NANO TECHNOLOGY: ECONOMIC ASPECTS, APPLICATIONS AND RISKS

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Abstract

The prospect of nano technology is reviewed. This covers the definitions, historical records, concerns, applications, scope of the future, risks economic aspects, and the need of regulations. From the prospect of economic potentials, it is concluded that Indonesia should take part in developing capabilities in nano technologies. This participation could be initiated by initiating a small study group in UNAS

Keywords: nanotechnology, nanomaterials, nanostructure, materials for energy, advanced functional materials, economic regulation

Introduction

Globally billions and billions of dollars have been invested in nanotechnology research and development. Looking forward that the 21st century is proclaimed to become the 'nano-century'. Scientists and engineers across the globe are exploring the new super materials that are durable, light, cheap that can be manufactured employing nanotechnology. Nanotechnology may also contribute to development (including global South) because of its potential in offering solutions especially in the fields of water (the use of water filters), energy (energy storage system and solar power), and health (portable diagnostic tests).

But at the same time these opportunities may also generate new risks, related to risks to the human body and environment. Much is still unknown related to the health hazard application of nanotechnology. Regulatory problems may come from non instant impact of the health hazard, and sophisticated costly in detecting the causality of nanotechnology. No matter how great is the economic potential and technical problem solving of nanotechnology, there still left fundamental questions on 'how are the risks and benefits taken into account? how can nanotechnologies travel from laboratory to market, and from geographical context to another?'

Regulatory are generally always behind the impact of technology development. In such case, the government should be aware of this fast-developed applied nanotechnology. A central study needs to be established not only on how to acquire, develop and apply nano technologies but also in anticipating what kind of regulation should be prepared.

Definitions

Nanoscience is the science of phenomena and how to manipulate materials at atomic or molecular scales. At these scales properties of the materials change significantly from those at a larger scale.
Nanotechnologies are the technologies that control the shape and size of materials at nanometers scale. These include the design, application, characterization, production of devices and systems. At millimetre scale one can observe ant and flea, while nanotechnology is rooted in the nanoscience, engineered at the nanoscale (about 1 to 100 nanometers). We can say also that nanotechnology refers to the constructing and engineering of the functional systems at very micro/ atomic/ moleculer level A nanometer is one billionth of a meter, let compared to the average of human hair sized which is about 25,000 nanometers. A nanometer is about three to four times the width of atoms. Nanomaterials are already being used in the daily practice widely. Following diagram represents the scope scale of nano interests

Examples of nanostructures are non-carbon nanotubes, nanowires, biopolymers, dendrimers

Nanomaterials can occur naturally like in the formation of dust cloud in forest fires, sea spray, geological mineral composites, ashes from volcano's activity, and viruses. They can also occur from human incidental activities like smoke from cooking, diesel exhaust, welding fumes, effluents from industries, and sand blasting. Most important is from human engineered nanomaterials like nanometals, quantum dots, nanotubes, pigments (e.g. sunscreen pigments), and nanocapsules.

Properties that change at a nanometer scale are related to thermal – melting temperatures, mechanical – adhesion (stickiness), electrical – current, optical – prisms. The important change of properties from macroscale to nanoscale are among other

Volume to surface area ratio

When objects get smaller, they create greater surface area to volume ratio. For instance, 1 cm cube has a surface area of 6 cm^2 and a volume of 1 cm^3 (ratio = 6:1); while 10 cm cube has a surface area of 600 cm^2 and a

volume of 1000 cm^3 (ratio = 0.6:1. In the form of sphere with radius 1cm, the ratio is 3:1, while if the radius is reduced to nano meter, the ratio becomes 30 million:1. This makes at very small sizes physical properties (magnetic, electric and optical) of materials can change. Examples are properties change in melting point, in fluorescence, in electrical conductivity, and in chemical reactivity. The bigger the surface size, the larger or greater amount of the material comes into contact with surrounding materials and increases reactivity. By tuning the size of the particle, nanomaterial properties can also be tuned e.g. changing the fluorescence color a particle can be identified. This offers a variety of functions to products.
EXAMPLE: Gold and silver nanoparticles can change colors by changing the sizes

Examples of nanomaterials:

Amorphous silica fume (nano-silica). Crystalline silica fume is used as an additive in paints or coatings, giving e.g. self-cleaning characteristics – it has a needle-like structure and sharp edges so is very toxic and is known to cause silicosis upon occupational exposure. Nano platinum or palladium in vehicle catalytic converters - higher surface area to volume of particle gives increased reactivity and therefore increased efficiency. Optical properties are directly dependent on size

History

The concept of nanotechnology was first introduced by Dr. Richard Feynman in 1959. In 1974, the term “Nano-technology" was introduced by Norio Taniguchi. In 1981, the invention of the scanning tunneling microscope and the discovery of fullerene(C60). In 1985 breakthrough and the emergence of nanotechnology. Early 2000s saw the beginnings of commercial applications of nanotechnology. These applications were limited to bulk application of nanomaterials such as silver nano platform as an antibacterial agent, nanoparticle-based transparent sunscreens, and carbon nanotubes for stain-resistant textiles.

Why concern nanotechnology?

1. It is because of the enormous economic and technical potentials in various applications, there are also big gaps in knowledge concerning the possible risks and difficulty in detecting and removing the nano material toxic, meanwhile in daily usages still absence of regulation. That is why there the potentials risks associated with nanotechnology. Adverse health effects in humans from deliberate or accidental exposure. There also adverse effects on the environment from deliberate or accidental

exposure. Some nanomaterials may have properties that can be potentially explosive at nanostructures.

2. Risk assessment problems come from : (i) Very difficult to detect nanomaterialas without sophisticated equipment; (ii) Difficult to predict how particles will behave in the environment (dispersed/clumped); (iii) Small size may result in particles passing into the body more easily (inhalation, ingestion, absorption); (iv) May be more reactive due to surface area to volume ratio; (v) Potential to adsorb toxic chemicals; (vi) Persistence - Longevity of particles in the environment and body are unknown
3. Difficulties in controlling toxicological effects, because all structures are likely to have a unique toxicological profile, particle size may be less important than the surface characteristics of the material, so that standard dose-response tests may not be appropriate
4. Nanotechnologies can be developed in two ways:
   Top-down where an object is cut smaller and smaller until attain size needed. Example is the method of etching a block of material down to the desired shape, as in the chips and processors. In top down approach nano objects and materials are created by larger entities without bouncing its atomic reactions. Solid-state techniques can also be used to create devices known as nanoelectromechanical systems or NEMS, which are related to microelctromechanical systems or MEMS. MEMS became practical once they could be fabricated using modified semiconductor device fabrication technologies, normally used to make electronics.
   Bottom-up where in the bottom up approach different materials and devices are constructed from molecular components of their own. They chemically assemble themselves by recognizing the molecules of their own breed. Examples of molecular self assembly are Watson crick base pairing, nano-lithoghraphy. In the bottom up nanotechnologies, we add atoms together one by one to attain desired property. From this one can obtain building materials atom by atom - like lego, nanoparticles such as C60, carbon nanotubes, quantum dots etc.

Applications

Various applications of nanotechnologies, among others:

1. Antibacterial effect of silver, Coatings - self-cleaning windows and stainproof clothing, Sunscreens and cosmetics, Catalysts Envirox™ cerium oxide, Nano remediation SAMMS technology to remove mercury.
2. Paper photographic paper, Filters nanofibres, Toothpaste to remineralise teeth, Food packaging, Paint improved adhesion and anti-fungal qualities/anti-graffiti, Clothes non-staining and anti-radiation.

3. Batteries (Black & Decker) phosphate nanocrystal technology, Cleaning products.
4. Particular Potential applications of carbon nanotubes.

Materials & Chemistry
– Ceramic and metallic CNT composites
– Polymer CNT composites (heat conducting polymers)
– Coatings (e.g. conductive surfaces)
– Membranes and catalysis, Tips of Scanning Probe Microscopes (SPM)

Medicine & Life Science
- Medical diagnosis (e.g. Lab on a Chip (LOC))
- Medical applications (e.g. drug delivery)
- Chemical sensors
- Filters for water and food treatment
- Nanotechnology in Drugs (Cancer)

Provide new options for drug delivery and drug therapies. Enable drugs to be delivered to precisely the right location in the body and release drug doses on a predetermined schedule for optimal treatment. Attach the drug to a nanosized carrier. They become localized at the disease site, i.e cancer tumour. Then they release medicine that kills the tumour. Current treatment is through radiotherapy or chemotherapy. Nanobots can clear the blockage in arteries.

Electronics & ICT
- Lighting elements, CNT based field emission displays
- Microelectronic: Single electron transistor
- Molecular computing and data storage
- Ultra-sensitive electromechanical sensors
- Micro-Electro-Mechanical Systems (MEMS)
- Electrodes made from nanowires enable flat panel displays to be flexible as well as thinner than current flat panel displays.

Nanolithography is used for fabrication of chips. The transistors are made of nanowires, that are assembled on glass or thin films of flexible plastic. E-paper displays on sunglasses and map on car windshields.

Nanotechnology in computers. The silicon transistors in your computer may be replaced by transistors based on carbon nanotubes. A carbon nanotube is a molecule in form of a hollow cylinder with a diameter of around a nanometer which consists of pure carbon. Nanorods is a upcoming technology in the displays techniques due to less consumption of electricity and less heat emission. Size of the microprocessors are reduced to greater extend. Researchers at North Carolina State University says that growing arrays of magnetic nanoparticles, called nanodots. Hewett Packard is developing a memory device that uses nanowires coated with titanium dioxide. One group of these nanowires is deposited parallel to another group. When a perpendicular nanowire is laid over a group of parallel wires, at each intersection a device called a memristor is formed. A memristor can be used as a single-component memory cell in an integrated circuit. By reducing the diameter of the nanowires, researchers believe memristor memory chips can achieve higher memory density than flash memory chips. Magnetic nanowires made of an alloy of iron and nickel are being used to create dense memory devices.

Chips produced by Intel before “i” series processors were between 65nm -45nm. Later with the help of nanotechnolgy 22nm chips were made which itself is a milestone. Advantages of using carbon nanotubes: ▫ Faster and smaller- carbon nanotubes can be used to produce smaller and faster components. This will also result in computers that consume less energy. ▫ High speed and high capacity memory. Allows circuits to be more accurate on the atomic level.

Energy

- Hydrogen storage, energy storage (super capacitors)
- Solar cells
- Fuel cells
- Superconductive materials

Carbon nanotubes

Have raised concerns due to a superficial likeness to asbestos fibres and extreme durability. Potential exposures during manufacturing, processing, product use and disposal. Have been researched more than most manufactured nanostructures.

Materials used Zinc oxide: Dirt repellent, hydrophobic, cosmetics & stain resistant. Silver ion: Healing property Aluminum silicate: Scratch resistance. Gold ion: Chip fabrication, drug delivery.

Nanotechnology in Fabrics. The properties of familiar materials are being changed by manufacturers who are adding nano-sized components to conventional materials to improve performance. For example, some clothing manufacturers are making water and stain repellent clothing using nano-sized whiskers in the fabric that cause water to bead up on the surface. In manufacturing bullet proof jackets. Making spill & dirt resistant, antimicrobial, antibacterial fabrics.

Nanotechnology in Mobile. Morph, a nanotechnology concept device developed by Nokia Research Center (NRC) and the University of Cambridge (UK). The Morph will be super hydrophobic making it extremely dirt repellent. It will be able to charge itself from available light sources using photovoltaic nanowire grass covering its surface. Nanoscale electronics also allow stretching. Nokia envisage that a nanoscale mesh of fibers will allow our mobile devices to be bent, stretched and folded into any number of conceivable shapes.

Other uses Cutting tools made of nanocrystalline materials, such as tungsten carbide, tantalum carbide and titanium carbide, are more wear and erosion-resistant, and last longer than their conventional counterparts. o. Silver nanocrystals have been embedded in bandages to kill bacteria and prevent infection. Nanoparticulate-based synthetic bone Formed by manipulating calcium and phosphate at the molecular level. Aerogels lightest known solid due to good insulating properties is used in space suits and are proposed to use in space craft.

Technology Transfer from Developing Countries

President Jokowi has stated the important of economic growth by practicing creative economics. The added values in economic creativity is dominated by the role of science-based technology. In 1957, Robert Merton Solow, an American economist , Nobel Winner for his work on the theory of economic growth, stated that economic growth are mostly determined by the role of creativity in science based technology like in the field of micro electronics, computers, communications, biotechnology, molecular biology that among others utilizing nanotechnologies. His theory was approved by the economic growth in America with its Silicon Valley, Japan with its silicon island, and many other countries with there nanotechnologies.

To speed up transfer technology, at the infant stage of development, it would be too difficult to get this transfer from developed countries, not only the gap of basic technology between advance and developing countries is too big, but also some reluctancy to become competitors. It may be easier to learn for this nanotech from emerging nano country like India.

Nanotechnology in India IIT Mumbai is the premier organization in the field of nanotechnology. Research in the field of health, environment, medicines are still on. Starting in 2001 the Government of India launched the Nano Science and Technology Initiative (NSTI). Then in 2007 the Nanoscience and Technology Mission 2007 was initiated with an allocation of Rupees 1000 crores for a period of five years. The main objectives of the Nano Mission are: - basic research promotion, - infrastructure development for carrying out front-ranking research, - development of nano technologies and their applications, - human resource development and - international collaborations.

CNT (Carbon Nano Technology) Research have been conducted. Results have been reported on the variable dependent on dose, testing model, purity and type of nanostructure. Some coated CNTs appear to move freely throughout the body (mice) whereas others are rapidly excreted Installation experiments have shown inflammatory, fibrotic and immune changes. Inhalation experiments have shown small changes in the lung Effects on the immune system, Effects on cell growth and death Modification of tube coating by aquatic organisms

There would be an entire nano surgical field to help cure everything from natural aging to diabetes to bone spurs. These nanorobots have the potential to take on human tasks as well as tasks that humans could never complete. The rebuilding of the depleted ozone layer could potentially be able to be performed. The future of nanotechnology could very well include the use of nanorobotics. Nanotechnology may make it possible to manufacture lighter, stronger and programmable materials that require less energy to produce than conventional material and that promise great fuel efficiency in land transportation, ships, aircrafts and space vehicles.

Economic prospect of nanotechnology

It was estimated that the market size within six years was since 2000, materials \$300B/yr, electronics \$180B/yr, pharmaceuticals \$100B/yr, chemical manufacture \$70B/yr, aerospace \$20B/yr, tools \$30B/yr, iImproved healthcare \$45B/yr, sustainability \$1 trillion, growing to \$2.6 trillion by 2014 (estimates by industry groups, source: NSF and LUX)
Based on The Nanotech Report, Nanotechnology was incorporated into more than \$30 billion worth of manufactured goods in 2005, and this figure was projected to grow exponentially to more than \$2.6 trillion in global manufactured goods by 2014.More than 1,000 nanotechnology products were on the market aimed at improving consumers' lives and another 400 products of nano instruments and test devices

Available in the shop are nano shirt, slacks, tie, tennis racket, odor/ bacteria eliminating socks, nano car wax. Moreover there are products of anticipatedburn and wound dressings, water filtration devices, paints, cosmetics, coatings, lubricants, textiles, memory/storage devices – medical diagnostics, displays, sensors, drug delivery, composite materials, solid state lighting, bio-materials, nano arrays, more powerful computers, protective armor, chem-bio suits, and chem-bio sensors nano biomaterials, microprocessors, new catalysts, portable energy cells, solar cells, tissue/organ regeneration, smart implants 2016 and beyond – molecular circuitry, quantum computing, new materials, fast chemical analyses

Scope In Future

Nanotechnology is a revolutionary science that will change all what we knew before. The future that we were just in science fiction will in the near future be real. This new technology will first of all, may make possible to keep us healthy when nanorobots capable of repairing every damage that we have in our body. Scientists eventually have the capability to manipulate the combination of atoms in an object and to turn it into a lighter, stronger, and more durable object than before, just by using carbon nanotubes that are known to be a hundred times stronger than steel and in addition to that they are very flexible. Nanotechnology is expected to provide abundant energy because it will transform energy more effectively.

Regulations

New generic nanotechnology regulations would be difficult to devise. More likely that current regulations/legislation will be adapted to take account of developments at the nanoscale.

Review by the European Commission on the regulatory aspects of nanotechnology: chemicals (REACH), worker protection (e.g. Directive 89/391/EEC), products (e.g. General Product Safety Directive), environmental protection (e.g. Directive 2006/12/EC on waste) "Current legislation covers in principle the potential health, safety and environmental risks in relation to nanomaterials ...."

Conclusions

It is concluded that Indonesia must be aware about the potential used of nano technologies. Central study needs to be established, anticipating on one hand the negative impact of used products available in the market based on nanotechnologies, developing the use of nanotechnologies on the other hand remembering the potential economic aspects of nanotechnologies. The authors believe that this central study could be initiated starting from a small group with the existing available measuring physics laboratory instrumentations in UNAS.

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