the world so far on the other. This material is produced commercially in many parts of the world; however, studied on reaching a high purity and length for carbon nanotubes used in cement and concrete is not the priority. Using them in such conditions yields very acceptable results too and its impure type can have a miraculous effect as a retrofitter on materials.

II. NANO COATING

For instance, we can name stone and wood coatings, brick coating, ceramics and tiles and concrete surface and binder cement coatings (figure 5).

The most important advantages of Nano coatings are creating a suitable insulating coating, preventing erosive factors from penetrating into these coatings, increasing resistance to heat conduction and erosion, friction and decay and the self-cleaning properties of such surfaces [6].

III. NANO WATER-RESISTANCE PROVIDERS

Absorbing water causes numerous and irrevocable damages to unprotected buildings. Efflorescence, peeling color layers, mildew and fungal, pollution absorption and dirtiness, early cracks and exhaustion, reduction in concrete strength and iron erosion are some of the visible and structural damages to a building [7]. Water-resistant materials composed of Nano particles create long-term protection for surfaces through proper penetration into materials. The building uses of water-resistance providers are newly-built buildings, old buildings, cement and concrete pieces, stubbles and stones. It should be mentioned that making buildings water-resistant is possible for different parts like foundation and columns, inner walls, walls and outer covers, toilets, built-in wirings and channels, ground and aerial water tanks and roofs (figure 6).

[12] The mass density or density of a material is defined as its mass per unit volume. The symbol most often used for density is ρ (the Greek letter rho).

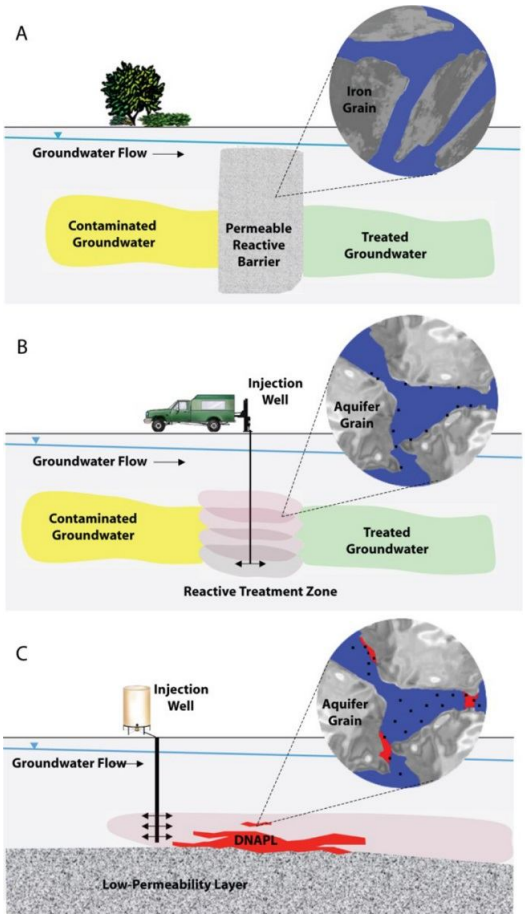

Figure 6: Nanotechnology for Groundwater Remediation [18]

Figure 5: An Example of a Nano coating [13]

IV. NANO GLASSES

Some typical applications of nanotechnology in glass making industry include products like self-cleaning glasses, energy controlling glasses and fire-protection glasses. Titanium dioxide Nano particles are used in making self-cleaning glasses (figure 7).

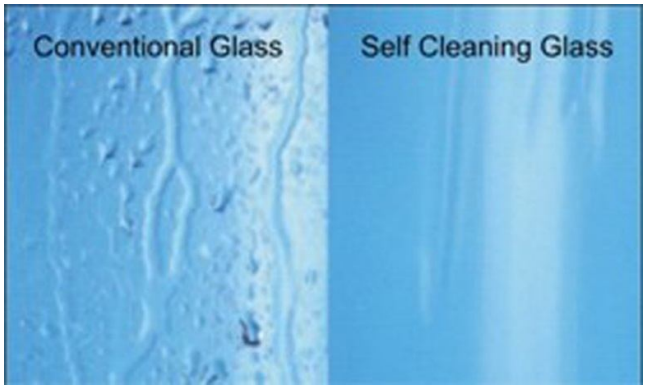

Figure 7: Self-cleaning Glass with Using Nanotechnology [14]

These glasses have anti-stain and disinfection properties. Fire-protection glasses are made through placing a transparent layer containing Nano silica particles between two glass sheets. Energy controlling glasses cause UV and infrared rays pass less and adjust the entrance of visible light and also prevents wasting energy inside buildings.

V. NANO ASPHALTS

Nano asphalts are the structural and constituent elements of bitumen and asphalt in micron and Nano scales. Using nanotechnology can improve the properties of these materials. Some example uses of Nano materials in improving the properties of asphalts are resistance to moisture-caused damages, increasing the strength and lifespan, saving in asphalt maintenance and repair costs, improving the key properties of asphalt like pressure strength[13], stress strength[14] and durability to tolerate exercised loads in high temperature.

VI. CLAY NANO COMPOSITES

One of the advantage of using clay Nano composites is building materials is the improvement in mechanical properties, increase in stiffness without reducing plasticity, resistance to heat and chemical factors, proper applicability, delaying ability and resistance to fire. The ability to delay the effect of flames cause the use of these materials in anti-fire coatings in products like floorings, insulators and building panels and parts and foams for cars, ships, planes and military industries (figure 8).

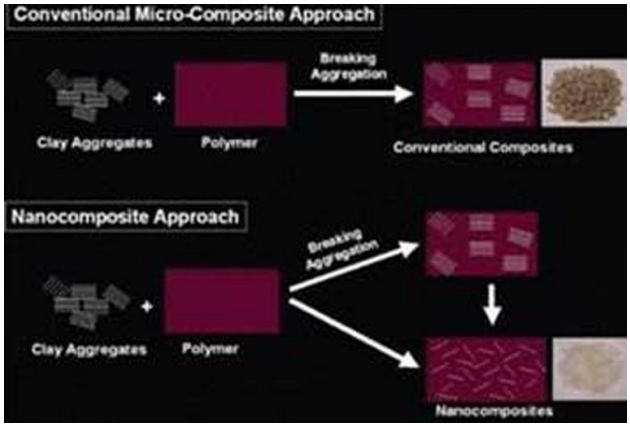

Figure 8: Different Principles Applied in Making Conventional Clay Micro-and Nano composites [15]

The low transfer of different gases like oxygen, water vapor and carbon dioxide[15] is another advantage of using Nano composites. These materials are transparent and almost colorless optically.

VII. THE APPLICATION OF NANO IN WATER PURIFICATION

There are various uses of nanotechnology in water industry. Some of these applications are the purification of pollutants and water wastes, discoloring drinking water, desalinating water, eliminating the arsenic[16] in water, nanotubes absorbing toxic gases and porous Nano polymers [7]. This technology can help with water purification through the following methods:

- Using Nano Metric filters[17] to increase water retrieval
- Purifying underground waters by organic and mineral parts (environment-friendly methods)
- Using Nano materials to improve the efficiency of Photo catalysts and chemical processes[18]
- Nano biosensors for quick detection of water pollution

4. NANOTECHNOLOGY AND ENERGY

Concerning energy, nanotechnology can considerably affect energy efficiency, saving and production and reduce energy consumption (figure 9).

[13] F_c

[14] F_s

[15] Carbon dioxide (chemical formula CO_2) is a chemical compound composed of two oxygen atoms covalently bonded to a single carbon atom. It is a gas at standard temperature and pressure and exists in Earth's atmosphere in this state. CO_2 is a trace gas comprising 0.039% of the atmosphere.

[16] Arsenic is the chemical element that has the symbol As. Arsenic occurs in many minerals, mainly combined with sulfur and metals, and also naturally in the native (elemental) state. It was first documented by Albertus Magnus in 1250.

[17] Using carbon nanotube filters make cleaning easier because increased strength, ability to reuse their resistance against the heat is.

[18] Nano particles utilizing lanthanum in ponds and pools can be effectively destroyed the phosphate and thus will prevent the growth of algae. Also, the use of magnetic Nano-crystals as the core system can control arsenic treatment (very dangerous toxic substance that is increased risk of cancer) to be effective.

Figure 9: Solar (Photovoltaic) Energy Farm Related to Nanotechnology and Energy [16]

For example, chemical substance producing companies have produces polymers strengthened by Nano particles which can a good replacement for the metal parts of car bodies. The wide use of these materials causes saving 1.5 billion liters per year [8].

Another market for this technology includes electric equipment. We can infer from industrial plans that the progresses made in LED[19]-based optic Nano equipment during the next 10 to 15 years may reduce the world energy consumption up to 10 percent. This will lead to save 100 billion dollars a year and reduce the emission of presently 200 million tons of carbon gases annually. Fundamental changes in lighting technology are expected to take place in the next 10 years. The semiconductors[20] used in light-emitting diodes[21] (LEDs) can be produced in a Nano scale and at a large rate. In America, about 20% of the total produced electricity is used for lighting (whether common incandescence lamps or florescent ones).

Also, nanotechnology promises considerable advancements in solar energy transformation and saving, thermoelectric transformers, batteries, highly-efficient fuel cells[22] and efficient electrical energy transfer lines. Different technologies are used today to provide more comfort and safety and save costs especially in consuming energy resources. In information technology (IT) for example, in now possible to control energy consumption through the development of systems which can measure and estimate environmental changes and conditions inside a building and react to them then.

5. NANOTECHNOLOGY AND THE ENVIRONMENT

The development of new technologies in the 21st century which has caused the industrial economy to flourish without any harm to human health and the environment is very important. Developing the green technologies that minimize the production and transportation of waste materials especially toxic ones has much contributed to pollution reduction. The progress of sciences and techniques in the field of nanotechnology in recent years caused great changes in industry, the environment and basic biosciences. The elimination of pollutants[23], the modification of polluted soils, the purification of surface and underground water, and the elimination of microorganisms, the reduction of water darkness and hardness, and desalination are some of the advantages of using this technology [8]. Nanotechnology guarantees the durability of natural resources and is able to eliminate small pollutions from water sources (less than 200 nm) and air (below 20 nm) and continuously measure and reduce pollution in larger areas (figure 10).

[19] An LED lamp (or, colloquially, LED light bulb) is a solid-state lamp that uses light-emitting diodes (LEDs) as the source of light. The LEDs involved may be conventional semiconductor light-emitting diodes, to organic LEDs (OLED), or polymer light-emitting diodes (PLED) devices, although OLED and PLED technologies are not commercially available in 2010.

[20] A semiconductor is a material with electrical conductivity due to electron flow (as opposed to ionic conductivity) intermediate in magnitude between that of a conductor and an insulator.

[21] A light-emitting diode (LED) is a semiconductor light source. LEDs are used as indicator lamps in many devices, and are increasingly used for lighting.

[22] A fuel cell is an electrochemical cell that converts energy from a fuel into electrical energy.

[23] For example, titanium dioxide oxygen molecule, as one of the most common photo catalyst, with water in the air react and cause the reaction between oxygen in the release of results and analysis of OH radicals in polluted air are NO_2.

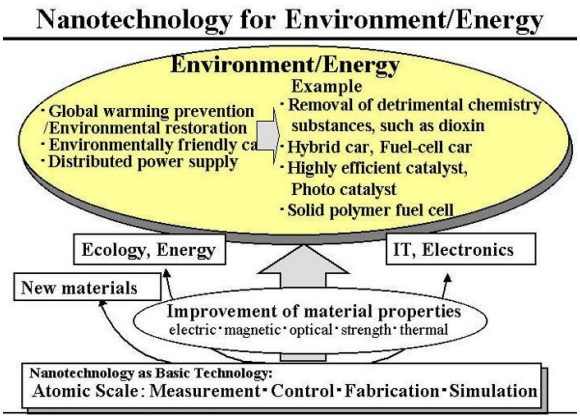

Figure 10: Nanotechnology for Environmental Energy [17]

Another aspect of this capability is the potential risks related to the use of nanotechnology products which are created if certain rules and regulations are not followed. Although nanotechnology makes existing products more effective and efficient, the size of these particles which is one of their important properties can jeopardize our health and the environment. The producers of different Nano products believe that are environmentally harmless in comparison to other products; however, further researches should be conducted on them. In order to remove these worries, attention to ISO, IEC, ANSI, ASTM and other regulations related to health and safety can help.

CONCLUSION

Today, the advancement of new technologies like nanotechnology is the world is regarded as a sign of the scientific and industrial progress of each country and any country do more activities in this field has a better potential for utilizing this technology. Accordingly, more principled researched and studies on nanotechnology seem necessary. Nanotechnology cause the change in the nature of most industries, new methods of making things, making smaller, cheaper, lighter, faster, more operable things and consuming less raw materials and, most importantly, consuming less energy. Any technology hesitate over investing in nanotechnology has jeopardized itself. One of the issues that will influence all aspects of our life sooner or later is nanotechnology. So, it is necessary to think about this issue well and prepare ourselves for it now in order to comprehend this revolution in all its aspects.

Nanotechnology is one of the new technologies with important and valuable applications in different industries like construction industry. As it was mentioned earlier, some of the applications of nanotechnology in construction industry include additives to concrete, glass and asphalt, water purification and coatings. This technology improves the properties of materials and created suitable features in them.

Many cases of using this technology are economically justifiable. Like all modern technologies, different Nano products should be sufficiently studied and examined before use and meeting international standards related to the concerned methods and materials should be taken into account.

SUGGESTION

The world is progressing in science and technology faster than can be imagined. We hear scientific advancements all over the world every day. In order to put using nanotechnology in construction industry into practice, providing necessary conditions and facilities (building laboratories and their necessary equipment), encouraging universities to support this field, conducting applied researches in different fields by research centers, necessary trainings at different levels and using the world experience are necessary. Culture creation, help to the qualitative and quantitative development of experts and encouraging researchers and industrialists to find out more about nanotechnology are the main primary activities. Concentration and the necessity to create harmony in all sectors in nanotechnology and encouraging the private sector to enter nanotechnology is one of the viewpoints shared by all countries in this regard.

The high costs of experiment for this unknown technology and the wide range of its activities make investing in this field difficult for many companies even the large ones. They prefer their superficial consideration of scientific researches and concentration on discovering and experimental developments. Hence, many companies gradually become aware of the great potentials of nanotechnology in industries and future products.

Nano science and nanotechnology depend on chemistry, physics, biology and many other engineering fields. Therefore, Nano covers the boundaries of different faculties in industrial universities and research centers and also the activity fields of most research boards. The technological strategies inside the country are responsible for the recognition of this issue and attention to the reasons for it.

ACKNOWLEDGEMENT

We also thank Dr. Hamed Nikbakht (PhD Graduate Researcher at University of Colorado Boulder) for providing us technical supports.

REFERENCES

1. E.Bell Trudy, 2007. Understanding Risk Assessment of Nanotechnology. United States National Nanotechnology Coordination Office.

2. Eric Drexler, 1990. Engines of Creation: The Coming Era of Nanotechnology. Anchor Books Editions, USA.
3. Surinder Mann, 2006. Nanotechnology and Construction, European Nanotechnology Gateway.

4. A.Jorio, M.S.Dresselhaus, and G.Dresselhaus, 2008. Carbon Nanotubes: Advanced Topics in the Synthesis, Structure, Properties and Applications, Volume 111 of Topics in Applied Physics Series. Springer Berlin Heidelrberg.

5. H.DAI, 2001. Nanotube Growth and Characterization: Synthesis, Structure, Properties, and Applications, Volume 80 of Topics in Applied Physics Series. Springer Berlin Heidelrberg, pp: 29-53.

6. Raymond H. Fernando, Li-Piin Sung, 2009. Nanotechnology Applications in Coating (Acs Symposium Series), American Chemical Society.
7. Mamadou Diallo, Jeremiah Duncan, Nora Savage, Anita Street, Richard Sustich, 2009. Nanotechnology Applications for Clean Water: Solutions for Improving Water Quality (Micro and Nano Technologies), William Andrew, NY, USA.
8. Geoffrey B. Smith, Claes-Goran S. Grangvist, 2010. Green Nanotechnology: Solutions Sustainability and Energy in the Built Environment, CRC Press, USA.
9. www.engineersgarage.com
10. www.chemistry.msu.edu
11. www.nature.com
12. www.pa.msu.edu
13. www.nanoprotect.co.uk
14. www.earthtechling.com
15. www.itech.dickinson.edu
16. www.energysavingtrust.org.uk
17. www.iranika.ir
18. www.nanonet.go.jp/english