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PERSPECTIVES FOR APPLICATIONS OF NANOTECHNOLOGY AND NANOMATERIALS IN MEDICINE

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Abstract: Nanotechnology is a new science that comprise several science fields (chemistry, biology, physics, material science and engineering) conducted devices or materials that have at least one dimension undersize of 100 nm. Nanomaterials are chemically or physically different to their macro-scale counterparts and may have unique health and environmental impacts. Nanoparticles can be synthesized by reactions in solid state (breaking the larger materials) and chemical methods (wet chemical synthesis).
Extremely small size enables nanoparticles to enter the human body through usual or unusual routes, pass through cell membranes, or cross the blood-brain barrier.
At present, potential use of nanotechnology in a range of applications at any stage in food industry: production, processing, packaging, labelling, transporting, tracing, keeping the quality of food product and extend the product shelf-life, leading to less food waste, water filtration, removal of undesirable tastes, flavors or allergens from food products.
Applications of nanotechnology and nanomaterials in medicine (Nanomedicine) based on Nano (bio) sensors enables rapid and sensitive detection of pathogenic bacteria and trace levels of viruses in small sample volumes, at lower costs. Early detection of pathogens enables accurate and prompt treatment.
Sensors to detect biofilm formation by bacteria on surfaces are developing.
Multi-drug resistant microorganisms (MDR) are one of the most serious and increasing global, public health threat. New strategies urgently needed to combat MDR, includes nanomaterials as very promising approach.
Metal nanomaterials (silver, gold, copper, titanium, zinc, magnesium, cadmium, and alumina) possess unique antimicrobial activities.
Researchers are developing:
- Method to release insulin from sponge-like matrix and Nano-capsules, when the glucose level rise
- Nano-particles to be taken orally (pills), could pass the intestines into the bloodstream
- Sensors to detect bacterial biofilms on surfaces
- Nano-particles to defeat viruses by delivering an enzyme that prevents their reproduction in the patients bloodstream
- Gelatin nanoparticles can be used to deliver drugs to damaged brain tissue
- Nanoparticles to deliver vaccine, allowing the vaccine a stronger immune response
Risks of nanotechnology are still unknown and unpredictable.
Keywords: applications, nanomedicine, nanoparticles, nanotechnology

1. INTRODUCTION

Nanotechnology, subsumes knowledge of several scientific fields (chemistry, biology, physics, material science and engineering), operates with (nano) devices or (nano) materials that have dimensions between 1 to 100 nm and presents one of the most challenging and promising science of the 21st century.

Application of nanotechnology to medicine is called nanomedicine. Major goal of nanomedicine is to improve, significantly, individual and global health, comprising three molecular technologies (Jokanovic, 2012):

- Nano materials and devices for advanced diagnostics and biosensors, targeted drug delivery, smart drugs and antimicrobials;
- Use of molecular medicine via genomics, proteomics and artificial engineered microbes;
- Medical nano robots that will allow rapid pathogen diagnosis and eradication, chromosome replacement and individual cell surgery *in vivo*.

2. HISTORY

First beginnings of use of nanoparticles date from 2000 years ago when Greeks and Romans used sulfide nanocrystals to dye hair. About 1000 years ago (Middle Ages), gold nanoparticles of different sizes were used to produce different colors in stained glass windows.

First concept, of nanotechnology connected with "There's Plenty of Room at the Bottom", written by Richard Feynman (1959), predicting possibility in the future to manipulate atoms and molecules, where different physical phenomenon's exist (gravity loses impact and importance, while surface tension and Van der Waals constants has more importance). He received the Nobel Prize in physics in 1965. He also wrote following books: *Unbounding the Future* (1991), and more recent technical book *Nanosystems: Molecular Machinery, Manufacturing, and Computation* (1992).

Term nanotechnology was introduced in 1974, by Norio Taniguchi, professor of Tokyo University of Science.

American engineer Eric Drexler is best known for popularizing the potential of molecular nanotechnology. He unknowingly used a related term in his 1986 book "Engines of Creation", to describe what later became known as molecular nanotechnology.

First book about nanomedicine was published in 1999.

Further development of nanotechnology and nanoscience was enabled by developing of Scanning tunneling microscope (STM) in 1981 by Gerd Binning and Heinrich Rohrer (at IBM Zürich). They received the Nobel Prize in Physics in 1986.

Great progress was enabled by development of fullerene (a molecule of carbon, 0, 7 nm in diameter), in the form of a hollow sphere, ellipsoid, tube, and many other shapes. Carbon nanotubes are manufactured as single wall or multiwall carbon nanotubes. Potential applications of fullerene is due ability to incorporate cations, as a carriers of radioactive materials or drugs for targeted therapy of malignant diseases of bones and soft tissues. Nanotubes can easily penetrate membranes such as cell walls, looks like miniature needles, at the cellular level.

3. APPLICATION OF NANOTECHNOLOGY

Products and methods of nanotechnology are applicable in: Manufacturing and Materials, Environment, Energy and Electronics, Information technology, Food industry and Medicine. Numerous companies are specializing in the production of new forms of nano-sized materials. Nanotechnologies are projected by 2020 to impact at least $3 trillion across the global economy. Worldwide may require at least 6 million workers to support nano-industry.

At the present, use of nanotechnology in food industry includes: production, processing, packaging, labelling, transporting, tracing, keeping the quality of food product and extend the product shelf-life, leading to less food waste, water filtration, removal of undesirable tastes, flavors or allergens from food products (Bata-Vidacs, 2013, Duncan, 2011).

4. NANOMEDICINE

Researchers have demonstrated that: gelatin nanoparticles can be used to deliver drugs to damaged brain tissue, nanoparticles to deliver vaccine, allowing the vaccine a stronger immune response.

Nano robots could actually be programmed to repair specific diseased cells, functioning in a similar way to antibodies in our natural healing processes.

Researchers are developing:

- a method to release insulin from sponge-like matrix and nano capsules, when the glucose level rises
- a nanoparticles to be taken orally (pills), could pass the intestines into the bloodstream
- Sensors to detect bacterial biofilm formation on surfaces
- Nano particle to defeat viruses by delivering an enzyme that prevents their reproduction in the patient's bloodstream
- Carriers of radioactive materials or drugs for targeted therapy of malignant diseases of bones and soft tissues.

Nanotechnology may provide rapid and sensitive detection of pathogenic bacteria and trace levels of viruses in small sample volumes, at lower costs than current in-use technologies. Early detection enables accurate and prompt treatment. Test for detection of: *E. coli O157:H7, S. aureus, S. typhimurium, C. jejuni, E. cloacae, B. subtilis, L. monocytogenes* and yeast (*Saccharomyces cerevisiae*) are developed.

Antibiotics have been one of the greatest success stories in medicine. But there is growing concern that the drugs usefulness is coming to an end. In 2015, in Europe more than 25,000 people died of bacterial infections that were resistant to antibiotics. Resistance to antibiotics poses a "Major global threat" to public health, says a report by the World Health Organization (WHO). The world is heading towards a post-antibiotic era in which many common infections will no longer have a cure. Some authorities consider microbial resistance as an apocalypse talking that: A terrible future could be on the horizon, which rips one of the greatest tools of medicine out of the hands of doctors.

Also, bacteria can adhere and produce biofilms on dental implants, catheters, artificial hips, prosthesis, contact lens, wounds and lungs.

The treatment options with respect to MDR (multi drug resistant bacteria): *Acinetobacter baumannii, Pseudomonas aeruginosa, Klebsiella pneumoniae, Escherichia coli, Proteus mirabilis, Staphylococcus aureus* (MRSA) are very limited. Major challenges for scientists and highest priorities of modern medicine and biotechnology has become developing of novel alternative methods.

Nanostructures used in Anti-infectious therapy (Belkemyshev, 2013):

- Zinc Oxide Nanoparticles
- Silver Nanoparticles
- Magnetite Nanoparticles such as Fe3O4
- Synthesis of Fe3O4 Nanoparticles
- Functionalized Magnetite Nanoparticles
- Antimicrobial Nanoshuttles
- Antimicrobial Nano-modified Surfaces (Anti-adherent Nano-surfaces)

Metal nanomaterials (silver, gold, copper, titanium, zinc, magnesium, cadmium, and alumina) possess advantage of unique antimicrobial activities. Some studies established that silver ions has strongest bactericidal effect, cooper and gold weaker one (Sondi, 2004). Inside the human body ionic silver quickly combines with chloride to form an insoluble compound called silver chloride which is far less reactive than metallic silver nanoparticles. Ionic silver cannot survive inside the human body because blood serum is rich in sodium and potassium chloride that quickly forming silver chloride. Only metallic silver nanoparticles can survive inside the body beacuse they are unaffected by chloride ions (Santos, 2013).

One of the earliest nanomedicine applications was the use of nanocrystalline silver which is as an antimicrobial agent for the treatment of wounds and burn dressing that is coated with nanocapsules containing antibiotics.

15 new EU research projects are devoted on antimicrobial resistance. Following three projects, nanotechnology-based are funded by the EU Seventh Framework Program (FP7):

- *PneumoNP* (Nano therapeutics to treat pneumonia infections)
- *FORMAMP* (Innovative Nano formulation of antimicrobial peptides to treat bacterial infectious diseases)
- NAREB (Nano therapeutics for antibiotic resistant emerging bacterial pathogens)

5. CONCERNS (BENEFITS VS RISKS)

Rapid emergence of nanotech applications in consumer products has raised a number of ethical and societal concerns ranging from possible health risks of using or consuming nano enabled products, to their effects on the environment, intellectual property rights governing them, and the new challenges they may raise.

The developments in food nanotechnology are comparable to those of genetically modified foods, another area that has been controversial, with many consumers being suspicious of the technology involved.

In a scientific paper published in March 2015, academic concern was expressed: Silver nanoparticles are a continuous source of ions that could be toxic for aquatic organisms that are swimming around or in the sediment. It will end up in the food chain (EFSA, 2011).

4. CONCLUSION

Nanotechnology and nanoparticles has a great potential for use in various fields with great challenge and perspective for use in medicine.

Major goal of nanomedicine to improve health and lives globally, by improving diagnostics and treatments of patients suffering from a range of disorders overcoming some of the difficulties experienced by usual medical approaches.

Nanomedicine can play an important role in ensuring enough of the drug enters the body, stays in the body for long periods and is targeted specifically to the areas that need treatment. AT the same time use of nanotechnology must be safe for the patients.

It is possible, by studying and identifying individual molecules, to diagnose disease in time to improve the prognosis for the patient.

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