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Review: Nanotechnology - The secret of fifth industrial revolution and the future of next generation

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Abstract. *Rai S, Rai A. 2015. Nanotechnology - The secret of fifth industrial revolution and the future of next generation. Nusantara Bioscience 7: 61-66.* Nanotechnology can be defined as a new and emerging technology with vast applications in the field of energy, electronic, cosmetics, textiles, medicine, agriculture and environment, etc. In India, since post-independence both science and economics have progressed in the last century. Nanotechnology has filled various gaps in technologies and will develop all aspects of economy including wages, employment, market currencies, exchange rates supply and demand, etc. Nanotechnology with reduced size may allow for automation of tasks which were previously inaccessible due to physical restrictions. The industrial revolution has been evolved during the 16 century, and as result of which, the world economy has been changed drastically Now energy resources and manufacturing play pivotal role in the development of economy and technologies. The new innovations of nanotechnology will change the scenario of the poor people with the power of economy. Today, we would be able to change the world by "*The fifth industrial revolution of nanotechnology*". The more striking is that it will cover-up the target ratio of economy since quarter century and accomplish the target ratio of economy within ten years. However, nanotechnology may have exerted toxicity. This may be harmful for the nature and living organisms Apart from that, there are some other implications such as ethical issues, which may in turnoff footsteps back and raises certain issues. In fact, there is a need of awareness among the common people in society. The focus of the present review is to discuss role of nanotechnology that is quite augmented in different industries and also in generating fifth revolution leading to better future of next generation.

Keywords: Emerging, industrial revolution, industries, nanotechnology

INTRODUCTION

The nanotechnology is a major breakthrough and is revolutionary as it will create extraordinary nano world in the present century (Grinin and Grinin 2013). The study of everything between 1-100 nm is known as nanotechnology. For example DNA molecule- the blueprint of life and basis of the genome is twisted double strand of molecules with size of about 2nm. Surprisingly, the width of human hair is approximately 80000 nm. More appropriately, nanotechnology is the creation of functional materials, devices and systems through control of matter at the range of 1-100 nanometers. Using nanotechnology researchers and manufactures can fabricate materials literally molecule by molecule (Mansoori et al. 2005). Nanotechnology is enhancing the quality of everyday products cosmetics, sunscreen, golf balls, clothing and cell phones by the use of nanoparticles and other nanodevices, and therefore it has become an important technology of 21st century. Richard Feynman in 29 December 1959 delivered a historical lecture at the annual meeting of American Physical Society at Caltech. Feynman gave his address entitled "There is a Plenty of Room at the Bottom". In 2002, Clinton announced the new national initiative popularly known as National Nanotechnology Initiative (NNI) to foster the tools of "next industrial revolution". McRay (2005) discussed the history and impact of nanotechnology in socio-economic perspectives. Gelfert (2012) analyzed philosophical, sociological and historical aspects of nanotechnology.

The vision for the nanotechnology is to improve and control over the development that how we build things so that the high quality products could be made, which are relatively cheaper. Nanotechnology is highly interdisciplinary and offers application in the field of energy, electronic, cosmetics, textiles, medicine, agriculture and environment, etc. (Mody and Choi 2013). Since post-independence both science and economics have progressed in the last century, that our understanding of both physical and economic realm is vast. Science has proved the change of labor by discovery of computer in the human history. Nanotechnology has filled various gaps in technologies and will develop all aspects of economy including wages, employment, market currencies, exchange rates supply and demand, etc. Nanotechnology with reduced size may allow for automation of tasks which were previously inaccessible due to physical restrictions.

The industrial revolution has been evolved during the 16 century in order to change the world economy, now energy, resources and manufacturing play pivotal role in the development of economy and technologies; for example, nanotechnology is used in stained glass painting

and coating is made up of silver and gold particles of different size and shapes. The new innovations of nanotechnology will change the scenario of the poor people with the power of economy. In last centuries the world has had such a rapid growth in technology that many of the current industrial activities seem to be far more vagueness. To add the vagueness the technology change seems to be more rife and rapid spur. Today, we would be able to change the new world by "*The fifth industrial revolution of nanotechnology*" which will change the "miracle world "that no one could imagine forever. The more striking is that it will cover-up the target ratio of economy since quarter century and accomplished the target ratio of economy within ten years. However, nanotechnology may have exerted toxicity. This may be harmful for the nature and living organisms Apart from that, there are some other implications such as ethical issues, which may in turnoff footsteps back and raises certain issues. In fact, there is a need of awareness among the common people in society.

The present review is focused at the role of nanotechnology that is quite augmented in different industries and also in generating fifth revolution leading to better future of next generation.

NANOTECHNOLOGY IN INDUSTRIES

There are many applications of nanotechnology in various industries. This technology has broad scope in daily life.

Food and beverages industries

Nanotechnology is increasingly important for the food sector (Seabra and Duran 2013). The food-products are enhancing with fast pace. Nanotechnology will contribute the development of stronger, lighter and less wasteful packing. This technology has given the new dimension to nutrient products to protect from harm pathogenic organisms. The potential benefits are large for industrial systems. Nanotechnologies wind up the aspects such as food safety and packing materials (Srilatha 2011). It is possible to protect food from pathogens using antimicrobial packing or edible films (Rai et al. 2013). To preserve food through filtering or protecting by nanoscapulation and biosensor sensors to filter or detect pathogenic or organic compounds this edible film is used for the preservation of fruits and other nutrient products. An application of nanotechnology in food and beverages and nutrient products improves food sensory with its better flavor, texture, appearance and quality through nano engineering. Such applications used in food materials are biodegradable polymers to compensate for their deficiencies such as poor moisture barrier properties. Traditional polymer nanocomposites e.g montmorillonite are used for the enhancement of gas properties.

In addition, nanoparticles coating is used for antimicrobial, corrosion resistance surface. Intelligent packing nanosensor labels are used to sense the quality of the food and food-products.

Textile industries

The use of nanotechnology in the textile industry has been increasing rapidly due to its attribute towards the consumer. It has a considerable potential for lucrative applications in cotton and textile industries. It economically extends the value of properties in textile and products. Application of nanotechnology in textile industry has tremendously increased the durability of fabrics, increase its comfortless and hygienic properties also reduces its production cost. Nanotechnology indicates various advantages as compared to conventional process in term of economy, energy saving, eco-friendly, controlled release of substance packing, separating and storing materials on microscopic scale for later use under controlled conditions. Silver nanoparticles and copper nanoparticles are used in the fabrics and for the future revolution in clothing. Moreover, the researchers employed nano titanium dioxide in textiles for self cleaning and UV-blocking properties (Duran et al. 2007). Zinc nanoparticles are also used in textiles for the protection from UV. Moreover, nanosilica is applied to improve the wrinkle resistance of cotton and silk.

The scenario of the textile industries is changing very fast. The use of antimicrobial agents in textile is increasing with fast pace (Lorena et al. 2013). The antimicrobials are used to protect the cloth from microbes which are usually responsible for deterioration of the cloth and fading of its color. These antimicrobials of nano origin also keep the cloth away from unpleasant odor. Moreover, the silver nanoparticles are used in masks, and wound dressings. In addition to silver, zinc and copper nanoparticles are also used in textile industries being antimicrobial in nature. In fact, the nanotech-based textiles would be next generation of chemically and biologically protective materials (Scott and Holly 2007).

Electronics

Nanotechnology is commonly accessible in daily electronic products such electronics are used in terms of cell phones, computers and other devices. Terabytes of data on devices smaller than sugar cubes. Computers that might operate by reading the brain - waves of the operator computer memory used to perform tasks the computer is on. Ram only holds information powered by electricity. Magnetic Ram would be able to hold information for up to next 10 years without power (Wu et al. 2013) computers would no longer need backup batteries making them lighter and smaller ferroelectric materials made up of crystals have the ability to change the polarization these crystals hold orientation until forced to change can be coded as binary memory since they do not revert spontaneously. RAM would not be erased effects data storage nanotechnologies provide ways to decrease the distance between the read and write head and the magnetic disks increasing with speed. Cell phones will be cheaper and efficient. Currently the functions of cell phones are limited. Inefficiency of radios and antennas waste battery power after nanotechnology cell phones will only need one radio and one antenna to increase batteries, which will have increased stronger capacity, storage increased wireless transfer speed. Phones

will be able to transfer full length movies in two seconds. Phones will be identifying their user by the smell of their pheromones leading to increase security. Future revolution in commercial trades is barcode scanners, robotic inspection system, and space elevator.

Construction industries

Nanotechnology is used significantly in the construction industry. In United States, 41% of energy is consumed in commercial buildings and residential houses by applications such as heating, lightning and air conditioner. The construction sector was among the first to be identified as a promising application area for nanotechnology back in the beginning of the 1990s; but today we see that the fragmented and conservative construction industry is falling behind other sectors in applying nanotechnology (Gann 2002). Studies targeted at the role of nanotechnology in construction are very few and mostly quite recent. They are mainly either technical (Bartos et al. 2004) or consist of consultancy reports presenting more a mapping of commercial nanoproducts than studies of trends, dynamics and impacts with an exception (Andersen 2007).

The enabling nature of nanotechnology implies that it can provide traditional construction materials with new functionalities including new eco-innovative solutions. The mentioned new reports identifies a wide range of commercially available products worldwide, illustrating that much is beginning to happen in this area (ANFoS 2006; Broekhuizen et al. 2011). Construction industry made the multidisciplinary system for this specific sector to improve the durability and enhance the performance of construction components, energy efficiency, safety of buildings, and living style comfort. For final product and coating such nanoparticles are utilized Titanium oxide is being used to remove dirt and pollution when exposed. These nanoparticles have cleaning property in concrete sulphur hydrophiliocity, antifogging and fouling resistances (in windows), and hence also used for ultraviolet protection and photo catalysis. Titanium oxide nanoparticles are being applied to exterior walls of building for self-cleaning function. It is the largest consumer of paint industry (Mann 2006).

The benefits of carbon nanotubes include mechanical durability and crack prevention in cement enhanced mechanical and thermal properties ion ceramics real time structuring health monitoring carbon nanotubes have potential use in many sectors automotive, electronic, energy and health industries. Silver nanoparticles are great antimicrobial in nature since time immemorial that's why it has been utilized in paintings, it also been used in air-conditioning, washing machines and refrigerators (Silver Nanotechnology Working Group 2014). Silicon dioxide nanoparticles exhibit mechanical strength in concrete coolant, light transmission, fire resistance, and flames proofing and anti-reflection.

Nanosized aluminium and nanoaluminium oxide are used to make surfaces scratch resistance. These surfaces also prevent decelerate formation of bad smells, fungus and mould. Zinc oxide-nanosized particles are used in both coatings and paints (Nazari et al. 2010). The copper nanoparticles are corrosion resistance and useful in formation of films on steel. Nanoclay in combination with nylon is used to increase the structural hardness in plastic polymer material. Thermoplastic Olefin nanocomposite materials are used for automotive parts.

Cerium oxide also been used as a diesel fuel combustion catalyst which has potential role in reduction of the fuel combustion, carbon monoxide emissions and other harmful exhaust (Sajith et al. 2010). Basic construction materials, concrete and steel are immensely benefited from nanotechnology because nanoparticles will lead to strong durable, self- heating, air purifying, fire resistance , easy to clean and quick compact concrete. Nanotechnology will also have a considerable impact on glass, and therefore, commonly used in 'smart windows,' which imply that they are multifunctional through their energy saving, easy cleaning and photovoltaic features.

Pharmaceutical industries

The research in pharmaceutical companies is focused on cancer, cardio-vascular diseases, and new and emerging diseases like ebola, HIV, Tuberculosis, etc. Nanotechnology is used for the process and synthesis of drugs and also as a development tool for diagnostics. One of the most important tools is miniaturization and automation in organic synthesis and biological screening on a nanoscale (Kumar 2011). Nanomedicines are most likely better than existing medicines and many pharmaceutical companies have begun utilizing to improve drug delivery and target (Jain et al. 2015). Nanomedicines are being tested for the ability to reach cell target that have more eluded conventional medicines like magnet which locate in the some part of membrane itself where the amount of structure or place is spoiled it directly transmit only that part and cures better only that part it is called the next revolution nanobots that could be programmed to attack the structure of cancer cells and viruses custom design therapies based on patient individual DNA (Freitas Jr 2005). It also include in other applications beauty, health, fashion, food and everything. Silver nanoparticles are manufactured using different synthetic routes that can be grouped in three techniques physical vapor deposition, ion implantation or wet chemistry.

Paper and pulp industries

Many existing processes and technology are explained to have bearings on micro and nano phenomena concepts which integrate the ideas in first time authentically. Wood trees agro residues and recycled fiber have bearing with microstructures, which has motivated massive research about nanocelloulose. This wonderful material which is the synthesized naturally in wood is composed of nanofibriles with its width 20 mn high aspect of ratio and remarkable strength.

Nano concepts in wet end paper making

In papermaking, nanotechnological advances were reported about a decade ago, though it could not be commercialized at a large scale. Nanofiber, nanofiller,

nanocomposites and nanoscale chemicals to be used in pulp and paper applications are in main focus. Because of the wide abundance, renewable and environmentally benign nature, and outstanding mechanical properties of nano based cellulosic materials, great attention has been paid to their use in pulp and paper, and other industries. There are a few micro particles and micro polymer technology for better retention and drainage properties at the wet and is the first application of nanotechnology. Micro and nano size high performance engineer minerals and oxide imparting superior optical surface and printable properties to the paper, it covers also paper machinery manufacturing rolls and fabrics with a nanobase (Chauhan and Chakrabarti 2012).

The Packaging Development Center, International Paper, has recently revealed their new technology for gas and moisture barrier for beverage packaging. The technology employs a nanoclay composite coating; similar nanocomposite coatings have also been used by International Paper in inkjet and digital printing paper, which have been marketed under the brand Jet Print Photo paper Cellulose nanocrystals function similar (Favier 1995).

Coating, packing, papers and printing

Nanotechnology is used in coating, packing, papers and printing production of intelligent wood and packing materials for security, counterfeiting safety and microbial purpose new types of antibacterial paper, tissue paper and newsprint have recently produced in nanotechnology. In addition considerable advances have been made to surface modify cellulose nanofibers and films and thus control the surface hydrophobicity, which is an important aspect to consider in food packing. PFI and industrial project partners demonstrated that nanocellulose can be produced industrially, in large scale (1.5 tones/day) and with low energy consumption (1600 kWh/ton). It means that the nanocellulose content widely produced from the wood quantity is immense. Adequate production and utilization of product need s more compressive understanding of nanocellulose chemistry (such as utilization in pulp and paper industry).

In 2010, the total global value of all nanotechnology expenditures in the paper industry was estimated as more than $3.2 billion. By 2015, it is expected that spending in this market will increase to more than $3.7 billion, reflecting an estimated compound annual growth rate (CAGR) of 2.8% for the total market. Printing speed continue to increase consumer demands more sharpen colored silica nanoparticles for high performance retention/drainage. The remarkable work is in progress concerning the transition of smart/multifunctional polymer coatings from laboratory curiosities for the identification of commercial applications. Intelligent or smart coatings, which combine the shielding aspect with sensor or actuator functions, has been based on their capabilities to respond to physical, chemical or mechanical stimuli by developing readable signals.

Nanomaterials would be used not only as advanced functional materials, but also as an integral part of complete smart structures composed of various elements including sensors, actuators, and control devices. Some of the key challenges in more advanced research areas are the understanding of corrosion protection mechanism imparted by conducting polymers and the advancement of micro/nanocapsulation as a mean to impart self-healing (Boura et al. 2010). However, some innovative applications seem to be ready for commercialization in a very nearby future, such as a coating using carbon nanotubes to conduct a current for evenly heating surface, which could be used on pipelines to reduce gas hydrate formation or to de-ice the blades on wind turbines (Rassenfoss 2011).

Current and future nanotech applications in the oil industry

Nanotech applications in the oil industry are not new; nanoparticles have been successfully used in drilling mud for the past 50 years. Only recently all the other key areas of the oil industry, such as exploration, primary and assisted production, monitoring, refining and distribution, are approaching nanotechnologies as the potential philosopher's stone for facing critical issues related to remote locations (such as ultra-deep water and arctic environments), harsh conditions (high-temperature and high-pressure formations), non conventional reservoirs (heavy oils, tight gas, tar sands). The general aim is to bridge the gap between the oil industry and nanotechnology community using various initiatives such as consortia between oil and service companies and nanotechnology excellence centers, networking communities, workshops and conferences and even dedicated research units inside some oil companies (Cocuzza et al. 2012).

Nanotechnology in defense

Defense is an important area where nanotechnology can be applied. There are various applications of nanotechnology in defense. Armors are being developed to withstand extreme conditions. The nano weapons are used in detection, defense and development. Interestingly nanotechnology can help us in fuel economy, soldier protection and stealth movement. One of the important area in defense is health of the defense personals. Nanotechnology can be applied in medicine, diagnosis of the patients and drug delivery.

The institute of Solider Nanotechnologies is a research centre founded through a US Army Research office contact with MIT. The goal of this entry is to create light wait and comfortable high-tech battle suit for the modern soldiers. They imagine that nanotechnology will help them create bullet resistant jumpsuit no thicker than ordinary spandex, that monitors health, eases injuries, communicates automatically reacts instantly to chemical and biological agents. Researchers hope to see this developing technology mature in the next 15 to 20 years.

MIT’s Prof Christine Ortize is taking a clue from nature in developing materials to protect the modern soldiers. She and her students are underway on research to examine the nanostructure of the scales of the snakes, dinosaur and other species that has been able to survive enemy attacks for over 96 million years.

In the field of sensors and its applications

According to Krishnamoorti (2006), non materials are excellent tool for the development of sensors and imaging-contrast agents due to the significant alterations in their optical, magnetic and electrical properties (in comparison to their bulk analogues) along with their ability to form (electrically and/or geometrically) percolated structures at low volume fractions. Such nanomaterials, when combined with smart fluids, can be used as extremely sensitive down hole sensors for temperature, pressure and stress even under extreme conditions. The ultimate evolution of devices for prospecting is represented by nanorobots, which should really provide an effective mapping of the reservoir. Now-a-days, nanorobots still remain a dream. But advances in nanosensor miniaturization are occurring rapidly and numerous theoretical and experimental investigations about the flow of multiphase fluids containing nanoparticles in porous media enrich the recent technical literature (Ryoo et al. 2010; Yu et al. 2010).

SAFETY AND HEALTH WITH EFFECTIVE FUTURE MEASURES AND PROSPECTS

The new scientific innovation of tremendous vast field such as engineering of nanoparticles (NPs) at the atomic scale of 100 nm or less, has led to numerous novel and useful wide applications in electronics, chemicals, environmental protection, biological medicine, paper and pulp industries etc. Manufacturers and consumers of the nanoparticles-related industrial products however, are likely to be exposed to these engineered nonmaterials, which have various physical and chemical properties.

Nanoparticles are related with emission free motion and can be easily released into the environment leading to human exposure. It is also very important to recognize that all nanoparticles do not exert toxicity. It depends upon the least chemical composition and shape. Nanoparticles are abundant in nature, as they are produced in many natural processes, including photochemical reactions, volcanic eruptions, forest fires, and simple erosion, and by plants and animals, e.g. shed skin and hair. Though we usually associate air pollution with human activities cars, industry, and charcoal burning, natural events such as dust storms, volcanic eruptions and forest fires can produce such vast quantities of nanoparticulate matter that they profoundly affect air quality. One particularly harmful volcanic product is particles, emission of carbon gasses composed of heavy metals, as these are known to be toxic to humans. Short-term effects of ash on health include: respiratory effects (nose and throat irritation, bronchitis symptoms), and eye and skin irritation. Several attempts are being made to reduce the toxicity level so as to provide safeguard to all consumer product which are likely to be entered in the emerging global markets such as China and India in addition to several European countries. In order to expand its horizon several measures should be there for example transparencies must be for all activities. There should be confidence building activities recurrently among customer values. So communication is the most important way to share the values about the newer product, there should be excellent scientific level research on toxicity associated with all the nanoproduct so that all the safeguard to be provided by this activity very efficiently.

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Effective measures includes (i) Transparency of all nano related activities, (ii) Communicate with stories focusing on customer value, (iii) Assure an excellent scientific level of research on risks of nanotechnologies, (iv)Balanced communication between risks, (v) Raise awareness of the nanotechnology community for the need of communication to the public, (vi) Learn from Biotech divide Nanotechnologies Green and Red, (vii) Evaluating the biological mechanisms for potential toxic effects integrating the models to assist in assessing possible hazards, (viii) Determining if a measure other than mass is more appropriate for determining the toxicity, (ix) Determining the exposure differ by work process, (x) Determining what happens to nanomaterials once enter the body, (xi) Identifying uses of nanotechnologies for application in occupational; safety and health, (xii) Evaluating effective applications to workers and safety health professionals. Nanoparticle library helps professional, industrial groups, members, employers and researchers to share information on material including their health and safety associated.

CONCLUSIONS

Nanotechnology has shown remarkable potential that can change incredibly the beautiful world by generation of a new revolution. The application of nanotechnology has great influence on the world in which we live. It is interdisciplinary or alliance of other applications such as consumer goods, electronics, computers, biotechnology, textile, food beverages, aerospace and defense, etc. All sectors of economy are to be profoundly impacted by nanotechnologies. The list of product used in daily need is enhancing, which include clothing, sunscreen, cosmetics, golf, etc. Research and development in nanotechnology is likely to change the traditional practices of design, analysis

and manufacturing for wide range of products. This impact will create challenges to the academic community in order to educate engineering and biology students with necessary knowledge, understanding skills to interact and provide leadership in the evolving world of nanotechnology.

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