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ARAB INDUSTRIAL DEVELOPMENT AND MINING ORGANIZATION

Study on the Industrial Applications of Nanotechnology

in the Arab World

(Promising Investment Opportunities)

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(AIDMO EXPERT)

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Abstract:

Arab countries is facing many immediate challenges in many fields such as energy, environment, and water resources due the rapid population growth, the depletion of groundwater reserves, and the impacts of climate change have led to severe water scarcity in Arab world. In order to face these challenges, Arab countries needs to adopt new technologies such as Nano and bio technologies. In this study, we will present the concept of nanotechnology and Nanomaterials and their potential applications in different fields and how nanotechnology help solve most of the problems in different aspect of life in the Arab world. Also, we will identify different investment opportunities in Nanomaterials and nanosytems that can open new jobs and transform the economy in the Arab world to a knowledge based society.

I. Introduction:

Global population is increasing, and according to a World Bank report, the global demand for energy will increase by 60% over the next 20 years. The energy generation from none renewable sources such as fossil fuels will increase tremendously in the coming future compared to the other sources.[1]Energy production is always associated with emission of Green House Gases (GHGS) which will have a direct impact on the environment as reported by Physical Science of Climate

Change: working group1(2007).[2] The report concluded that "Global atmospheric concentrations of carbon dioxide, methane and nitrous oxide have increased markedly as a result of human activities since 1750 and now far exceed pre-industrial values determined from ice cores spanning many thousands of years".The report also concluded that the global increases in CO2 concentration are due primarily to fossil fuel use and land use change, while those of methane and nitrous oxide are primarily due to agriculture.

Also, fresh water supplies are decreasing and it is predicted that by the year 2025, 48 countries will be short of fresh water. Water purification and desalination are some of the focus areas aimed at meeting future water demands globally. Currently, 600 million people in the world facing water scarcity. Arab countries are considered one of the top most water scarce countries in the world. High population growth, the depletion of groundwater reserves and the impacts of climate change have led to severe water scarcity in Arab world.

During the past two centuries, Mankind has experienced several technology revolutions in: namely industrial, agricultural, medical and information technology. Materials engineering and products were larger in size than the Nano size and therefore had many limitations. Nanotechnology is regarded as the next scientific/industrial revelation of twenty-first

Century and one of the most important technologies in the world today compared to the major revolution in the history of mankind as shown in figure1.Nanotechnology will play a major role in the world's future economy.

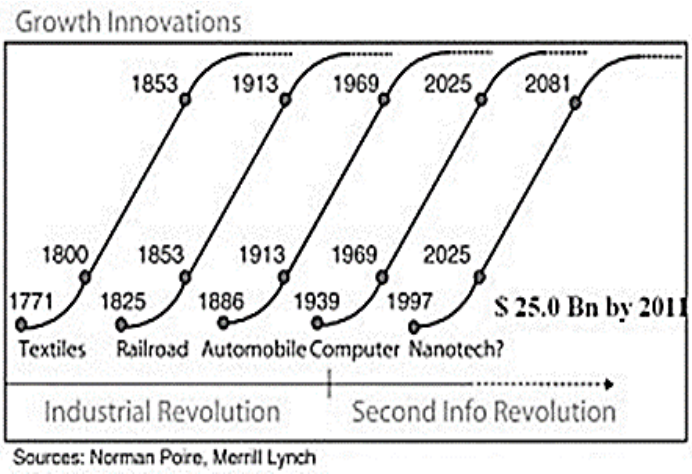

Figure 1: Nanotechnology and other major innovation revolutions. Nanotechnology is expected to be a major revolution as important as the Automobile and Personal computers[3]

If the proliferation of today's technologies is any indication of the speed and power of change in the economy, in the near future nanotechnology will lead to an even more dramatic paradigm shift. The evolution of a "Nano-economy" as contrasted by a "petro-economy" of today is an intriguing idea. Fundamental nanotechnology innovations, yet to come will set the timeline for economic transformation of the nations.

Nanotechnology is defined as utilization and manipulation of matter at scale between 1-100 nanometers called Nanoscale. 'Nano' is comes from the Greek word for 'dwarf' or small.

However, there are different definitions of nanotechnology. Mainly the following definitions:

The development and use of devices that have a size of only a few nanometers. www.physics.about.com

"Research and technology development at the atomic, molecular or macromolecular level in the length scale of approximately 1 - 100 nm range, to provide a fundamental understanding of phenomena and materials at the nanoscale and to create and use structures, devices and systems that have novel properties and functions because of their small and/or intermediate size." www.nano.gov

"Branch of engineering that deals with things smaller than 100 nm (especially with the manipulation of individual molecules)." www.hyperdictionary.com

"The art of manipulating materials on an atomic or molecular scale especially to build microscopic devices." Miriam Webster Dictionary

At the nanometer scale, the energy and physical properties of matter changes. The small size of nanomaterial, explained in term of quantum effects. Nanomaterials have an increased surface-to-volumeratio compared to bulk materials. As a results, material such as metals will have different properties from the same material in a bulk form. For example, bulk silver is non-toxic, whereas Nano silver is very active and can kill viruses and bacteria. Other Properties such as electrical conductivity, strength, melting point, and color change at the nanoscale. The same metal can become a semiconductor or an insulator. Nanometer is defined as 1 billionth of a meter (1 nm = 1/1000000000 m) as shown in figure 2. At this

scale, materials behave differently, and provide a variety of applications and give us the ability to build smarter and lighter materials and devices or shapes and products on that scale. As a result, these particles have unique properties that differ than the bulk materials.At that scale, the rules of physics and chemistry no longer valid and any materials start to have unique and surprising properties. Some materials may become very strong or more conductive or reactive. For example, Carbon which we know is in the form of graphite is not strong, but Carbon Nanotubes is 10 times stronger than steel. Copper which is an opaque substance become transparent. Platinum which is an inert material become catalyst. Aluminum which is a stable material turns combustible. Silicon insulators become conductors. Gold which is solid, inert and yellow on room temperature at micro scale becomes liquid and red in color at nanoscale on room temperature. It also gets unusual catalytic properties not seen at macro scale.

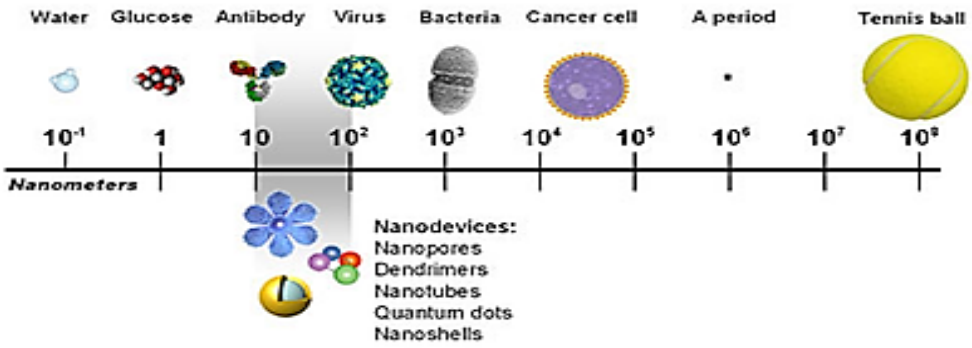

Figure 2: Comparison of different object and their scale and Nanoscale.

Nanotechnology is relatively new and emerging field of science, nanotechnology was first mentioned by the physicist Richard Feynman in his talk "There's Plenty of Room at the Bottom", were he described the possibility of synthesis via direct manipulation of atoms. The

term “Nanotechnology” was first introduced by Norio Taniguchi in 1974.But remained largely theoretical until the 1980s. The invention of the scanning tunneling microscope (STM) lead to the first direct manipulation of individual atoms. A major breakthrough occurred in 1989 by IBM were they used such a machine to spell out their corporate logo, by arrange 35 individual xenon atoms on a substrate of chilled crystal of nickel.

This technology opens new frontiers by enabling us to deal with matter at molecular level and engineer materials atoms by atom, and molecule by molecule. And also offers the possibility of designing nanostructured materials that possess novel electronic, optical, magnetic, and catalytic properties due to their finite small size and high surface area giving nanotechnology enormous potential for future development.[4] The mile stone of the growth of Nanotechnology is shown in figure3.

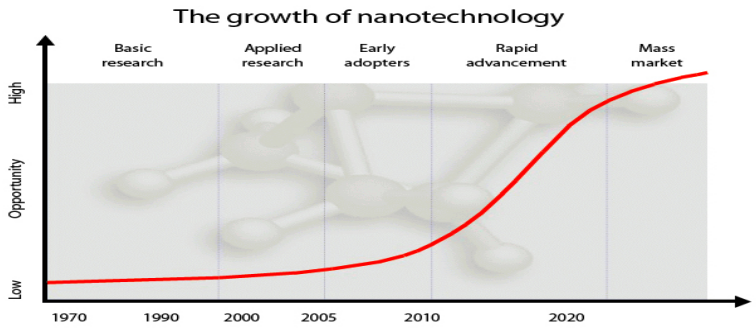

Figure 3: Nanotechnology Growth.[5]

The rapid development of this technology attracted governments and private sectors attention which result in a hug funding and investments opportunities in in all sectors. In fact Nanotechnology market is projected to be the next trillion dollars market. The world total investment in Nanotechnology R&D is growing exponentially and reach to 12.6 billion in

2008 divided between private sector (6 billion), Public sector (6.4 billion), National governments (4.6 Billion), and Local governments and organizations (1.8 billion) as shown in Figure 4.

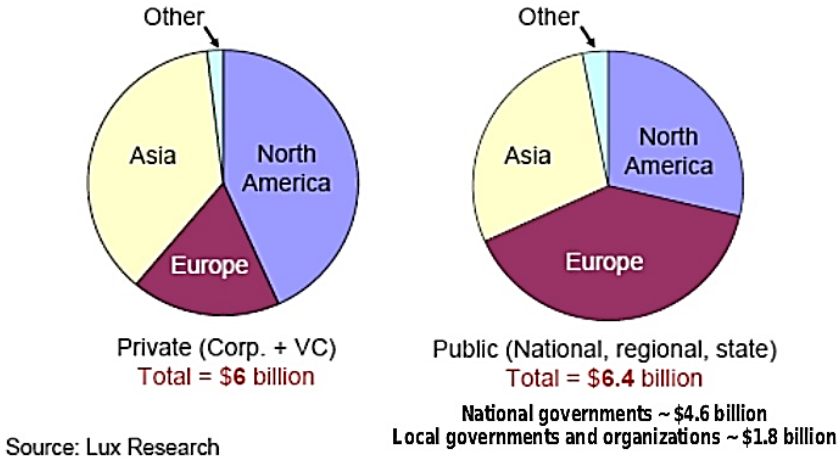

Figure 4: world total investment in Nanotechnology R&D.

Figure5 below shows a significant increase in government nanotechnology funding by different countries in the world in 2011.

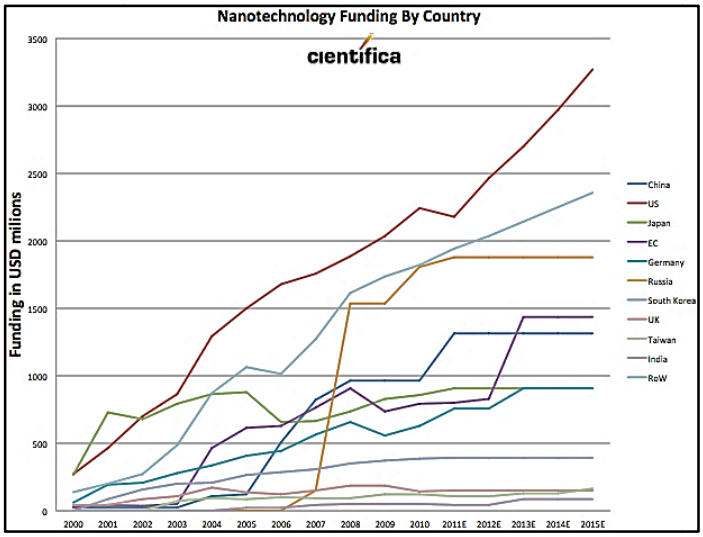

Figure 5: Nanotechnology funding by different countries in the world.[6]

This potential is realized by United States government by lunching nationwide Nanotechnology initiative in 201. Figure 6 shows the 2011 US proposed federal funding in all potential nanotechnology applications including education.

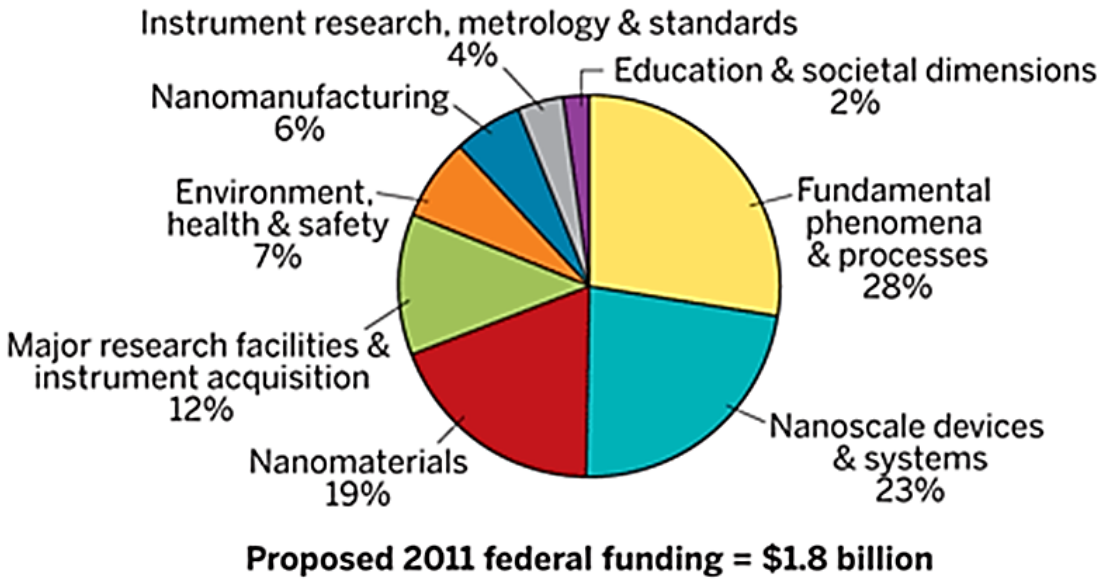

Figure 6: Proposed 2011 US federal funding [7]

The above figures shows that governments have great interest in the potential economic benefit of nanotechnology. In the last 29 years, Nanotechnology has proven the capability to help societies to achieve their goals by improving efficiencies and growth in various economic sectors such as medicine, energy and manufacturing. The huge funding and initiatives by many countries resulted inexponential growth in the number of scientific publications in the field of Nanotechnology. Figure 7 shows the number of Nanotechnology publications by the top five producing countries in the world from 1990 to 2010.

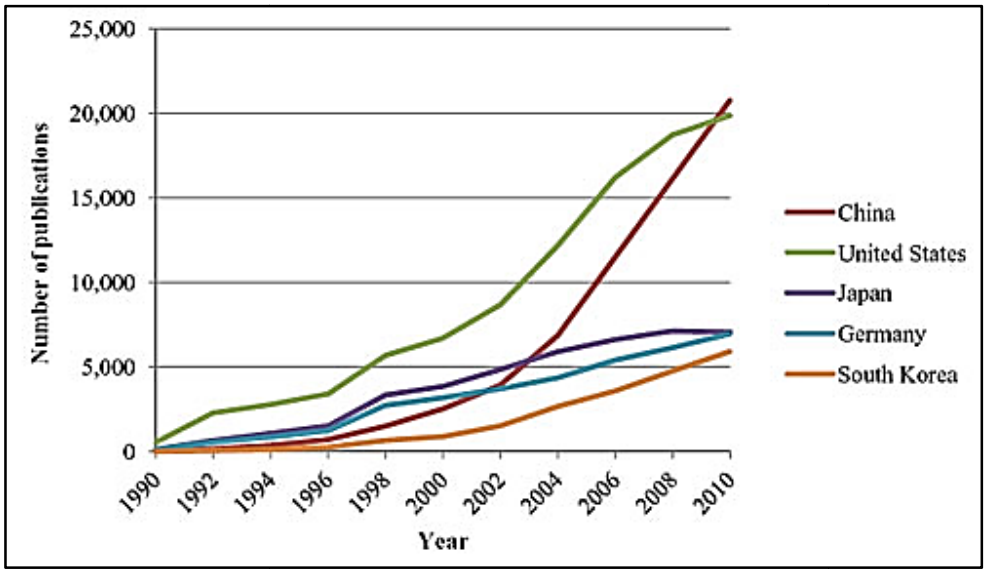

Figure 7: Nanotechnology Publications by Five Top Producing Countries[8]

This interest and investment are also translated to a number of filed Nanotechnology patents by different countries in the world as shown in figure 8 below.

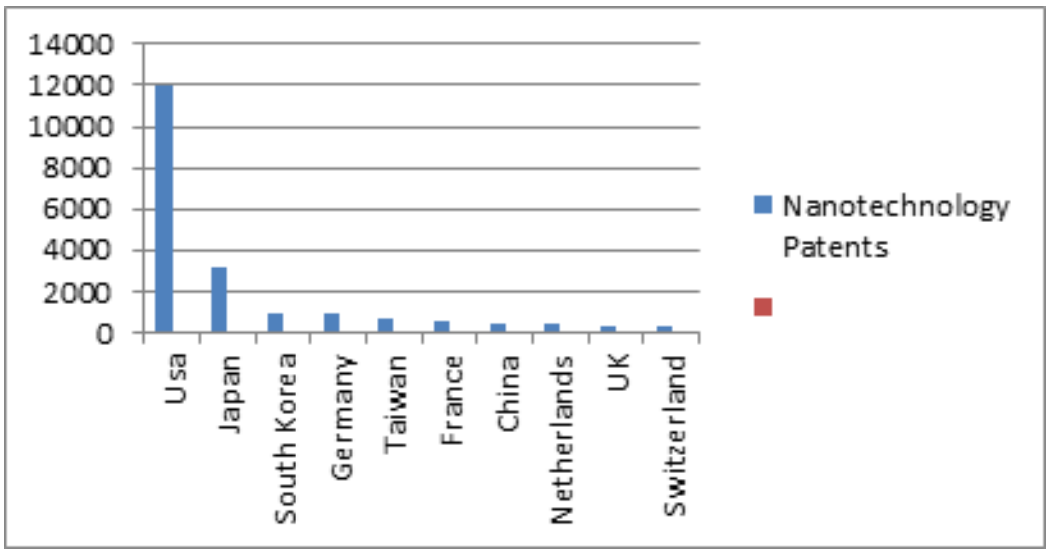

Figure 8[9] *Distribution of nanotechnology patent by country (Source: http//: Nanomaterial comnfrences.com)*

The future outlook of nanotechnology is very promising and will lead to trillion dollars market as projected by many world's leading financial and economic organizations as shown in figure 9 below. The future market will not only focuses on the nanomaterial and devices, but it will be extended to other markets that incorporate nanomaterial in other products.

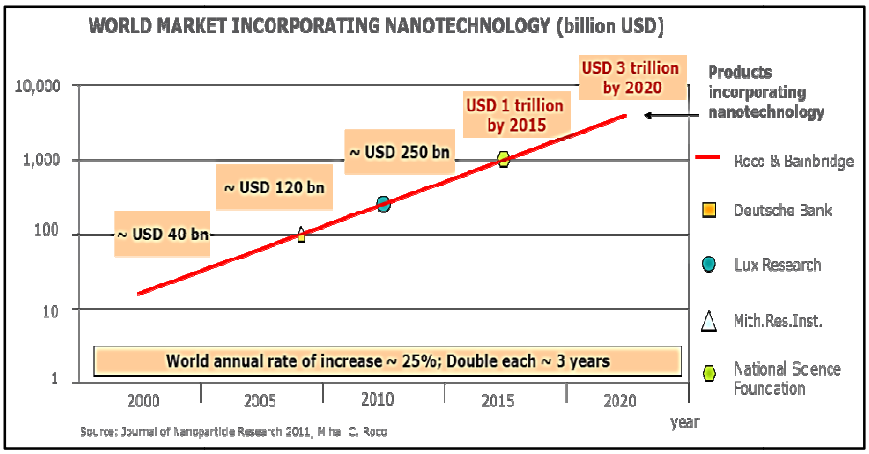

Figure 9:Nanotechnology market projection and invistment opportuntty [10](Source: Nanostart investment)

The Visionary future Nanotechnology will witness even more promises and opens new avenues for a greater impact on human's life. The convergence of Nano technological, biotechnological and information technological research fields as shown in figure 10 will lead to a better understanding to the human body and will utilize new functionalizes based on a high level intelligence by stimulating human mind and the design of smart and efficient products to fight disease and solve many problems.[11]

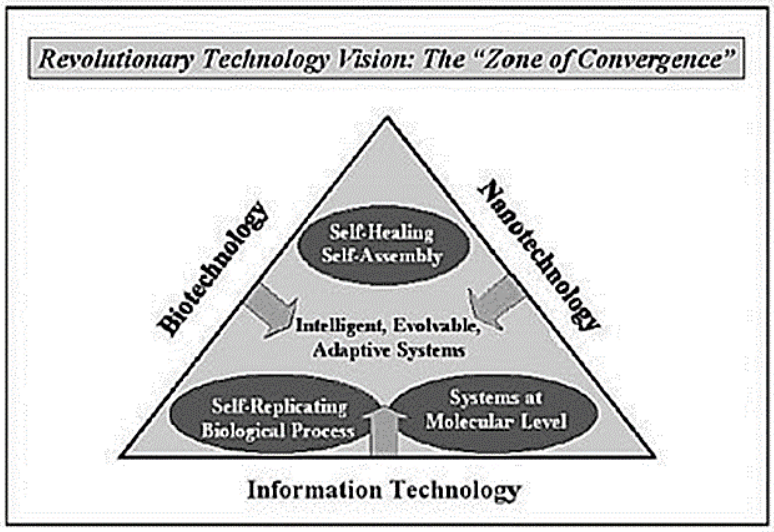

Figure 10: the visionary technological developments by convergence of nanotechnology, biotechnology and information technology (Source: AZ- Nano)

Controlling and building of materials and structures from atoms and molecular components based on linking of physical, chemical and biological properties and function under well-defined control will lead to major technical utilization materials and functionality. Through Nanotechnology, we will be able for the first time in history to design our materials based on our intended use and need. In the near future, Nanotechnology will likely solve many problems in mankind's life including cancer treatment, water scarcity, global warming, and aging. Based on the given data, Nanotechnology represent a great investment opportunity and Nano enables products will address all aspects of our life.Nanotechnology is likely to change everything around us from medicine, to computers, to buildings, to automobiles, and to the clothes we wear.Here is a potential and exciting applications of selected Nanomaterials:

- **Nanopowders**

The unusual properties of particles nanoparticles less than 100 nm allow a range of new and improved materials with many of applications, such as new catalysts for environmental remediation; improved food shelf-life and packaging; and novel drug delivery devices.

- **Carbon nanotubes**

Graphite can be rolled into a cylinder with a diameter of about 1 nm. These strong but light 'carbon nanotubes' can be used in many applications, such as sensors, fuel cells, computers and other electronic devices.

- **Graphene**

Graphene is a two-dimensional atomic-scale carbon with hexagonal lattice. Graphene is one of the most important Nanomaterials in all times and has many important and new properties such as a strength (207 times stronger than steel and extremely high heat and electric conductivity, and is nearly transparent with high optical properties. Graphene can be used in many applications such as in light bulbs, electronics, biological engineering, filtration, lightweight/strong composite materials, photovoltaic solar cells and energy storage, , paints and coatings, lubricants, oils and functional fluids, capacitors and batteries, thermal management applications, display materials and packaging, inks and 3D-printers' materials, and barriers and films.[12]

- **Nanomembrane for water and air filtration**

  These materials can solve one of the most pressing problems in mankind, safe, clean, affordable water.

- **Molecular electronic**

  Silicon computer chips and industry is reaching the physical and technical limit in less than 20 years. Nanoelectronic will replace the microelectronics.

- **Quantum dots**

  Thesenanostructures are very small and containsmany of free electrons and sometimes called “artificial atoms”. These materials has endless applications, such as counterfeit-resistant inks, new bio-sensors, quantum electronics, and photonics.

II. Nanotechnology in The Arab World

The pupulation in the arab word is increasing exponentionally and reachs approximetly 400 Million in the year 2015. Approximately 70% of this population in have limited natural resources the lowest GDP per capita in the world.As a result the arab world is facing major challenges including water, energy and food. In the top of that the arab countries is undergoing major changes in their social and infostructure. Starting by the arab spring and ending up with three major wars. All these challenges and changes deaccelarate the development and increase the poverity and deseases.Dealing with

challenges facing the arab word, it's difficult for governments to adopt long-term strategies for development of science and technology.

It is unfortunate fact that arab countries spend just 0.3% of their gross domestic product (GDP) on science and technology, compared to 1-3% in other developing countries and the average publication rate of arab scientist is less than 1% of the world's peer-reviewed scientific articles as shown in table1 below.[13]

Table 1: Publication Impact (2006-2007).

Country	Publications	Total Citations	Average Publication Impact
USA	8657	20796	2.40
UK	1611	3363	2.09
Germany	2581	5174	2.00
France	1790	3156	1.76
Italy	1053	1654	1.57
Japan	3032	4504	1.49
South Africa	58	76	1.31
People's R China	6124	7954	1.30
South Korea	2140	2741	1.28
India	1130	1302	1.15
Taiwan	1337	1517	1.13
Iran	220	236	1.07
Egypt	82	52	0.63
Saudi Arabia	14	8	0.57
Kuwait	4	1	0.25
United Arab Emirates	8	1	0.13

However, this fact was reliazed by a number of arab countries which leads to a major investment in mega project such as Qatar Foundation (QF) and Science and Technology park(QSTP) in Qatar, King Abdullah University of Science and Technology (KAUST) in Saudia Arabia, (KISR) in Kuwait Masdar Institute in UAE and other projects in other arab

counties. These projects are designed to quicklybuild scientific capacity in critical areas of scienceand technology and build knowledg based sociaty.

Nanotechnology is not strage to the arab world. Nanomaterials were found in islamic history. For example the glowing, glittering "luster" ceramic glazes used in the Islamic world which contained silver or copper or other metallic nanoparticles and "Damascus" saber blades contained carbon nanotubes and cementite nanowires—an ultrahigh-carbon steel formulation that gave them strength, resilience, the ability to hold a keen edgeas shown in figure 11.

Figure 11:a) Islamic "luster" ceramic glazes found in Iraq. b) "Damascus"steel made from carbon nanotube.

Unlike the other major industrial revelutions, Nanotechnology is not exclusive to a certain country or region and sometimes regarded as the "Technology of the Poor". Nanotechnology research can be done with simple instrumentations and local materials. Nanotechnology can offer apportunity to the arab countries become one of the pioneering in this field. Arab countries have the natural reseources and wealth and the educated scientists to use nanotechnology resolve many challenges facing the arab nations.

The feisability of using Nanotechnology to face the region's challenges is not fully relized by many stratigy decision makers in the arab world as stated by Mohamed H.A.

Hassan, executive director of TWAS, the academy of sciences for the developing world, and president of the African Academy of Sciences.[14]

However, in the recent years, Arab region witteness a major development in the field of nanotechnology. Many major initiatives on nanotechnology research have been launched by several Arab countries in order to build their scientific capacity and accelerate research intiatives to keep up with latest developments in nanotechnology field. Several oil-rich countries such as Qatar, Saudia Arabia, Kuwait , United Arab Emirates (UAE), have allocated large funds from Gross Demostic Products (GDP) to establish and support Nanotechnology initiatives in the field of energy, water, envoroment, medicine, food, andlocal industries.[15]Also, these countries attracted international researchers through generous incentives and collaborated with major international research centers and universities. Several National Nanotechnology institutions were established in Saudi Arabia, Eygpt, Jordan, UAE, and Oman. Major Arab nanotechnology initiative in 12-13 Jan, 2010, Cairo Egypt was lunched by League of Arab States.

A tramendus imapact have been noticed after these developments and initiatives in the field of Nanotechnology in the arab word. This impact is evident in the number of publication and patent after lunching the nanotechnology intiatives. Table 2 represent the the rapid increase in the number of publicationsin the field of nanotechnology in the arab world as reported byAlfeeli *et. al*. A fair comparison between 2007 and 2013, shows a great progress in this field in the Arab world.[16]

Table 2: Summary of nanotechnology status in the Arab countries.

Country	Population in millions [34]	Number of institutions conducting nanotechnology research	Number of nanotechnology-related publications[a]		Total publications	Number of nanotechnology-related publications per million
			2002–2007	2008–2013		
Saudi	26.5	11	44	1398	1442	56
Tunisia	10.7	8	139	418	557	52
Emirates	5.3	5	37	190	227	43
Kuwait	2.6	2	27	58	85	33
Jordan	6.5	2	44	143	187	29
Egypt	83.6	4	385	1634	2019	24
Oman	3	2	13	49	62	21
Qatar	1.9	2	1	20	21	11
Morocco	32.3	1	45	142	187	6

[a]The number of publications in peer-reviewed journals in the topics related to nanoscience and nanotechnology during the period January 2002 to March 2013. The data obtained searching for the phrase 'nano' in the title using the SciFinder database.

III. Nanotechnology Applications in the Arab world (Promising Investment Opportunities)

a) Nanotechnology Applications in energy

Energy demands continue to increase, as well as growing concern about climate change and the limited resources of oil reserves in the world is accelerating. As a consequence, the need to explore alternatives to oil-based energy economy. The International Energy Agency (IEA) forecasts that global demand for energy is expected to increase 37 % by 2040 as economies in both developing and emerging countries. It is projected that the population of the world will increase 10 billion and energy demand will reach 28 TW in the year 2050.Currently, 80% of the world's primary energy is generated by burning fossil fuels such as oil, coal, and gas and the peak production of conventional oil is 'likely to occur before 2030. This led to catastrophic climate change, pollution. All these factors requires a new and novel approaches to increase energy efficiency and seek a "clean" alternative energy sources. Using sustainable renewable energy sources like solar and wind seems the alternative solution to meet the world's energy demand with minimum impact on the environment. Recent development in nanotechnology opened new door for more efficient cost effective, envoromently friendly, and sustainable technologies capable of reducing the dependence on the traditional energy.Nanotechnology can help to utilize sustainable energy more efficiently. Building a new cheap photovoltaic cells with better materials that can generate electricity from the sun's light at maximized efficiencies. Also, building new batteries with better performance and higher energy density such as mobile lithium ion and sulfur ion batteries

that can be used in electric and hybrid cars. Nanotechnology also can provide new ways to conserve energy anda better energy efficient insulation materials. Nanotechnology can improve energy and energy efficiency through the following applications.[17]

- **Nanotechnology based solar cells can provide better conversion of sunlight to electricity, cheaper to manufacturing cost, simple installation, easy manufacturing (paintable manufacturing processes) using flexible rolls.**
- **Nanotechnology can improve the efficiency of fuel production using nanocatalyst and increase fuel consumption efficiency in vehicles and power by reducing friction.**
- **Enables the production of new batteries such as lithium-ion battery which are less flammable, fast charging, high efficiency, with lighter weight, and a higher power density.**
- **Recycling of waste heat in many devices and processes such computers, automobiles, and power plants to electrical power.**
- **Developing carbon nanotubes containing wires that reduces the resistance in the electric grid and thus reduce transmission power loss. Below are some examples of important advances in these areas.**

1. Photovoltaic Solar cells

Photovoltaic solar cells have developed over the years. Currently there are three generations of photovoltaic solar cells[18]. The first generation is solar cells that build using high - quality single crystalline silicon based on single p - n junction with very high efficiency (approximately 33%). This type of solar cells required expensive facilities. The

second generation solar cells is based on cadmium telluride(CdTe), copper indium gallium selenide (CIGS), amorphous silicon which require less energy and production cost. But usually this type have less energy conversion and low efficiencies. The third generation solar cell technologies is based on nanostructured materials that uses multi junctions, more concentrated sun light, uses thermal energy to increase the voltage and carrier collection. This type provide higher efficiencies at low cost. For example, using nanometer - scale single crystalline semiconductors particles such as Si (Nanocrystal quantum dot s (NQD s), the light absorption and emission wavelengths can be controlled base on the particle size due to the quantum confinement. The other type of Nano based solar cells uses light absorbing Nanocrystal supported on conductive polymers or high surface area mesoporous metal oxides such as TiO2. This type of solar cells have a theoretical efficiency close to 40%.[19]There other types of Nano based solar cells such as Nanocrystalline CdTe and CdS films on indium tin oxide (ITO) - coated glass substrates reported by Singh et al[20], low - cost thin - film Dye - sensitized photoelectrochemical solar cells (PES or Gr ä tzel cells) solar cells[21], [22],[23], and finally Organic or polymer based solar cells with low efficiencies od 105-6%. [24], [25].

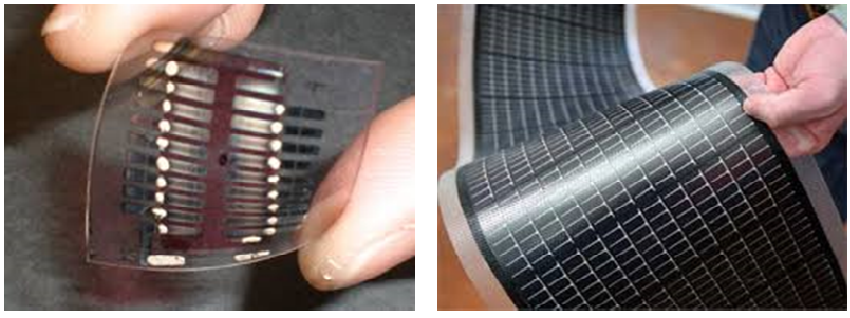

Figure 12: Nano based solar cells

B) Fuel Cells

Fuel cells defined as an electrochemical energy device that convert fuel such as hydrogen, methanol, ethanol, or methane on electrode (anode) when it reacts with an oxidant such oxygen, or air on another electrode (cathode) separated by an electrolyte such as proton - conducting polymer membrane. The electrodes act as catalysts, promoting the oxidation half - reaction of the fuel on the anode and reduction half -reaction of oxygen on the cathode. The electrons released at the anode are directed through an outer circuit to produce electricity. The role of the electrolyte to transport the charge (H +, OH −, O 2 −) to link the two half - redox reactions. Unlike batteries, fuel cells extract chemical energy from external reactants (fuels,oxidants) and convert it to electrical energy.There three types of fuel cell, the first type is proton exchange membrane fuel cell (PEMFC), alkaline fuel cell (AFC) and phosphoric acid fuel cell (PAFC) are typical low - temperature fuel cells (operating temperature < 200 ° C). The last two: molten carbonate fuel cell (MCFC) and solid oxide fuel cell (SOFC) belong to the high - temperature fuel cell class, with operating temperatures above 600 ° C.[26]

Catalysts play an important role inproducing fuels such as hydrogen or methanol to produce hydrogen ions. Typically high cost Platinum metal catalyst used in this process. Platinum nanoparticles is used to reduce the amount of platinum needed in the fuel cells, or many scientist are using of other material nanoparticles to replace platinum entirely in order to lower the cost. Also, since membranes are essential part in Fuel cells which allow hydrogen ions to pass through the cell and prevent other atoms or ions, such as oxygen, to pass through. Nanotechnology is used to make more efficient membranes; which leads to build light weight and longer lasting fuel cells. Nanotechnology also opens the possibility of

designing smaller fuel cells that can replace batteries in handheld devices such as tablets, IPad, or laptop computers. This types of fuel cell using methanol as a fuel and often called DMFC's (direct methanol fuel cell). Also, they last longer than conventional batteries and faster charging by inserting a new cartridge of methanol into the device.

Another type of so Fuel cells can be used to replace batteries in electric cars. Hydrogen fuel cells can be used to power cars. The improvements of the catalysts and membranes, developing a lightweight and safe hydrogen fuel tank to store the fuel is very important. Developing new ways to save energy with the synthesis of new hydrogen storage materials and nanocatalyst that can be used to fuel cells to convert CO to CO2 to prevent CO poisoning in fuel cells. Researchers are trying to develop a new lightweight Nanomaterials that will absorb the hydrogen, store it, and release it when needed. It is expected that hydrogen powered cars will be used in the year 2020 according to theUSA Department of Energy.

C) Reduction of energy consumption

A reduction of energy consumption can be reached by a better insulation systems such as using Aerogels or Nanocomposits as insulating materials. Also, using more efficient lighting such as CFL (compact fluorescent) bulbs which can produce 9 watts and costs $1.40 and has 8000 hours lifetime or LED light which can produce 13 watts and costs $20 with lifetime of 25000 hours. The latest breakthrough is extend the light bulbs efficiency by using quantum caged atoms (QCAs) to reduce the energy consumption for illumination. Typical light pulps converts approximately 5% of the electrical energy into light.Another applications of

nanotechnology is improving the combustion systems by using lighter and stronger materials in the transportation sector.

Through the use of nanotechnology, developing energy capture, transfer, and storage materials will help millions of the people in the Arab world to have access to clean energy sources and electricity and the manufacturing of this materials will create new jobs and positive impact and the economy and on the society.

Finally, Nanotechnology will have potentially significant impacts on energy efficiency, storage and production. Nanomaterials can be used to monitor and remediate environmental problems; improve control emissions from a wide range of sources, and develop new, 'green' processing technologies that minimize the generation of undesirable by-products. Developing new Nanocrystalline material catalyst supports that yield catalysts with well-defined pore sizes in the range of 1 that can be applied in removal of ultra-fine contaminants, and to develop a nanoparticle-reinforced polymeric material that can replace metallic components in the auto industry; as well as the reduction of gasoline consumption and reduce the related dioxide emissions. The impact on industrial control, manufacturing and processing will be impressive and result in saving energy.

b) Nanotechnology in Medicine

In the recent years, health care system in the world faces many challenges and there is increased demand for better, cheaper healthcare. Due to the accelerated changes in the world's economies, aging population growth, and the emerging of middle class causing a

huge burden on the national healthcare systems in many countries in the world and the strong demands for immediate medical treatment. To overcome this challenges, Nanotechnology can playcrucial role in solving health related issues. Nanotechnology has the potential to revolutionize the medicine and health. It can personalized medicine, and make cheaper, and safer. [27]

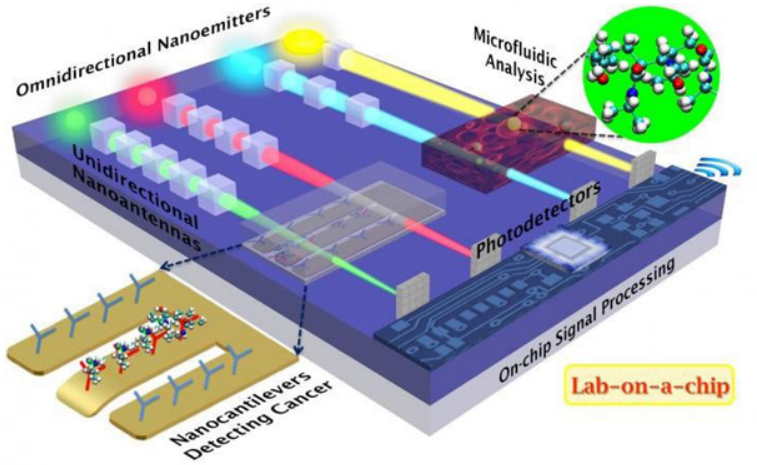

Figure 13: Lab on a chip concept

Below are some recent advances and applications of Nanotechnology in medicine:

- Enhancing medical imaging and diagnostics using semiconducting Nanocrystals called Quantum. These materials when illuminated with ultraviolet light, can emit a wide spectrum of bright colors which can be used to locate and identify specific types of cells using imaging techniques such as MRIand the conventional dyes and provide more information.

- Gold nanoparticles can be used to detect early-stage Alzheimer's disease and cancer cells.
- Targeting to cancer cells and deliver the treatment without affecting normal tissues.
- Using nanotechnology to spur the growth of nerve cells such as damaged spinal cord or brain cells by injecting nanostructured gel to fills the space between cells and encourages new cells to grow or using nanofibers to regenerate damaged spinal nerves.
- Using microfluidic lab on a chip to monitor and manipulate individual cells and track the movements of cells and individual molecules.

Using nanoparticles for drug delivery enables precise delivery of strong medications to specific and needed part in the body, such as a tumor or infection part. This means that these medications can act more effectively – and with fewer side effects in the rest of the body. Nanoparticles have also enabled a totally new approach to cancer treatment; by injecting a magnetic nanoparticle fluid directly into the tumor and applying an external electromagnetic field, the tumor then destroyed by heating it from the inside out. The application of nanotechnology will also make pockets devices, by enabling bulky, expensive laboratory analysis and diagnostic technology to be miniaturized onto a silicon chip, putting within reach the dream of a complete hospital laboratory. Fully automated biochips will soon be able to quickly and cheaply detect pathogens or other biomolecules, such as those associated with cardiovascular disease or other widespread health issues. In the field of pharmaceutical

research, too, the technology of drug discovery is benefitting enormously from these Nano biotechnology-based systems.

These advances and others can bring a great opportunity to Arab world to reduce the amount of medicine and detect and cure a large number of cancers and other diseases and at the same time create a sustainable healthy and safer health processes. This can contribute the society and economy at large.

C) Nanotechnology in Water and Environment

The immediate challenge after solving energy challenge and finding sustainable energy sources is the water scarcity. Many parts of the world have a lake of clean water resources. United Nations reported that approximately more than one billion people in developing and develop countries including some of the Arab countries don't have access to clean water. In the more developed countries, the water resources is contaminated pharmaceutical and pesticide. Arab countries currently have access to 1% of the world's total water resources that is about 500 m3 per capita per year availability of renewable water resources. 85% of these resources is used for agriculture. According to latest statistics published by United Nations, approximately 12 Arab countries suffer from severe water shortages. Many Arab countries are fighting survival fight for water. UNEP urge Arab states to take action to implement plans for integrated water resources management and adoption of new technologies.

Contamination of various water resources by heavy metals is of great concern because of the toxic effect to the health of human being and other livings. Environmental and water

contamination becomes a major issue in recent years due to the discharged of colored and toxic dyes into the water supply system. These dyes are emitted by major industries such as paper, plastic, and pharmaceutical[28],[29]. The presence of dyes such methalyn blue, and other Phenols and phenolic dyes show sever effects on humans, animals, and plants. It was found that the presence of these dyes can affect the nature of water and inhibit the sunlight penetration and reduce photosynthetic reaction[30]. Also, Wastewater contains high levels of pathogenicmicroorganisms; therefore, water disinfection represents a very an important factor in Environmental and water treatment.

Nanomaterials offered cost-effective solutions for many environmental problems such as waste water treatment, pollution, and anti-bacterial treatment. Nanoparticle catalysts are characterized by large surface area, high dispersion and strong interaction with other materials[3132] ,[3334]. Such materials provide clean water from polluted water sources in both large-scale and portable applications, and detect and clean up environmental contaminants. Nanotechnology can provide innovative solutions with optimized filters which can remove chemicals and carcinogens from water with unprecedented efficiency. These nanofilters are already enabling a new generation of treatment plants which can purify large quantities of water in a short time. Nanoparticles used as catalysts for chemical or photochemical destruction of contaminants. Also nanosized zerovalent iron used for the removal of metals and organic compounds from water; and Nanofilteration membranes. For the removal of metals and other inorganic ions, mainly nanosized metal oxides, natural nanosized clays have been used. Also, oxidized and hydroxylated CNTs are represent a good absorbers for metals.[35]

Figure 14: Nanorust can cleans arsenic from fresh drinking water.

(Image Source: www.sciencedaily.com, Image courtesy of Rice University)

Recent nanotechnology advances in the field of water treatment and desalination are:

- Achieving affordable and clean drinking water by rapid, cheaper detection of impurities in and filtration and purification of water. For example, using magnetic interactions between rust nanoparticles can remove arsenic or carbon tetrachloride from water.
- Development of photocatalytic materials for cleaning water using sun light energy
- Development of nanostructured filters capable of removing virus from water
- Developments new cheaper and low energy deionization technique using nanofibers electrodes for water desalination.

- Development of nanotechnology sensitive sensors to detect and monitor contaminants in water.
- Development of Nanofibers membranes to remove salt from water.
- Development of highly porous electrodes made from nanomaterial that can be used in capacitive water desalination.

Air pollution Arab countries is among the lowest in the world. The pollution levels is way less than many cities around the world. This probably is attributed to the low level of industrial activity. For example in 2004, the carbon dioxide emissions was about 1,348.4 metric tons, compared to the other countries in the world (12,162.9 to 13,318.6 metric tons). The Arab region is one of least responsible countries in terms of greenhouse emission and contribution to the climate change (less than 4.7 % carbon dioxide contribution), which lower than some regions in Africa, as reported by the global Human Development Report (HDR) 2008 and world development indices for 2007. However, some Arab countries especially oil and gas producing countries are among the top of the list in CO2 emission per capita.

Nanotechnology offers new capabilities for preventing highly toxic pollutants and provide effective monitoring of pollutants or their impact on the environment. Nanotechnology also capable of providing new and cheapersolutions to clean air and soil. Nanotechnology can contribute to the air purification and reduce industrial emission. For example latest technologies and product adopt Nanomaterials in the following applications:

• Catalytic converters: Nanocatalyst are used as a three-way catalytic converter based on noble metal nanoscale particles. Recent research to use other class of Nanomaterials minimize the amount of noble metal but with the same catalytic performance.

• Filtration/separation: the use of nanofibers filter media in automobile and airplanes industry. Also, a new Nanofibers coated filter media are adopted for dust removal in many at industrial plants and gas turbines.

• Development and optimization of Nano-structured membranes for CO2 capture from power plant flue gases.

• Development of new class of materials called Metal Organic Frameworks (MOFS) for CO2 absorption (these materials can absorb 9 times its weight)

• Nanocatalysts: Nanocatalysts for sustainable air purification are very important in industrial and construction (nanoscale titanium dioxide are being used in cement photo-catalytic active concrete surfaces can be produced for air purification in towns.

•Development of nanofabric "paper towel," woven from potassium manganese oxide wires, that can absorb 20 times its weight in oil for cleanup applications.

d) Nanotechnology Applications in Agriculture

Arab population is considered one of the fast growing rate in the world (about of 1.9%) compared to the average world rate of 1.2 percent, which lead to a major challenge in the food security and availability of domestic food supply. Agriculture in the Arab world is suffering from many problems such as limited water resources, lake of renewable water

resources, poor resources management, rainfallshifting patterns as a result of climate change, and the estimated per capita water availability is expected to cut in half by 2050.[36]Nanotechnology can help the Arab region by providing innovative and novel solutions based on Nanomaterials to encounter these challenges.

Nanotechnology can play a crucial role in agricultural production by utilizing Nanomaterials in plant protection, fertilization, and water management. Using Nanomaterials in agriculture will help in many areas such as:

- Develop Nanomaterials such as hydrogels that can be mixed with the soil and store water and prevent evaporation.
- Developed nanoscale powders of nutrition product that have a high surface area which make it easy to be absorbed.
- Develop new fertilizer particles to minimize the excess use of dangerous fertilizers.
- Developed new materials based on polymer-nanoparticles nanocomposits to be used in the water delivery systems

e) Nanotechnology Applications in Oil and Gas Industry

Arab countries are fortunate to have a proven oil reserves than any other world (713.6 billion barrels), which account for 43 %of the world's total proven reserves. Arab countries produces an average output of 26.3 million barrels per day (2011), which is nearly nearly third of world oil supply of the world. Also, the Arab oil reserves is the cheapest to find, develop, and produce (the production cost is between $3 and $5 per barrel).The Arab

countries are among the top countries who hold proven natural gas reserves (55 trillion cubic meters (Tcm), 2011-2012), which as accounted for more than a quarter of the world's total proven gas reserves.[37]

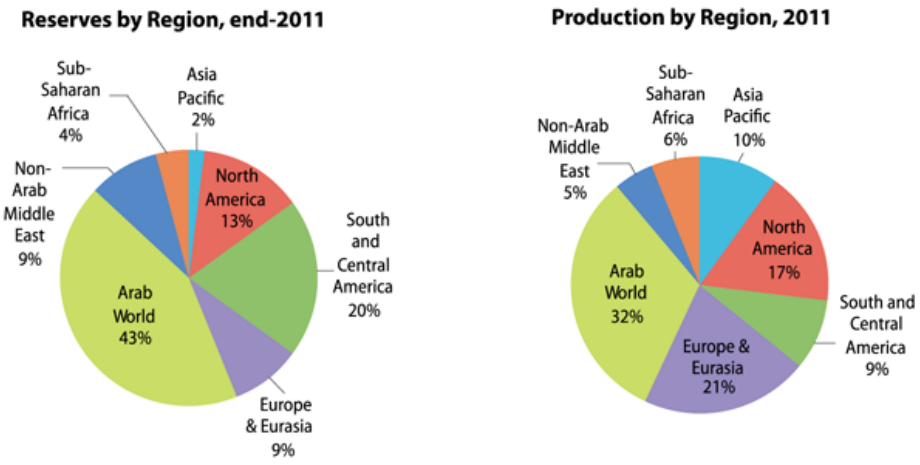

Figure 15: oil Reserve by the region in the world

Nanotechnology can revolutionized the oil and gas industry. Nanotechnology can be used to enhance the development of oil and gas exploration and production. Nanomaterials can improve thermal conductivity, separation, and reduce material's corrosion and hence geothermal-energy production. Nanoscale metals already have been used to delineate ore deposits for exploration. Also, Nanotechnology can the drilling speed and process using nanofluid, which result reducing the damage to the reservoir rock in the well and extract more oil.

Nanotechnology can be widely used to enhance development of standard and unconventional gas resources. It can improve the Liquefied-natural-gas (LNG) infrastructure, efficiency, quality, and gas-to-liquids (GTL) process technology by developing super pipe lines, floating GTL platforms; production, regasification, and resolve storage and transport

issues. Furthermore, it can help the production of methane hydrates and gas to the market based electricity transport rather than the gas pipeline transport. More important, Nanotechnology can be used to developing Nanocatalysts and nanoscale membranes for GTL production, and Nanomaterials for compressed-natural-gas transport or long-distance electricity transmission.[38]

Potential advances of nanotechnology in oil and gas industry are:

• Nanotechnology can enhance performance and reliability of the drilling equipment by increasing the strength and durability under extreme conditions such as high-temperature and high-pressure.

• design new hydrophobic or hydrophilic Nanomaterials for water flood applications in drilling operation.

• design new Lightweight rugged Nanomaterials that reduce for offshore platforms, and more- energy efficient transportation vessels.

• Design temperatures and pressure Nano sensors and imaging techniques for extreme environment operations such as deep wells and provide data on reservoir environment and hence improve drilling cost.

f) Industrial Applications of Nanotechnology

Arab world is considered one of the fastest developing economies in the world, the middle class is growing to almost 44% of the region's economy. There is more than 150 million people with household consumption. 60% of the Arab countries are classified as middle class.[39]The total Arab League GDP is estimated to be more than $2.3 trillion in 2011. Which make it world's eighth largest economy in the world as shown in the figure below.[40]

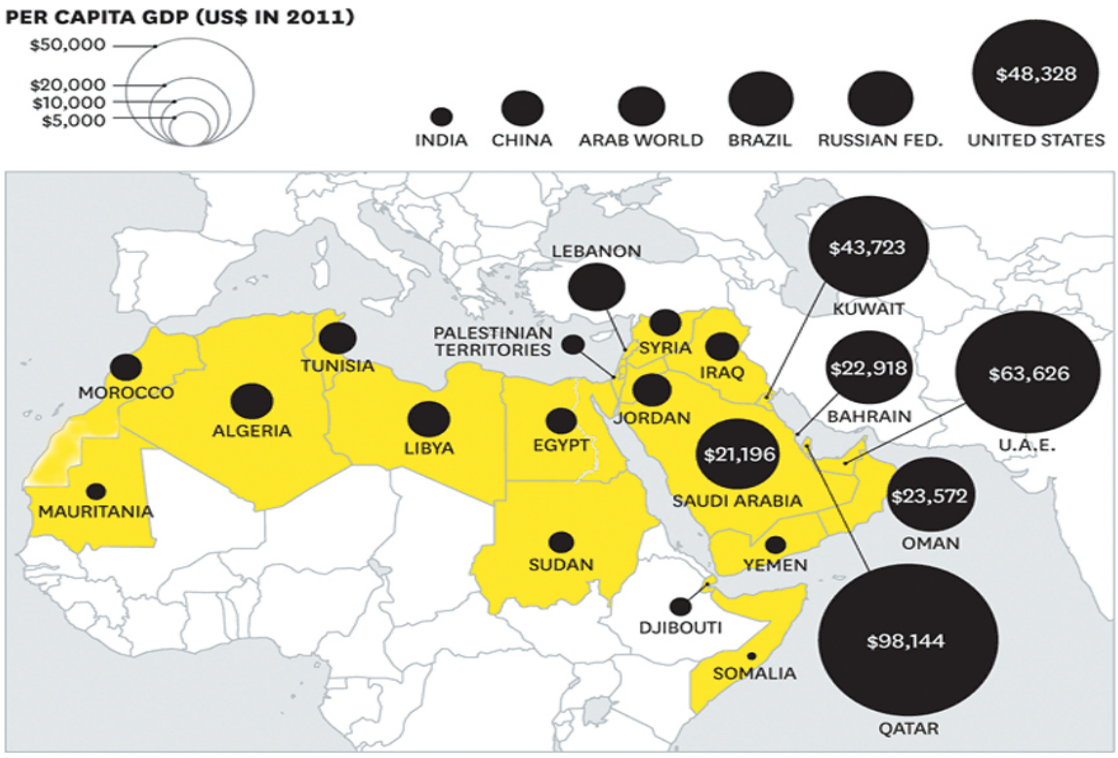

Figure 16: Per capita GDP in the Arab world[41]

Therefore, adoption of nanotechnology in the Arab world will enhance the economy and reduce the unemployment by creating new jobs.

Nanotechnology is widely used in consumer goods, many industries and products incorporated Nanomaterials in them. There a number of products in the market contained Nanomaterials and many people do not realize it. These products contained new functionalities never found before in the same products. For example, some products are easy-to-clean or have scratch-resistant properties. Other materials such as new cars have lighter and stronger made from carbon nanotube, a new glass that repel water, clothing are stain repellant or wrinkle free, sunscreen with 100% UV protection, smart textiles and

"wearable electronics", and many more. As mentioned before, Nanotechnology is expected to revolutionized the technology in all aspect of our life and create a new Jobs and business opportunities by improving the material's performance and create intelligent products and devices that positive impact on the economy and the society.

All these functionalities can be achieved by synthesizing nanoscale building blocks with precisely controlled size and composition and then to assemble them into larger structures with unique properties and functions, thus revolutionizing segments of materials manufacturing. This method can bring lighter, stronger, and programmable materials, reductions in life-cycle costs through lower failure rates, and innovative devices based on new principles and architectures.

Nanotechnology can be used in the following industrial sectors[42]:

- **Food sector:**
  - Development of biosensors for bacteria identification and food quality monitoring.
  - Development of Nanomaterials and coating for intelligent, active, and smart food packaging.
  - Development of anti-microbial agents such as silver nanoparticles for the surface of the coated film on the packaging.
  - Development of Nanomaterials for Nano encapsulation of bioactive food compounds

- **Construction Materials and Coatings**:

Develop cheap,lighter, strong, safe, and envoromently friendly Nanomaterials such as carbon nanotubes, silica aerogels, Nano cement, and nanocomposits.

- Develop Nano sensors to monitor everything in the building.
- Utilized waste materials to create new sustainable Nanomaterials to be used in new buildings.
- Develop nanoparticle for anti-corrosion coating to prevent structural damage.
- Develop none flammable and thermal insulation materials and coating based on Nano clays and silica aerogels to reduce energy consumption and enhance the safety in buildings
- Develop self-cleaning and photocatalytic coating to be used on the outer envelope of the building.

- **Textile:**

- Develop nanofibers to make functional textile such as water and stain-repellent or wrinkle-free.
- Develop heat resistance coating for
- Develop electrostatic resistance textile by integrate carbon nanoparticle membranes.
- Develop smart textile for monitoring of human body temperature and heart rate and solar chargers.
- Develop wound dressing textile which has silver nanoparticles as anti-bacteria agent.

- **Aerospace and cars:**
  - Develop lighter and stronger materials for aircraft to increase their performance and reduce energy consumption.
  - Develop lighter and stronger materials for vehicles to make it faster and safer.
  - Develop lubricant for combustion engines to reduce wearing and increase the heat resistant.
  - Develop Nano coating for the outer parts of the airplanes and cars to reduce the drag force and hence reduce the fuel consumption.
  - Develop Nano scratch resistance coating for cars.
- **Catalysts:**

  Nanocatalysts have extremely large surface to volume ratio and are considered one of the important Nanomaterials in many sectors such as oil and gas industry, water treatment, energy production, production of chemicals and fuels, catalytic convertors, solar cells, and fuel cells. It considered as one of the important application in the Arab world because it can solve many problems such water treatment and it can be wildly used in petrochemical and oil refinery and reduce the dependence on the import from outside companies. Nanocatalysts can be used in many applications:

  - Reducing the amount of platinum in the cars catalytic convertor.
  - Using Nano phtocatalysts such as Titanium and zinc dioxide in water treatment and air purification.
  - Using Low temperature Nanocatalysts for petrochemicals to reduce energy consumption.

- Using Nanocatalysts to produce new chemicals and plastics.
- Produce fuel from air
- Using photo catalysts split water to produce hydrogen fuel.
- Using photo catalyst to break CO2 to carbon and oxygen using the sun light.
- Engineering of biodegradable plastic materials with super thermal, mechanical and electrical characteristics. For example, it can be make easy-to biodegrade plastic bags.

There many more industrials applications of nanotechnology in other sectors such as electronics and communications such antennas and computer chips.

IV. Case Studies

Case study 1: Aerogel material for Thermal Insulation [43]

Thermal insulation is considered one of the main factors of reducing heat and energy consumption in buildings. There are many insulation materials used to reduce energy consumption and heat loss in buildings, such as: cellulose, glass wool, rock wool, polystyrene, urethane foam.., etc. Most of these materials are considered less effective and costly.

Silica Aerogels are ultra-light, highly porous and highly thermal insulating materials. Because of this unique combination of properties, aerogels are being considered for applications as varied as thermal and sound insulation for aerospace applications, as absorbents for environmental remediation and as supports for catalysts. Aerogels are also mechanically

fragile, so their commercialization has been slow and generally limited to granulate and panels of limited thickness.

Recently, Dr. Khaled Saoud and his collaborator from USA, Dr. Massimo with the support from Qatar National Research Fund (QNRF) reported a breakthrough in aerogel fabrication of highly strong Aerogels. The new Aerogel synthesis is in one pot for native and cross-linked alcogels and no solvent exchanges are necessary. Monoliths can be fabricated in a few hours instead of days, and large volumes of fresh solvent are not required by the process. The results are of particular relevance, since they dramatically shorten fabrication times of native and, most importantly, cross-linked aerogel monoliths with large sizes. We have synthesized samples using base- and acid-catalyzed chemistries, varied alkoxide concentration and, for cross-linked aerogels, monomer concentration. Depending on alkoxide concentration, native oxide aerogels had densities between about 0.06 and 0.17 g cm-3 and surface areas between about 300 and 500 m2 g-1. Figure 1 shows our synthesized Aerogels.

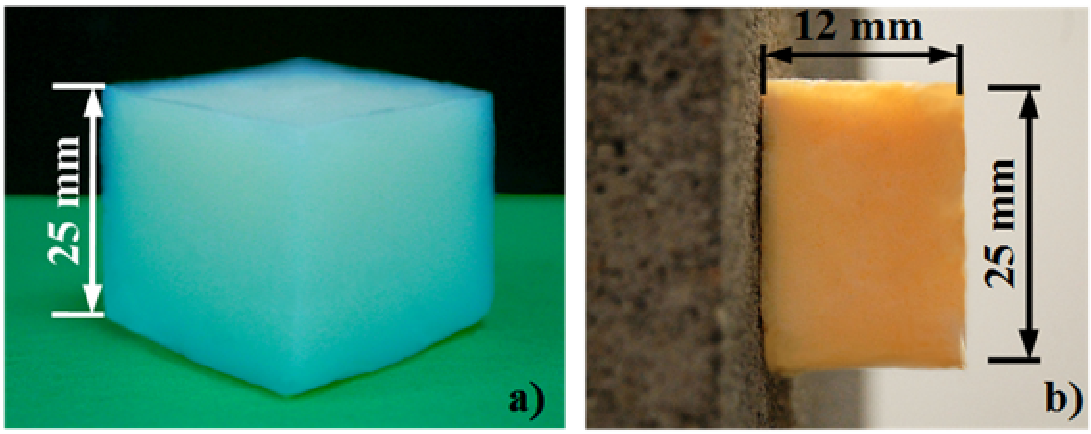

Figure 17: Aerogel material for energy consumption reduction.

Also, they developed alternative fabrication methods which enable to produce custom parts which are made mechanically strong by reinforcing the regions of highest solicitation with a polymer. They have fabricated custom parts that may be used as insulation of selected parts of internal combustion engines, passive fire protection of structural elements in building, and lightweight footwear for extreme cold conditions. We also have developed cost-effective and scalable procedures for fabricating these custom- shaped aerogels.

This research could lead to manufacturing of energy saving materials that can be used in the Arab region to reduce energy consumption especially in the hot Arab countries such as the gulf countries.

Case Study 2: Silver/Zinc Oxide Photo catalyst (Ag/ZnO) for Waste Water Treatment[44]

It is predicted that by the year 2025 that 48 countries will be short of fresh water. Currently, 600 million people in the world facing water scarcity. Nanotechnology can offer a great opportunity to provide new and novel methods to solve water scarcity challenge. Nanotechnology can offer tailor–made solutions suitable for water cleaning and removing a particular contaminant from waste water, water harvesting for ambient air using different Nano–based techniques which is not possible with the current technologies.

The concept of nanotechnology is used to provide a new solutions based on recycling waste water and convert waste water as sustainable resource to produce clean drinking, irrigation, or industrial water. Dr. Khaled Saoud and his collaborator Dr. Joydeep Dutta developed new silver on zinc oxide photo catalyst (Ag/ZnO) for waste water treatment capable of removing toxic dye and kill the bacteria in water. The Photo catalyst is tested for

discoloration of MB in water under visible solar radiation and then using UV/Ag/ZnO system. We found that Ag/ZnO nanoparticles remove the color of Methylene Blue (MB) from water. Also, UV/Ag/ZnO system confirms the removal of MB from aqueous solutions containing 5 mg/L MB using small amount of Ag/ZnO Photo catalyst completely. The photocatalytic activities of Ag/ZnO system were investigated under light and in the dark. The results indicate that the catalyst have high catalytic and antibacterial activities under visible light and in the dark. The enhanced photocatalytic activity of Ag/ZnO nanoparticles is attributed to the presence of Ag ion and the synergetic effect, surface Plasmon effect of Ag nanoparticles, improved charge-transfer, and the prevention of the electro-hole recombination in ZnO. Figure 15 show TEM micrographs of our Ag-/ZnO nanoparticles.

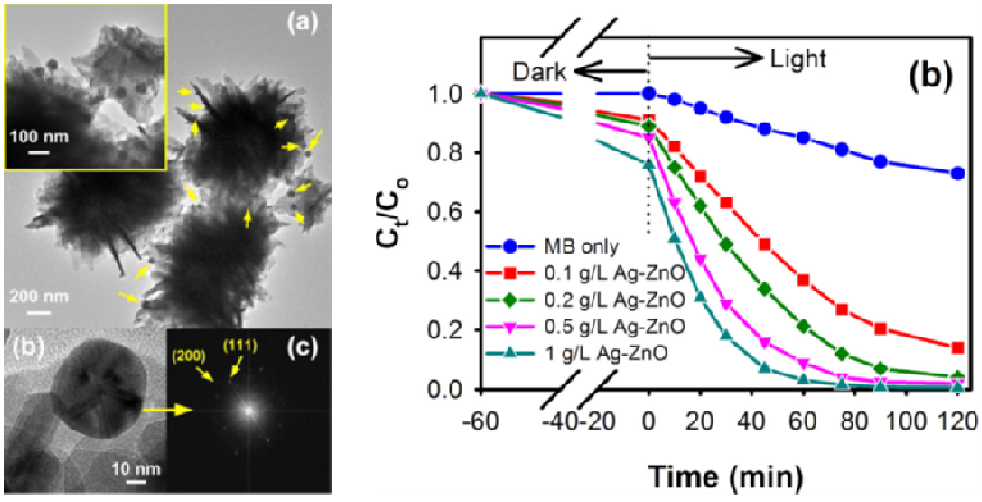

Figure 18: Transmission electron Microscope (TEM) image of Ag/ZnO photo catalyst and Methalyn blue degradation.

V. Summary

Nanotechnology is definedas the manipulating of material at very small scale- at the level of atoms and molecules (less than 100 nm) and, at this level, the regular physics and chemistry rules no longer applied , as results many properties of these materials are begin to change and become unique, and sometimes show a surprising properties . These physical characteristics of the materials differ from the characteristics of the same material under the normal conditions,and this new and improved material properties can be used in different applications in the Arab world. These applications are summarized in the use of nanotechnology to produce smart materials, and change the function of materials, for example, lubricants, paints and replace are replaced with super strong materials with high-quality electrical characteristics which can be applied in all manufacturing sectors. For example, Nanotechnologycan beused to improve a wide range of properties such as engineering of biodegradable plastic materials withsuperthermal, mechanical and electrical characteristics and thus can be a form of easy-to biodegrade plastic bags.

The Arab countries efforts to achieve Arab sustainable industrial development and to ensure the competitiveness and the transition to a knowledge-based economy and bring about the desired and requirements to catch up with scientific and technological progress the world. Nanotechnology is used to solve the most important problems in the all-inclusive areas of life in the Arab world. Were science and Nanotechnology become a comprehensive scientific revolution and is used to solve the most important problems in all areas of life such energy , Agriculture , Health and Medicine nanoscale , remove the pollution of the environment , communications , materials , manufacturing, electronics, and consumer goods , etc. which have significant economic impact and is expected that the production volume of materials, products , technologies, and services will reach $ 2.6 trillion in 2015 and provides more than 7 million jobs in the same year. Finally, Arab countries must adopt and invest heavily Nanotechnology and other science and technology fields to achieve the desired advancement of production knowledge and technological desired development processes and hence become science based societies.

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Arab Industrial Development and Mining Organization
(AIDMO)

Study on the Industrial Applications of Nanotechnology in the Arab World

(Promising Investment Opportunities)

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Study on the Industrial Applications of Nanotechnology in the Arab World

(Promising Investment Opportunities)

Abstract:

Arab countries is facing many immediate challenges in many fields such as energy, environment, and water resources due the rapid population growth, the depletion of groundwater reserves, and the impacts of climate change have led to severe water scarcity in Arab world. In order to face these challenges, Arab countries needs to adopt new technologies such as Nano and bio technologies. In this study, we will present the concept of nanotechnology and Nanomaterials and their potential applications in different fields and how nanotechnology help solve most of the problems in different aspect of life in the Arab world. Also, we will identify different investment opportunities in Nanomaterials and nanosytems that can open new jobs and transform the economy in the Arab world to a knowledge based society.

I. Introduction:

Global population is increasing, and according to a World Bank report, the global demand for energy will increase by 60% over the next 20 years. The energy generation from none renewable sources such as fossil fuels will increase tremendously in the coming future compared to the other sources.[1]Energy production is always associated with emission of Green House Gases (GHGS) which will have a direct impact on the environment as reported by Physical Science of Climate

Change: working group1(2007).[2] The report concluded that "Global atmospheric concentrations of carbon dioxide, methane and nitrous oxide have increased markedly as a result of human activities since 1750 and now far exceed pre-industrial values determined from ice cores spanning many thousands of years".The report also concluded that the global increases in CO2 concentration are due primarily to fossil fuel use and land use change, while those of methane and nitrous oxide are primarily due to agriculture.

Also, fresh water supplies are decreasing and it is predicted that by the year 2025, 48 countries will be short of fresh water. Water purification and desalination are some of the focus areas aimed at meeting future water demands globally. Currently, 600 million people in the world facing water scarcity. Arab countries are considered one of the top most water scarce countries in the world. High population growth, the depletion of groundwater reserves and the impacts of climate change have led to severe water scarcity in Arab world.

During the past two centuries, Mankind has experienced several technology revolutions in: namely industrial, agricultural, medical and information technology. Materials engineering and products were larger in size than the Nano size and therefore had many limitations. Nanotechnology is regarded as the next scientific/industrial revelation of twenty-first

Century and one of the most important technologies in the world today compared to the major revolution in the history of mankind as shown in figure1.Nanotechnology will play a major role in the world's future economy.

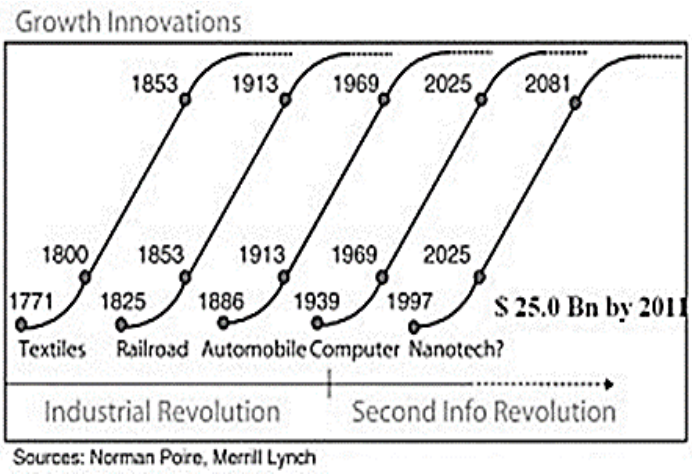

Figure 1: Nanotechnology and other major innovation revolutions. Nanotechnology is expected to be a major revolution as important as the Automobile and Personal computers[3]

If the proliferation of today's technologies is any indication of the speed and power of change in the economy, in the near future nanotechnology will lead to an even more dramatic paradigm shift. The evolution of a "Nano-economy" as contrasted by a "petro-economy" of today is an intriguing idea. Fundamental nanotechnology innovations, yet to come will set the timeline for economic transformation of the nations.

Nanotechnology is defined as utilization and manipulation of matter at scale between 1-100 nanometers called Nanoscale. 'Nano' is comes from the Greek word for 'dwarf' or small.

However, there are different definitions of nanotechnology. Mainly the following definitions:

The development and use of devices that have a size of only a few nanometers. www.physics.about.com

"Research and technology development at the atomic, molecular or macromolecular level in the length scale of approximately 1 - 100 nm range, to provide a fundamental understanding of phenomena and materials at the nanoscale and to create and use structures, devices and systems that have novel properties and functions because of their small and/or intermediate size." www.nano.gov

"Branch of engineering that deals with things smaller than 100 nm (especially with the manipulation of individual molecules)." www.hyperdictionary.com

"The art of manipulating materials on an atomic or molecular scale especially to build microscopic devices." Miriam Webster Dictionary

At the nanometer scale, the energy and physical properties of matter changes. The small size of nanomaterial, explained in term of quantum effects. Nanomaterials have an increased surface-to-volumeratio compared to bulk materials. As a results, material such as metals will have different properties from the same material in a bulk form. For example, bulk silver is non-toxic, whereas Nano silver is very active and can kill viruses and bacteria. Other Properties such as electrical conductivity, strength, melting point, and color change at the nanoscale. The same metal can become a semiconductor or an insulator. Nanometer is defined as 1 billionth of a meter (1 nm = 1/1000000000 m) as shown in figure 2. At this

scale, materials behave differently, and provide a variety of applications and give us the ability to build smarter and lighter materials and devices or shapes and products on that scale. As a result, these particles have unique properties that differ than the bulk materials.At that scale, the rules of physics and chemistry no longer valid and any materials start to have unique and surprising properties. Some materials may become very strong or more conductive or reactive. For example, Carbon which we know is in the form of graphite is not strong, but Carbon Nanotubes is 10 times stronger than steel. Copper which is an opaque substance become transparent. Platinum which is an inert material become catalyst. Aluminum which is a stable material turns combustible. Silicon insulators become conductors. Gold which is solid, inert and yellow on room temperature at micro scale becomes liquid and red in color at nanoscale on room temperature. It also gets unusual catalytic properties not seen at macro scale.

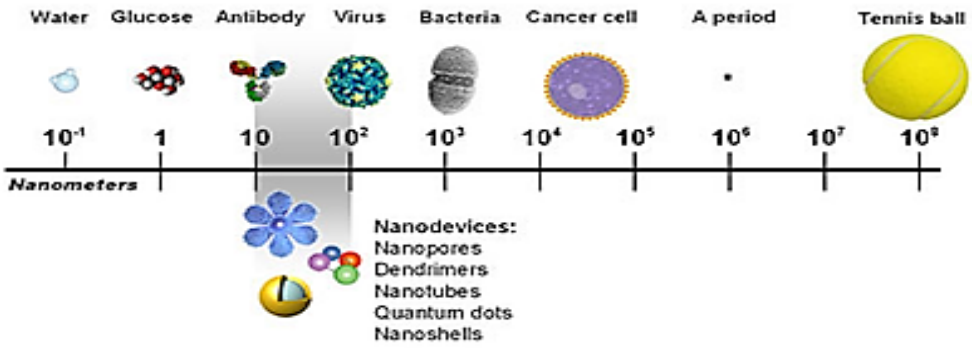

Figure 2: Comparison of different object and their scale and Nanoscale.

Nanotechnology is relatively new and emerging field of science, nanotechnology was first mentioned by the physicist Richard Feynman in his talk “There’s Plenty of Room at the Bottom”, were he described the possibility of synthesis via direct manipulation of atoms. The

term “Nanotechnology” was first introduced by Norio Taniguchi in 1974.But remained largely theoretical until the 1980s. The invention of the scanning tunneling microscope (STM) lead to the first direct manipulation of individual atoms. A major breakthrough occurred in 1989 by IBM were they used such a machine to spell out their corporate logo, by arrange 35 individual xenon atoms on a substrate of chilled crystal of nickel.

This technology opens new frontiers by enabling us to deal with matter at molecular level and engineer materials atoms by atom, and molecule by molecule. And also offers the possibility of designing nanostructured materials that possess novel electronic, optical, magnetic, and catalytic properties due to their finite small size and high surface area giving nanotechnology enormous potential for future development.[4] The mile stone of the growth of Nanotechnology is shown in figure3.

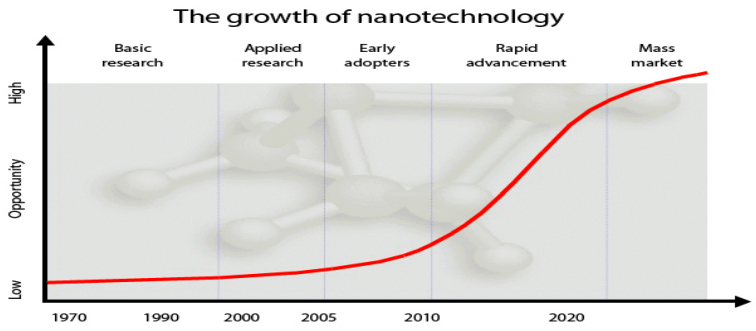

Figure 3: Nanotechnology Growth.[5]

The rapid development of this technology attracted governments and private sectors attention which result in a hug funding and investments opportunities in in all sectors. In fact Nanotechnology market is projected to be the next trillion dollars market. The world total investment in Nanotechnology R&D is growing exponentially and reach to 12.6 billion in

2008 divided between private sector (6 billion), Public sector (6.4 billion), National governments (4.6 Billion), and Local governments and organizations (1.8 billion) as shown in Figure 4.

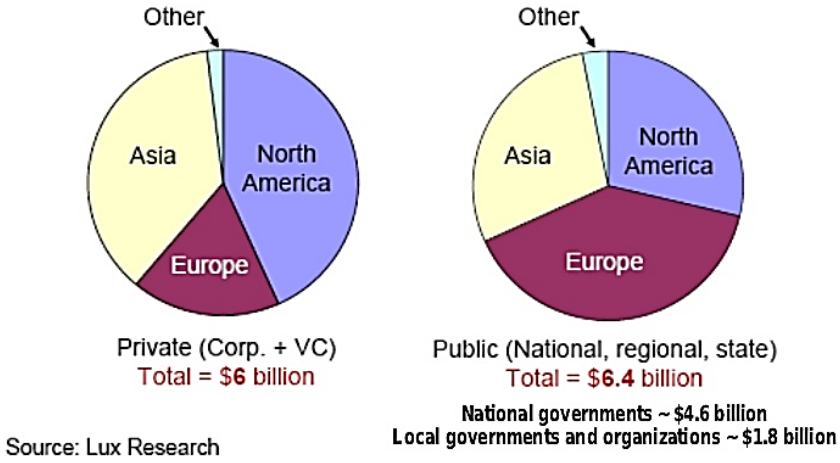

Figure 4: world total investment in Nanotechnology R&D.

Figure5 below shows a significant increase in government nanotechnology funding by different countries in the world in 2011.

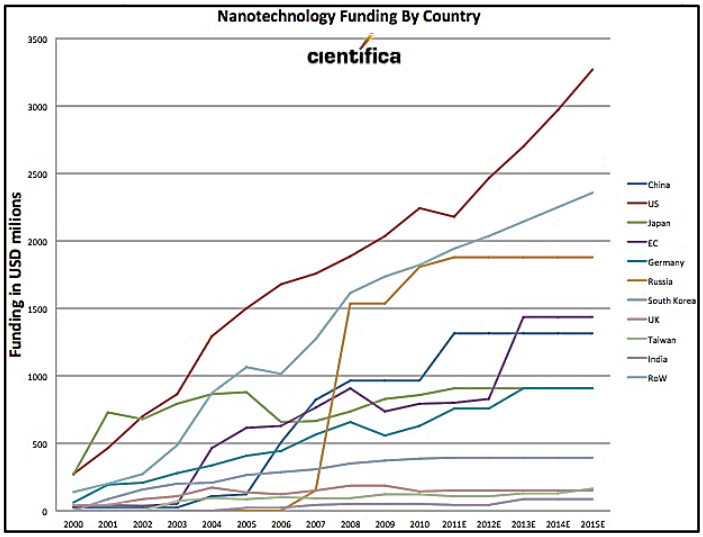

Figure 5: Nanotechnology funding by different countries in the world.[6]

This potential is realized by United States government by lunching nationwide Nanotechnology initiative in 201. Figure 6 shows the 2011 US proposed federal funding in all potential nanotechnology applications including education.

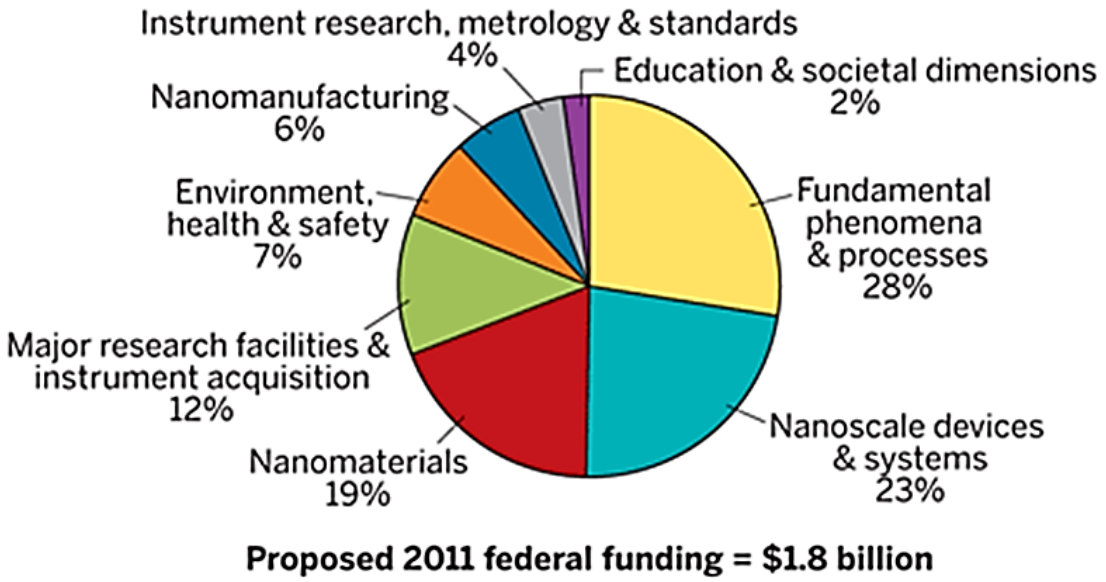

Figure 6: Proposed 2011 US federal funding [7]

The above figures shows that governments have great interest in the potential economic benefit of nanotechnology. In the last 29 years, Nanotechnology has proven the capability to help societies to achieve their goals by improving efficiencies and growth in various economic sectors such as medicine, energy and manufacturing. The huge funding and initiatives by many countries resulted inexponential growth in the number of scientific publications in the field of Nanotechnology. Figure 7 shows the number of Nanotechnology publications by the top five producing countries in the world from 1990 to 2010.

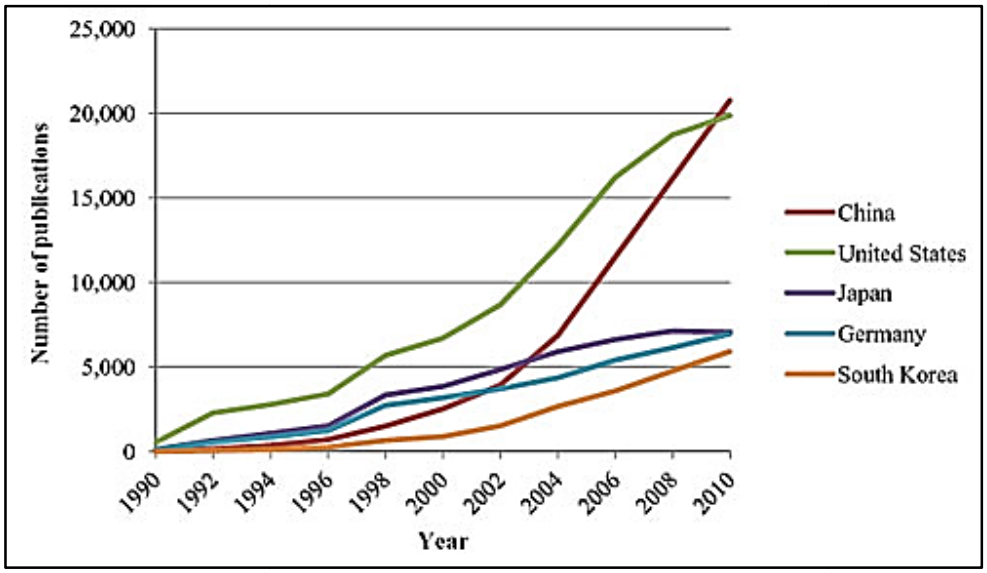

Figure 7: Nanotechnology Publications by Five Top Producing Countries[8]

This interest and investment are also translated to a number of filed Nanotechnology patents by different countries in the world as shown in figure 8 below.

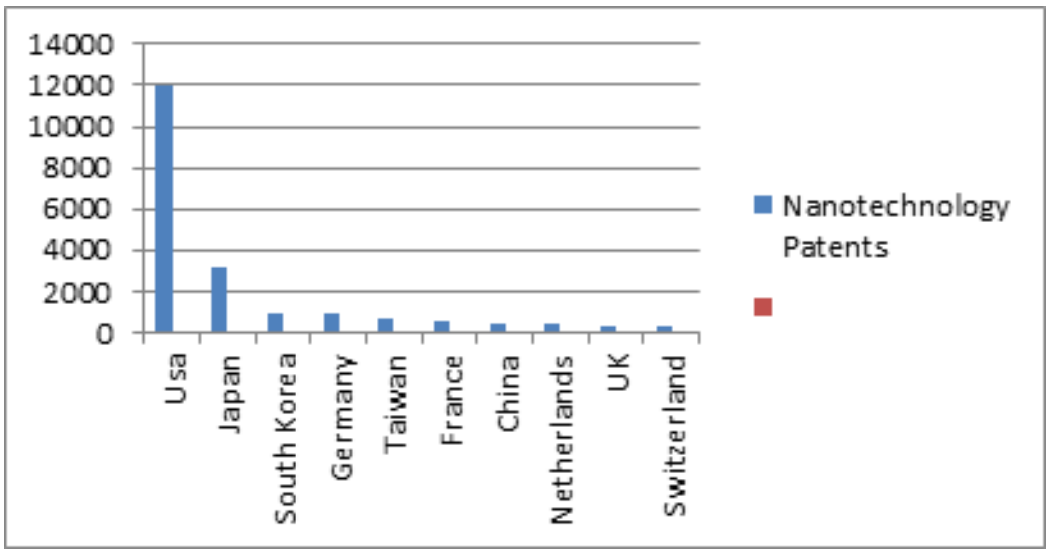

Figure 8[9] *Distribution of nanotechnology patent by country (Source: http//: Nanomaterial comnfrences.com)*

The future outlook of nanotechnology is very promising and will lead to trillion dollars market as projected by many world's leading financial and economic organizations as shown in figure 9 below. The future market will not only focuses on the nanomaterial and devices, but it will be extended to other markets that incorporate nanomaterial in other products.

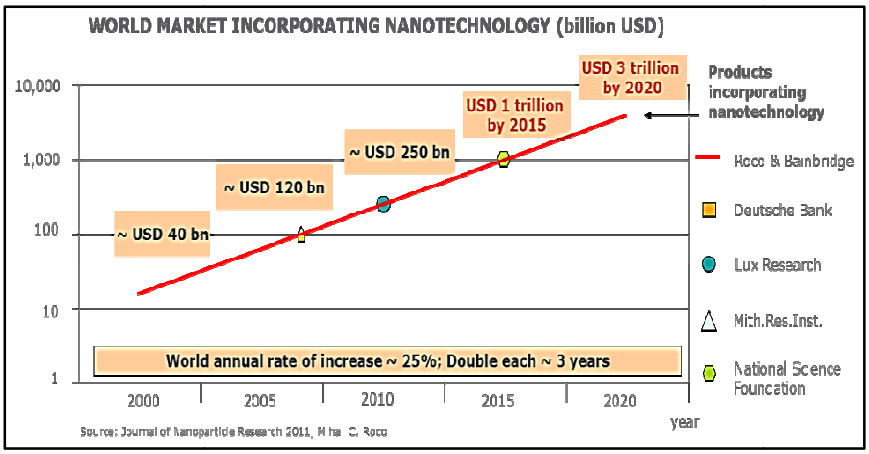

Figure 9:Nanotechnology market projection and invistment opportuntty [10](Source: Nanostart investment)

The Visionary future Nanotechnology will witness even more promises and opens new avenues for a greater impact on human's life. The convergence of Nano technological, biotechnological and information technological research fields as shown in figure 10 will lead to a better understanding to the human body and will utilize new functionalizes based on a high level intelligence by stimulating human mind and the design of smart and efficient products to fight disease and solve many problems.[11]

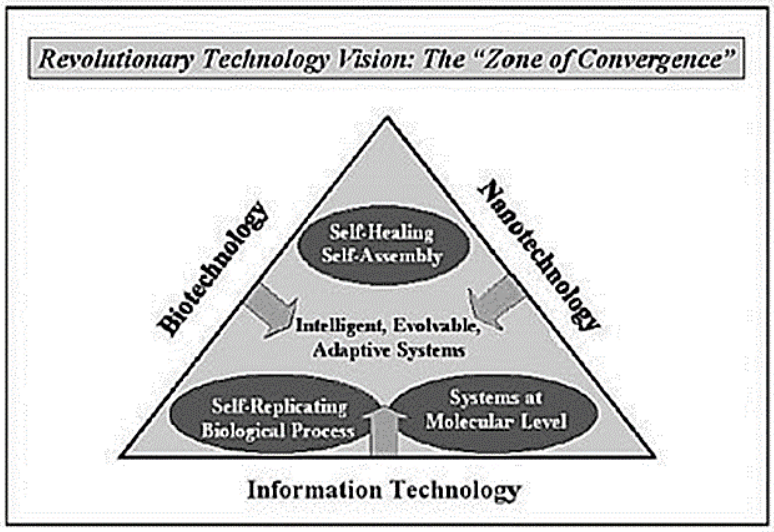

Figure 10: the visionary technological developments by convergence of nanotechnology, biotechnology and information technology (Source: AZ- Nano)

Controlling and building of materials and structures from atoms and molecular components based on linking of physical, chemical and biological properties and function under well-defined control will lead to major technical utilization materials and functionality. Through Nanotechnology, we will be able for the first time in history to design our materials based on our intended use and need. In the near future, Nanotechnology will likely solve many problems in mankind's life including cancer treatment, water scarcity, global warming, and aging. Based on the given data, Nanotechnology represent a great investment opportunity and Nano enables products will address all aspects of our life.Nanotechnology is likely to change everything around us from medicine, to computers, to buildings, to automobiles, and to the clothes we wear.Here is a potential and exciting applications of selected Nanomaterials:

- **Nanopowders**

The unusual properties of particles nanoparticles less than 100 nm allow a range of new and improved materials with many of applications, such as new catalysts for environmental remediation; improved food shelf-life and packaging; and novel drug delivery devices.

- **Carbon nanotubes**

Graphite can be rolled into a cylinder with a diameter of about 1 nm. These strong but light 'carbon nanotubes' can be used in many applications, such as sensors, fuel cells, computers and other electronic devices.

- **Graphene**

Graphene is a two-dimensional atomic-scale carbon with hexagonal lattice. Graphene is one of the most important Nanomaterials in all times and has many important and new properties such as a strength (207 times stronger than steel and extremely high heat and electric conductivity, and is nearly transparent with high optical properties. Graphene can be used in many applications such as in light bulbs, electronics, biological engineering, filtration, lightweight/strong composite materials, photovoltaic solar cells and energy storage, , paints and coatings, lubricants, oils and functional fluids, capacitors and batteries, thermal management applications, display materials and packaging, inks and 3D-printers' materials, and barriers and films.[12]

- **Nanomembrane for water and air filtration**

  These materials can solve one of the most pressing problems in mankind, safe, clean, affordable water.

- **Molecular electronic**

  Silicon computer chips and industry is reaching the physical and technical limit in less than 20 years. Nanoelectronic will replace the microelectronics.

- **Quantum dots**

  Thesenanostructures are very small and containsmany of free electrons and sometimes called “artificial atoms”. These materials has endless applications, such as counterfeit-resistant inks, new bio-sensors, quantum electronics, and photonics.

II. Nanotechnology in The Arab World

The pupulation in the arab word is increasing exponentionally and reachs approximetly 400 Million in the year 2015. Approximately 70% of this population in have limited natural resources the lowest GDP per capita in the world.As a result the arab world is facing major challenges including water, energy and food. In the top of that the arab countries is undergoing major changes in their social and infostructure. Starting by the arab spring and ending up with three major wars. All these challenges and changes deaccelarate the development and increase the poverity and deseases.Dealing with

challenges facing the arab word, it's difficult for governments to adopt long-term strategies for development of science and technology.

It is unfortunate fact that arab countries spend just 0.3% of their gross domestic product (GDP) on science and technology, compared to 1-3% in other developing countries and the average publication rate of arab scientist is less than 1% of the world's peer-reviewed scientific articles as shown in table1 below.[13]

Table 1: Publication Impact (2006-2007).

Country	Publications	Total Citations	Average Publication Impact
USA	8657	20796	2.40
UK	1611	3363	2.09
Germany	2581	5174	2.00
France	1790	3156	1.76
Italy	1053	1654	1.57
Japan	3032	4504	1.49
South Africa	58	76	1.31
People's R China	6124	7954	1.30
South Korea	2140	2741	1.28
India	1130	1302	1.15
Taiwan	1337	1517	1.13
Iran	220	236	1.07
Egypt	82	52	0.63
Saudi Arabia	14	8	0.57
Kuwait	4	1	0.25
United Arab Emirates	8	1	0.13

However, this fact was reliazed by a number of arab countries which leads to a major investment in mega project such as Qatar Foundation (QF) and Science and Technology park(QSTP) in Qatar, King Abdullah University of Science and Technology (KAUST) in Saudia Arabia, (KISR) in Kuwait Masdar Institute in UAE and other projects in other arab

counties. These projects are designed to quicklybuild scientific capacity in critical areas of scienceand technology and build knowledg based sociaty.

Nanotechnology is not strage to the arab world. Nanomaterials were found in islamic history. For example the glowing, glittering "luster" ceramic glazes used in the Islamic world which contained silver or copper or other metallic nanoparticles and "Damascus" saber blades contained carbon nanotubes and cementite nanowires—an ultrahigh-carbon steel formulation that gave them strength, resilience, the ability to hold a keen edgeas shown in figure 11.

Figure 11:a) Islamic "luster" ceramic glazes found in Iraq. b) "Damascus"steel made from carbon nanotube.

Unlike the other major industrial revelutions, Nanotechnology is not exclusive to a certain country or region and sometimes regarded as the "Technology of the Poor". Nanotechnology research can be done with simple instrumentations and local materials. Nanotechnology can offer apportunity to the arab countries become one of the pioneering in this field. Arab countries have the natural reseources and wealth and the educated scientists to use nanotechnology resolve many challenges facing the arab nations.

The feisability of using Nanotechnology to face the region's challenges is not fully relized by many stratigy decision makers in the arab world as stated by Mohamed H.A.

Hassan, executive director of TWAS, the academy of sciences for the developing world, and president of the African Academy of Sciences.[14]

However, in the recent years, Arab region witteness a major development in the field of nanotechnology. Many major initiatives on nanotechnology research have been launched by several Arab countries in order to build their scientific capacity and accelerate research intiatives to keep up with latest developments in nanotechnology field. Several oil-rich countries such as Qatar, Saudia Arabia, Kuwait , United Arab Emirates (UAE), have allocated large funds from Gross Demostic Products (GDP) to establish and support Nanotechnology initiatives in the field of energy, water, envoroment, medicine, food, andlocal industries.[15]Also, these countries attracted international researchers through generous incentives and collaborated with major international research centers and universities. Several National Nanotechnology institutions were established in Saudi Arabia, Eygpt, Jordan, UAE, and Oman. Major Arab nanotechnology initiative in 12-13 Jan, 2010, Cairo Egypt was lunched by League of Arab States.

A tramendus imapact have been noticed after these developments and initiatives in the field of Nanotechnology in the arab word. This impact is evident in the number of publication and patent after lunching the nanotechnology intiatives. Table 2 represent the the rapid increase in the number of publicationsin the field of nanotechnology in the arab world as reported byAlfeeli *et. al*. A fair comparison between 2007 and 2013, shows a great progress in this field in the Arab world.[16]

Table 2: Summary of nanotechnology status in the Arab countries.

Country	Population in millions [34]	Number of institutions conducting nanotechnology research	Number of nanotechnology-related publications[a]		Total publications	Number of nanotechnology-related publications per million
			2002–2007	2008–2013		
Saudi	26.5	11	44	1398	1442	56
Tunisia	10.7	8	139	418	557	52
Emirates	5.3	5	37	190	227	43
Kuwait	2.6	2	27	58	85	33
Jordan	6.5	2	44	143	187	29
Egypt	83.6	4	385	1634	2019	24
Oman	3	2	13	49	62	21
Qatar	1.9	2	1	20	21	11
Morocco	32.3	1	45	142	187	6

[a]The number of publications in peer-reviewed journals in the topics related to nanoscience and nanotechnology during the period January 2002 to March 2013. The data obtained searching for the phrase 'nano' in the title using the SciFinder database.

III. Nanotechnology Applications in the Arab world (Promising Investment Opportunities)

a) Nanotechnology Applications in energy

Energy demands continue to increase, as well as growing concern about climate change and the limited resources of oil reserves in the world is accelerating. As a consequence, the need to explore alternatives to oil-based energy economy. The International Energy Agency (IEA) forecasts that global demand for energy is expected to increase 37 % by 2040 as economies in both developing and emerging countries. It is projected that the population of the world will increase 10 billion and energy demand will reach 28 TW in the year 2050.Currently, 80% of the world's primary energy is generated by burning fossil fuels such as oil, coal, and gas and the peak production of conventional oil is 'likely to occur before 2030. This led to catastrophic climate change, pollution. All these factors requires a new and novel approaches to increase energy efficiency and seek a "clean" alternative energy sources. Using sustainable renewable energy sources like solar and wind seems the alternative solution to meet the world's energy demand with minimum impact on the environment. Recent development in nanotechnology opened new door for more efficient cost effective, envoromently friendly, and sustainable technologies capable of reducing the dependence on the traditional energy.Nanotechnology can help to utilize sustainable energy more efficiently. Building a new cheap photovoltaic cells with better materials that can generate electricity from the sun's light at maximized efficiencies. Also, building new batteries with better performance and higher energy density such as mobile lithium ion and sulfur ion batteries

that can be used in electric and hybrid cars. Nanotechnology also can provide new ways to conserve energy anda better energy efficient insulation materials. Nanotechnology can improve energy and energy efficiency through the following applications.[17]

- **Nanotechnology based solar cells can provide better conversion of sunlight to electricity, cheaper to manufacturing cost, simple installation, easy manufacturing (paintable manufacturing processes) using flexible rolls.**
- **Nanotechnology can improve the efficiency of fuel production using nanocatalyst and increase fuel consumption efficiency in vehicles and power by reducing friction.**
- **Enables the production of new batteries such as lithium-ion battery which are less flammable, fast charging, high efficiency, with lighter weight, and a higher power density.**
- **Recycling of waste heat in many devices and processes such computers, automobiles, and power plants to electrical power.**
- **Developing carbon nanotubes containing wires that reduces the resistance in the electric grid and thus reduce transmission power loss. Below are some examples of important advances in these areas.**

1. Photovoltaic Solar cells

Photovoltaic solar cells have developed over the years. Currently there are three generations of photovoltaic solar cells[18]. The first generation is solar cells that build using high - quality single crystalline silicon based on single p - n junction with very high efficiency (approximately 33%). This type of solar cells required expensive facilities. The

second generation solar cells is based on cadmium telluride(CdTe), copper indium gallium selenide (CIGS), amorphous silicon which require less energy and production cost. But usually this type have less energy conversion and low efficiencies. The third generation solar cell technologies is based on nanostructured materials that uses multi junctions, more concentrated sun light, uses thermal energy to increase the voltage and carrier collection. This type provide higher efficiencies at low cost. For example, using nanometer - scale single crystalline semiconductors particles such as Si (Nanocrystal quantum dot s (NQD s), the light absorption and emission wavelengths can be controlled base on the particle size due to the quantum confinement. The other type of Nano based solar cells uses light absorbing Nanocrystal supported on conductive polymers or high surface area mesoporous metal oxides such as TiO2. This type of solar cells have a theoretical efficiency close to 40%.[19]There other types of Nano based solar cells such as Nanocrystalline CdTe and CdS films on indium tin oxide (ITO) - coated glass substrates reported by Singh et al[20], low - cost thin - film Dye - sensitized photoelectrochemical solar cells (PES or Gr ä tzel cells) solar cells[21], [22],[23], and finally Organic or polymer based solar cells with low efficiencies od 105-6%. [24], [25].

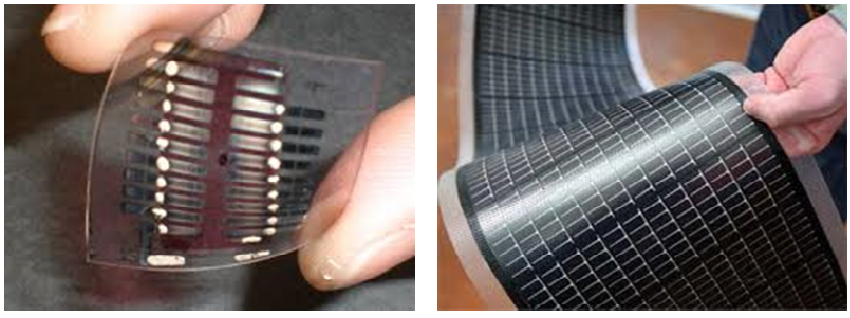

Figure 12: Nano based solar cells

B) Fuel Cells

Fuel cells defined as an electrochemical energy device that convert fuel such as hydrogen, methanol, ethanol, or methane on electrode (anode) when it reacts with an oxidant such oxygen, or air on another electrode (cathode) separated by an electrolyte such as proton - conducting polymer membrane. The electrodes act as catalysts, promoting the oxidation half - reaction of the fuel on the anode and reduction half -reaction of oxygen on the cathode. The electrons released at the anode are directed through an outer circuit to produce electricity. The role of the electrolyte to transport the charge (H +, OH −, O 2 −) to link the two half - redox reactions. Unlike batteries, fuel cells extract chemical energy from external reactants (fuels,oxidants) and convert it to electrical energy.There three types of fuel cell, the first type is proton exchange membrane fuel cell (PEMFC), alkaline fuel cell (AFC) and phosphoric acid fuel cell (PAFC) are typical low - temperature fuel cells (operating temperature < 200 ° C). The last two: molten carbonate fuel cell (MCFC) and solid oxide fuel cell (SOFC) belong to the high - temperature fuel cell class, with operating temperatures above 600 ° C.[26]

Catalysts play an important role inproducing fuels such as hydrogen or methanol to produce hydrogen ions. Typically high cost Platinum metal catalyst used in this process. Platinum nanoparticles is used to reduce the amount of platinum needed in the fuel cells, or many scientist are using of other material nanoparticles to replace platinum entirely in order to lower the cost. Also, since membranes are essential part in Fuel cells which allow hydrogen ions to pass through the cell and prevent other atoms or ions, such as oxygen, to pass through. Nanotechnology is used to make more efficient membranes; which leads to build light weight and longer lasting fuel cells. Nanotechnology also opens the possibility of

designing smaller fuel cells that can replace batteries in handheld devices such as tablets, IPad, or laptop computers. This types of fuel cell using methanol as a fuel and often called DMFC's (direct methanol fuel cell). Also, they last longer than conventional batteries and faster charging by inserting a new cartridge of methanol into the device.

Another type of so Fuel cells can be used to replace batteries in electric cars. Hydrogen fuel cells can be used to power cars. The improvements of the catalysts and membranes, developing a lightweight and safe hydrogen fuel tank to store the fuel is very important. Developing new ways to save energy with the synthesis of new hydrogen storage materials and nanocatalyst that can be used to fuel cells to convert CO to CO2 to prevent CO poisoning in fuel cells. Researchers are trying to develop a new lightweight Nanomaterials that will absorb the hydrogen, store it, and release it when needed. It is expected that hydrogen powered cars will be used in the year 2020 according to theUSA Department of Energy.

C) Reduction of energy consumption

A reduction of energy consumption can be reached by a better insulation systems such as using Aerogels or Nanocomposits as insulating materials. Also, using more efficient lighting such as CFL (compact fluorescent) bulbs which can produce 9 watts and costs $1.40 and has 8000 hours lifetime or LED light which can produce 13 watts and costs $20 with lifetime of 25000 hours. The latest breakthrough is extend the light bulbs efficiency by using quantum caged atoms (QCAs) to reduce the energy consumption for illumination. Typical light pulps converts approximately 5% of the electrical energy into light.Another applications of

nanotechnology is improving the combustion systems by using lighter and stronger materials in the transportation sector.

Through the use of nanotechnology, developing energy capture, transfer, and storage materials will help millions of the people in the Arab world to have access to clean energy sources and electricity and the manufacturing of this materials will create new jobs and positive impact and the economy and on the society.

Finally, Nanotechnology will have potentially significant impacts on energy efficiency, storage and production. Nanomaterials can be used to monitor and remediate environmental problems; improve control emissions from a wide range of sources, and develop new, 'green' processing technologies that minimize the generation of undesirable by-products. Developing new Nanocrystalline material catalyst supports that yield catalysts with well-defined pore sizes in the range of 1 that can be applied in removal of ultra-fine contaminants, and to develop a nanoparticle-reinforced polymeric material that can replace metallic components in the auto industry; as well as the reduction of gasoline consumption and reduce the related dioxide emissions. The impact on industrial control, manufacturing and processing will be impressive and result in saving energy.

b) Nanotechnology in Medicine

In the recent years, health care system in the world faces many challenges and there is increased demand for better, cheaper healthcare. Due to the accelerated changes in the world's economies, aging population growth, and the emerging of middle class causing a

huge burden on the national healthcare systems in many countries in the world and the strong demands for immediate medical treatment. To overcome this challenges, Nanotechnology can playcrucial role in solving health related issues. Nanotechnology has the potential to revolutionize the medicine and health. It can personalized medicine, and make cheaper, and safer. [27]

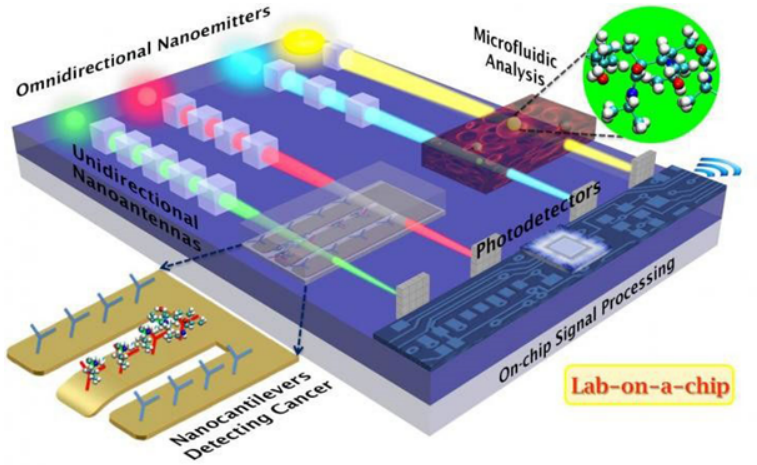

Figure 13: Lab on a chip concept

Below are some recent advances and applications of Nanotechnology in medicine:

- Enhancing medical imaging and diagnostics using semiconducting Nanocrystals called Quantum. These materials when illuminated with ultraviolet light, can emit a wide spectrum of bright colors which can be used to locate and identify specific types of cells using imaging techniques such as MRIand the conventional dyes and provide more information.

- Gold nanoparticles can be used to detect early-stage Alzheimer's disease and cancer cells.
- Targeting to cancer cells and deliver the treatment without affecting normal tissues.
- Using nanotechnology to spur the growth of nerve cells such as damaged spinal cord or brain cells by injecting nanostructured gel to fills the space between cells and encourages new cells to grow or using nanofibers to regenerate damaged spinal nerves.
- Using microfluidic lab on a chip to monitor and manipulate individual cells and track the movements of cells and individual molecules.

Using nanoparticles for drug delivery enables precise delivery of strong medications to specific and needed part in the body, such as a tumor or infection part. This means that these medications can act more effectively – and with fewer side effects in the rest of the body. Nanoparticles have also enabled a totally new approach to cancer treatment; by injecting a magnetic nanoparticle fluid directly into the tumor and applying an external electromagnetic field, the tumor then destroyed by heating it from the inside out. The application of nanotechnology will also make pockets devices, by enabling bulky, expensive laboratory analysis and diagnostic technology to be miniaturized onto a silicon chip, putting within reach the dream of a complete hospital laboratory. Fully automated biochips will soon be able to quickly and cheaply detect pathogens or other biomolecules, such as those associated with cardiovascular disease or other widespread health issues. In the field of pharmaceutical

research, too, the technology of drug discovery is benefitting enormously from these Nano biotechnology-based systems.

These advances and others can bring a great opportunity to Arab world to reduce the amount of medicine and detect and cure a large number of cancers and other diseases and at the same time create a sustainable healthy and safer health processes. This can contribute the society and economy at large.

C) Nanotechnology in Water and Environment

The immediate challenge after solving energy challenge and finding sustainable energy sources is the water scarcity. Many parts of the world have a lake of clean water resources. United Nations reported that approximately more than one billion people in developing and develop countries including some of the Arab countries don't have access to clean water. In the more developed countries, the water resources is contaminated pharmaceutical and pesticide. Arab countries currently have access to 1% of the world's total water resources that is about 500 m3 per capita per year availability of renewable water resources. 85% of these resources is used for agriculture. According to latest statistics published by United Nations, approximately 12 Arab countries suffer from severe water shortages. Many Arab countries are fighting survival fight for water. UNEP urge Arab states to take action to implement plans for integrated water resources management and adoption of new technologies.

Contamination of various water resources by heavy metals is of great concern because of the toxic effect to the health of human being and other livings. Environmental and water

contamination becomes a major issue in recent years due to the discharged of colored and toxic dyes into the water supply system. These dyes are emitted by major industries such as paper, plastic, and pharmaceutical[28],[29]. The presence of dyes such methalyn blue, and other Phenols and phenolic dyes show sever effects on humans, animals, and plants. It was found that the presence of these dyes can affect the nature of water and inhibit the sunlight penetration and reduce photosynthetic reaction[30]. Also, Wastewater contains high levels of pathogenicmicroorganisms; therefore, water disinfection represents a very an important factor in Environmental and water treatment.

Nanomaterials offered cost-effective solutions for many environmental problems such as waste water treatment, pollution, and anti-bacterial treatment. Nanoparticle catalysts are characterized by large surface area, high dispersion and strong interaction with other materials[3132] ,[3334]. Such materials provide clean water from polluted water sources in both large-scale and portable applications, and detect and clean up environmental contaminants. Nanotechnology can provide innovative solutions with optimized filters which can remove chemicals and carcinogens from water with unprecedented efficiency. These nanofilters are already enabling a new generation of treatment plants which can purify large quantities of water in a short time. Nanoparticles used as catalysts for chemical or photochemical destruction of contaminants. Also nanosized zerovalent iron used for the removal of metals and organic compounds from water; and Nanofilteration membranes. For the removal of metals and other inorganic ions, mainly nanosized metal oxides, natural nanosized clays have been used. Also, oxidized and hydroxylated CNTs are represent a good absorbers for metals.[35]

Figure 14: Nanorust can cleans arsenic from fresh drinking water.

(Image Source: www.sciencedaily.com, Image courtesy of Rice University)

Recent nanotechnology advances in the field of water treatment and desalination are:

- Achieving affordable and clean drinking water by rapid, cheaper detection of impurities in and filtration and purification of water. For example, using magnetic interactions between rust nanoparticles can remove arsenic or carbon tetrachloride from water.
- Development of photocatalytic materials for cleaning water using sun light energy
- Development of nanostructured filters capable of removing virus from water
- Developments new cheaper and low energy deionization technique using nanofibers electrodes for water desalination.

- Development of nanotechnology sensitive sensors to detect and monitor contaminants in water.
- Development of Nanofibers membranes to remove salt from water.
- Development of highly porous electrodes made from nanomaterial that can be used in capacitive water desalination.

Air pollution Arab countries is among the lowest in the world. The pollution levels is way less than many cities around the world. This probably is attributed to the low level of industrial activity. For example in 2004, the carbon dioxide emissions was about 1,348.4 metric tons, compared to the other countries in the world (12,162.9 to 13,318.6 metric tons). The Arab region is one of least responsible countries in terms of greenhouse emission and contribution to the climate change (less than 4.7 % carbon dioxide contribution), which lower than some regions in Africa, as reported by the global Human Development Report (HDR) 2008 and world development indices for 2007. However, some Arab countries especially oil and gas producing countries are among the top of the list in CO2 emission per capita.

Nanotechnology offers new capabilities for preventing highly toxic pollutants and provide effective monitoring of pollutants or their impact on the environment. Nanotechnology also capable of providing new and cheapersolutions to clean air and soil. Nanotechnology can contribute to the air purification and reduce industrial emission. For example latest technologies and product adopt Nanomaterials in the following applications:

• Catalytic converters: Nanocatalyst are used as a three-way catalytic converter based on noble metal nanoscale particles. Recent research to use other class of Nanomaterials minimize the amount of noble metal but with the same catalytic performance.

• Filtration/separation: the use of nanofibers filter media in automobile and airplanes industry. Also, a new Nanofibers coated filter media are adopted for dust removal in many at industrial plants and gas turbines.

• Development and optimization of Nano-structured membranes for CO2 capture from power plant flue gases.

• Development of new class of materials called Metal Organic Frameworks (MOFS) for CO2 absorption (these materials can absorb 9 times its weight)

• Nanocatalysts: Nanocatalysts for sustainable air purification are very important in industrial and construction (nanoscale titanium dioxide are being used in cement photo-catalytic active concrete surfaces can be produced for air purification in towns.

•Development of nanofabric "paper towel," woven from potassium manganese oxide wires, that can absorb 20 times its weight in oil for cleanup applications.

d) Nanotechnology Applications in Agriculture

Arab population is considered one of the fast growing rate in the world (about of 1.9%) compared to the average world rate of 1.2 percent, which lead to a major challenge in the food security and availability of domestic food supply. Agriculture in the Arab world is suffering from many problems such as limited water resources, lake of renewable water

resources, poor resources management, rainfallshifting patterns as a result of climate change, and the estimated per capita water availability is expected to cut in half by 2050.[36]Nanotechnology can help the Arab region by providing innovative and novel solutions based on Nanomaterials to encounter these challenges.

Nanotechnology can play a crucial role in agricultural production by utilizing Nanomaterials in plant protection, fertilization, and water management. Using Nanomaterials in agriculture will help in many areas such as:

- Develop Nanomaterials such as hydrogels that can be mixed with the soil and store water and prevent evaporation.
- Developed nanoscale powders of nutrition product that have a high surface area which make it easy to be absorbed.
- Develop new fertilizer particles to minimize the excess use of dangerous fertilizers.
- Developed new materials based on polymer-nanoparticles nanocomposits to be used in the water delivery systems

e) Nanotechnology Applications in Oil and Gas Industry

Arab countries are fortunate to have a proven oil reserves than any other world (713.6 billion barrels), which account for 43 %of the world's total proven reserves. Arab countries produces an average output of 26.3 million barrels per day (2011), which is nearly nearly third of world oil supply of the world. Also, the Arab oil reserves is the cheapest to find, develop, and produce (the production cost is between $3 and $5 per barrel).The Arab

countries are among the top countries who hold proven natural gas reserves (55 trillion cubic meters (Tcm), 2011-2012), which as accounted for more than a quarter of the world's total proven gas reserves.[37]

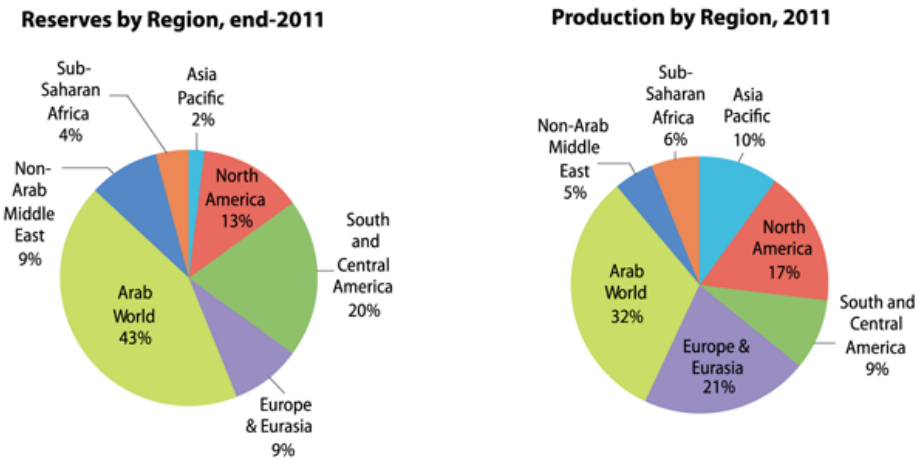

Figure 15: oil Reserve by the region in the world

Nanotechnology can revolutionized the oil and gas industry. Nanotechnology can be used to enhance the development of oil and gas exploration and production. Nanomaterials can improve thermal conductivity, separation, and reduce material's corrosion and hence geothermal-energy production. Nanoscale metals already have been used to delineate ore deposits for exploration. Also, Nanotechnology can the drilling speed and process using nanofluid, which result reducing the damage to the reservoir rock in the well and extract more oil.

Nanotechnology can be widely used to enhance development of standard and unconventional gas resources. It can improve the Liquefied-natural-gas (LNG) infrastructure, efficiency, quality, and gas-to-liquids (GTL) process technology by developing super pipe lines, floating GTL platforms; production, regasification, and resolve storage and transport

issues. Furthermore, it can help the production of methane hydrates and gas to the market based electricity transport rather than the gas pipeline transport. More important, Nanotechnology can be used to developing Nanocatalysts and nanoscale membranes for GTL production, and Nanomaterials for compressed-natural-gas transport or long-distance electricity transmission.[38]

Potential advances of nanotechnology in oil and gas industry are:

• Nanotechnology can enhance performance and reliability of the drilling equipment by increasing the strength and durability under extreme conditions such as high-temperature and high-pressure.

• design new hydrophobic or hydrophilic Nanomaterials for water flood applications in drilling operation.

• design new Lightweight rugged Nanomaterials that reduce for offshore platforms, and more- energy efficient transportation vessels.

• Design temperatures and pressure Nano sensors and imaging techniques for extreme environment operations such as deep wells and provide data on reservoir environment and hence improve drilling cost.

f) Industrial Applications of Nanotechnology

Arab world is considered one of the fastest developing economies in the world, the middle class is growing to almost 44% of the region's economy. There is more than 150 million people with household consumption. 60% of the Arab countries are classified as middle class.[39]The total Arab League GDP is estimated to be more than $2.3 trillion in 2011. Which make it world's eighth largest economy in the world as shown in the figure below.[40]

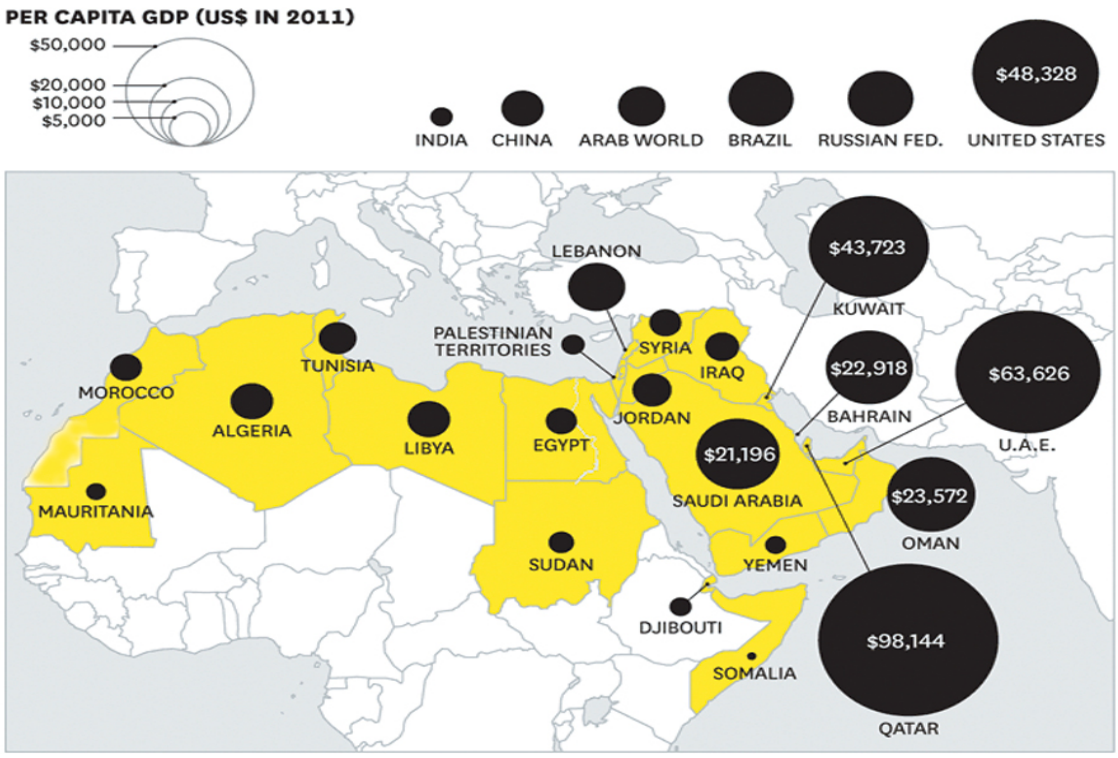

Figure 16: Per capita GDP in the Arab world[41]

Therefore, adoption of nanotechnology in the Arab world will enhance the economy and reduce the unemployment by creating new jobs.

Nanotechnology is widely used in consumer goods, many industries and products incorporated Nanomaterials in them. There a number of products in the market contained Nanomaterials and many people do not realize it. These products contained new functionalities never found before in the same products. For example, some products are easy-to-clean or have scratch-resistant properties. Other materials such as new cars have lighter and stronger made from carbon nanotube, a new glass that repel water, clothing are stain repellant or wrinkle free, sunscreen with 100% UV protection, smart textiles and

"wearable electronics", and many more. As mentioned before, Nanotechnology is expected to revolutionized the technology in all aspect of our life and create a new Jobs and business opportunities by improving the material's performance and create intelligent products and devices that positive impact on the economy and the society.

All these functionalities can be achieved by synthesizing nanoscale building blocks with precisely controlled size and composition and then to assemble them into larger structures with unique properties and functions, thus revolutionizing segments of materials manufacturing. This method can bring lighter, stronger, and programmable materials, reductions in life-cycle costs through lower failure rates, and innovative devices based on new principles and architectures.

Nanotechnology can be used in the following industrial sectors[42]:

- **Food sector:**
  - Development of biosensors for bacteria identification and food quality monitoring.
  - Development of Nanomaterials and coating for intelligent, active, and smart food packaging.
  - Development of anti-microbial agents such as silver nanoparticles for the surface of the coated film on the packaging.
  - Development of Nanomaterials for Nano encapsulation of bioactive food compounds

- **Construction Materials and Coatings**:

Develop cheap,lighter, strong, safe, and envoromently friendly Nanomaterials such as carbon nanotubes, silica aerogels, Nano cement, and nanocomposits.

- Develop Nano sensors to monitor everything in the building.
- Utilized waste materials to create new sustainable Nanomaterials to be used in new buildings.
- Develop nanoparticle for anti-corrosion coating to prevent structural damage.
- Develop none flammable and thermal insulation materials and coating based on Nano clays and silica aerogels to reduce energy consumption and enhance the safety in buildings
- Develop self-cleaning and photocatalytic coating to be used on the outer envelope of the building.

- **Textile:**

- Develop nanofibers to make functional textile such as water and stain-repellent or wrinkle-free.
- Develop heat resistance coating for
- Develop electrostatic resistance textile by integrate carbon nanoparticle membranes.
- Develop smart textile for monitoring of human body temperature and heart rate and solar chargers.
- Develop wound dressing textile which has silver nanoparticles as anti-bacteria agent.

- **Aerospace and cars:**
  - Develop lighter and stronger materials for aircraft to increase their performance and reduce energy consumption.
  - Develop lighter and stronger materials for vehicles to make it faster and safer.
  - Develop lubricant for combustion engines to reduce wearing and increase the heat resistant.
  - Develop Nano coating for the outer parts of the airplanes and cars to reduce the drag force and hence reduce the fuel consumption.
  - Develop Nano scratch resistance coating for cars.
- **Catalysts:**

  Nanocatalysts have extremely large surface to volume ratio and are considered one of the important Nanomaterials in many sectors such as oil and gas industry, water treatment, energy production, production of chemicals and fuels, catalytic convertors, solar cells, and fuel cells. It considered as one of the important application in the Arab world because it can solve many problems such water treatment and it can be wildly used in petrochemical and oil refinery and reduce the dependence on the import from outside companies. Nanocatalysts can be used in many applications:

  - Reducing the amount of platinum in the cars catalytic convertor.
  - Using Nano phtocatalysts such as Titanium and zinc dioxide in water treatment and air purification.
  - Using Low temperature Nanocatalysts for petrochemicals to reduce energy consumption.

- Using Nanocatalysts to produce new chemicals and plastics.
- Produce fuel from air
- Using photo catalysts split water to produce hydrogen fuel.
- Using photo catalyst to break CO2 to carbon and oxygen using the sun light.
- Engineering of biodegradable plastic materials with super thermal, mechanical and electrical characteristics. For example, it can be make easy-to biodegrade plastic bags.

There many more industrials applications of nanotechnology in other sectors such as electronics and communications such antennas and computer chips.

IV. Case Studies

Case study 1: Aerogel material for Thermal Insulation [43]

Thermal insulation is considered one of the main factors of reducing heat and energy consumption in buildings. There are many insulation materials used to reduce energy consumption and heat loss in buildings, such as: cellulose, glass wool, rock wool, polystyrene, urethane foam.., etc. Most of these materials are considered less effective and costly.

Silica Aerogels are ultra-light, highly porous and highly thermal insulating materials. Because of this unique combination of properties, aerogels are being considered for applications as varied as thermal and sound insulation for aerospace applications, as absorbents for environmental remediation and as supports for catalysts. Aerogels are also mechanically

fragile, so their commercialization has been slow and generally limited to granulate and panels of limited thickness.

Recently, Dr. Khaled Saoud and his collaborator from USA, Dr. Massimo with the support from Qatar National Research Fund (QNRF) reported a breakthrough in aerogel fabrication of highly strong Aerogels. The new Aerogel synthesis is in one pot for native and cross-linked alcogels and no solvent exchanges are necessary. Monoliths can be fabricated in a few hours instead of days, and large volumes of fresh solvent are not required by the process. The results are of particular relevance, since they dramatically shorten fabrication times of native and, most importantly, cross-linked aerogel monoliths with large sizes. We have synthesized samples using base- and acid-catalyzed chemistries, varied alkoxide concentration and, for cross-linked aerogels, monomer concentration. Depending on alkoxide concentration, native oxide aerogels had densities between about 0.06 and 0.17 g cm-3 and surface areas between about 300 and 500 m2 g-1. Figure 1 shows our synthesized Aerogels.

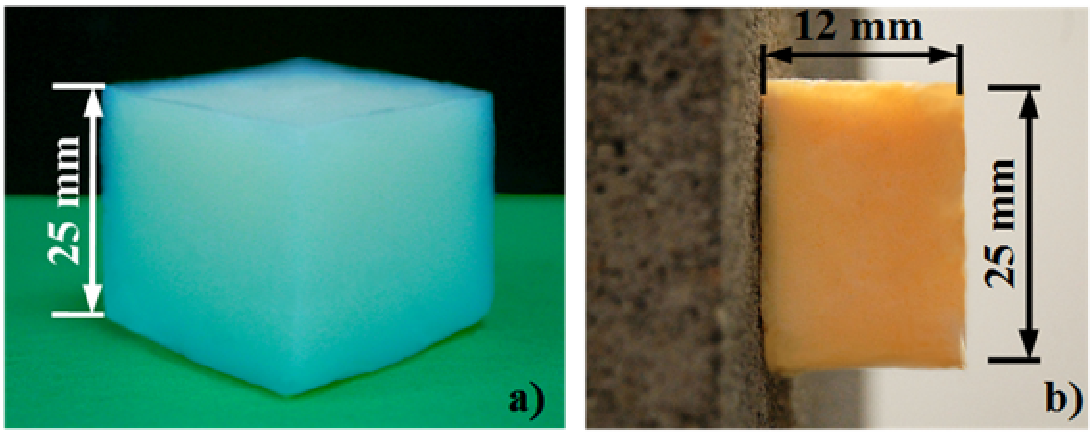

Figure 17: Aerogel material for energy consumption reduction.

Also, they developed alternative fabrication methods which enable to produce custom parts which are made mechanically strong by reinforcing the regions of highest solicitation with a polymer. They have fabricated custom parts that may be used as insulation of selected parts of internal combustion engines, passive fire protection of structural elements in building, and lightweight footwear for extreme cold conditions. We also have developed cost-effective and scalable procedures for fabricating these custom- shaped aerogels.

This research could lead to manufacturing of energy saving materials that can be used in the Arab region to reduce energy consumption especially in the hot Arab countries such as the gulf countries.

Case Study 2: Silver/Zinc Oxide Photo catalyst (Ag/ZnO) for Waste Water Treatment[44]

It is predicted that by the year 2025 that 48 countries will be short of fresh water. Currently, 600 million people in the world facing water scarcity. Nanotechnology can offer a great opportunity to provide new and novel methods to solve water scarcity challenge. Nanotechnology can offer tailor–made solutions suitable for water cleaning and removing a particular contaminant from waste water, water harvesting for ambient air using different Nano–based techniques which is not possible with the current technologies.

The concept of nanotechnology is used to provide a new solutions based on recycling waste water and convert waste water as sustainable resource to produce clean drinking, irrigation, or industrial water. Dr. Khaled Saoud and his collaborator Dr. Joydeep Dutta developed new silver on zinc oxide photo catalyst (Ag/ZnO) for waste water treatment capable of removing toxic dye and kill the bacteria in water. The Photo catalyst is tested for

discoloration of MB in water under visible solar radiation and then using UV/Ag/ZnO system. We found that Ag/ZnO nanoparticles remove the color of Methylene Blue (MB) from water. Also, UV/Ag/ZnO system confirms the removal of MB from aqueous solutions containing 5 mg/L MB using small amount of Ag/ZnO Photo catalyst completely. The photocatalytic activities of Ag/ZnO system were investigated under light and in the dark. The results indicate that the catalyst have high catalytic and antibacterial activities under visible light and in the dark. The enhanced photocatalytic activity of Ag/ZnO nanoparticles is attributed to the presence of Ag ion and the synergetic effect, surface Plasmon effect of Ag nanoparticles, improved charge-transfer, and the prevention of the electro-hole recombination in ZnO. Figure 15 show TEM micrographs of our Ag-/ZnO nanoparticles.

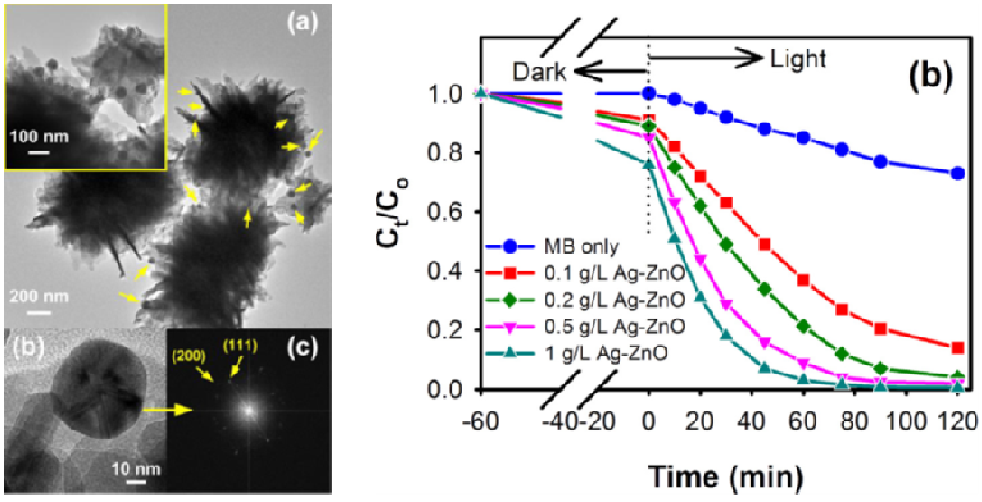

Figure 18: Transmission electron Microscope (TEM) image of Ag/ZnO photo catalyst and Methalyn blue degradation.

V. Summary

Nanotechnology is definedas the manipulating of material at very small scale- at the level of atoms and molecules (less than 100 nm) and, at this level, the regular physics and chemistry rules no longer applied , as results many properties of these materials are begin to change and become unique, and sometimes show a surprising properties . These physical characteristics of the materials differ from the characteristics of the same material under the normal conditions,and this new and improved material properties can be used in different applications in the Arab world. These applications are summarized in the use of nanotechnology to produce smart materials, and change the function of materials, for example, lubricants, paints and replace are replaced with super strong materials with high-quality electrical characteristics which can be applied in all manufacturing sectors. For example, Nanotechnologycan beused to improve a wide range of properties such as engineering of biodegradable plastic materials withsuperthermal, mechanical and electrical characteristics and thus can be a form of easy-to biodegrade plastic bags.

The Arab countries efforts to achieve Arab sustainable industrial development and to ensure the competitiveness and the transition to a knowledge-based economy and bring about the desired and requirements to catch up with scientific and technological progress the world. Nanotechnology is used to solve the most important problems in the all-inclusive areas of life in the Arab world. Were science and Nanotechnology become a comprehensive scientific revolution and is used to solve the most important problems in all areas of life such energy , Agriculture , Health and Medicine nanoscale , remove the pollution of the environment , communications , materials , manufacturing, electronics, and consumer goods , etc. which have significant economic impact and is expected that the production volume of materials, products , technologies, and services will reach $ 2.6 trillion in 2015 and provides more than 7 million jobs in the same year. Finally, Arab countries must adopt and invest heavily Nanotechnology and other science and technology fields to achieve the desired advancement of production knowledge and technological desired development processes and hence become science based societies.

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