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Application of Nanotechnology in Practice

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ABSTRACT

Nanotechnologies are defined as technologies of the future and the application of nanotechnologies in practice is a current topic of interest for young learners. With its methods and achievements in various spheres of life, nanotechnologies are considered as advanced technologies or also known as high technologies. There is numerous research in the field of nanotechnologies, accompanied by great scientific interest, as they deal with the creation and application of new materials with extremely small structures, as well as substances with micro- or macro-sizes. Newly created products and technologies or improved existing ones are changing people's lives these days.

Young people initially receive their knowledge in the scientific field of nanotechnologies in the subject Chemistry and Environmental Protection. It is a profiled preparation, studying the properties of colloidal-dispersed systems. It has been found that these properties depend on the polydispersity, on the size, structure and state of the particles in their solution, and these particles, known as nanoparticles, are considered a discovery of the modern science. The pursuit of scientists to obtain materials with extremely small sizes and valuable properties is the basis of the latest developments in the field of nanotechnology.

One of the goals of the study is for students to discover the importance of nanotechnology in various areas of life, to expand their theoretical knowledge, presented in the educational content, to search for scientific information and to present this current topic to their peers. The fields of application of nanotechnology are many and it is not possible to show them all. The article presents some examples of the contribution of nanotechnology in the following fields - medicine and pharmacy, computers and microelectronics. Impact measurement of nanoparticles on the environment and human health is also indicated.

By gaining in-depth knowledge of the subject, students can develop an interest that can be the basis of their professional choice. They can choose a college major, in which they will learn about the latest achievements in the field of nanotechnology, in addition, they will develop their analytical thinking, connecting their knowledge from different disciplines - chemistry, biology, physics and informatics.

Keywords: nanotechnology, application in practice.

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INTRODUCTION

Application of nanotechnology in practice

Nanotechnologies are defined as technologies of the future. They are modern and rapidly developing fields in science and in practice. They are considered by scientists as an interdisciplinary field that unites chemistry with physics, informatics, materials science and biology. In recent years, many studies have been done on the properties of nanoparticles that they impart to materials. Nanomaterials are impacting people's lives, changing them by creating new technologies and improving existing technologies and products.

The article presents various applications of nanotechnology such as medicine, pharmacy, robotics, microelectronics and computers, industry, energy sector. The impact that nanotechnology has on the environment is also of interest. In medicine, nanotechnology is used for early diagnosis and the creation of new drugs to treat serious diseases, and for the creation of medical tools. In nanorobotics, machines and devices are created with extremely small sizes and have various applications at the atomic level. Nanomaterials, also, contribute to the development of microelectronics and computers. In the field of energy, new ways of converting and storing solar energy are being discovered through nanotechnology. The development of more efficient and economical lighting fixtures defines an important place for nanotechnology in this branch of industry. Along with all the innovations that this field offers, scientists are also closely monitoring the effect of the use of nanomaterials on the environment.

Nanotechnology studies the creation, manufacture and application of structures, systems and devices by controlling matter at the microscopic level [1]. Through nanotechnology, substances with micro- or macro-sizes, as well as new materials with extremely small sizes, are created.

Nanoparticles have specific properties determined by their structure and size - from 1 to 100 nm. The term "nano" comes from ancient Greek and means "dwarf" The size of the nanoparticles is the reason nanomaterials / semiconductors, metals / to have their typical physical - chemical properties, used by scientists to create nano-sized materials, also called nanomaterials.

EXPERIMENTAL

The research and analysis methods are used in this article to evaluate the role and application of nanotechnology in the practice. The information on the preparation and use of substances with new properties at the nano- level is presented from literary sources. Scientists are developing new methods for producing nanoparticles based on their specific properties determined by their structure and size.

RESULTS AND DISCUSSION

Different types of nanomaterials are known quantum dots / nano-sized semiconductors /, carbon nanotubes, fullerenes, graphene, aerogel, aero graphite, nanocomposites, metal nanoparticles - mainly from noble metals - gold, silver and platinum /, magnetic nanoparticles, polymer nanoparticles, nanoceramics.

Areas of application of nanotechnology

Medicine

Quantum dots unlock the future of biology and medicine, offering precise visualization, sensitive detection, targeted drug delivery, phototherapy, tissue monitoring, and personalized medicine (Fig. 1) [2]. To treat cancer, caused by damage at the cellular and molecular level, patients are prescribed fluids containing nano-

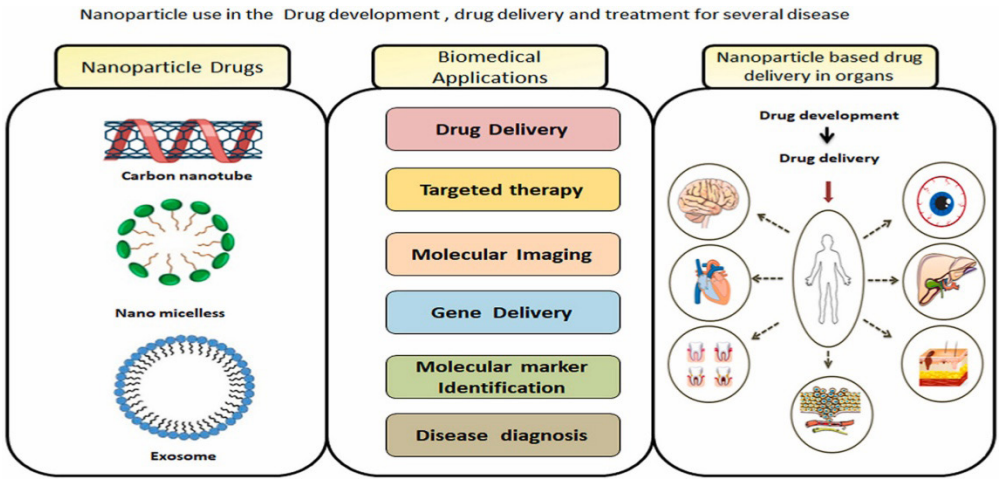

Fig. 1. Drug delivery [2].

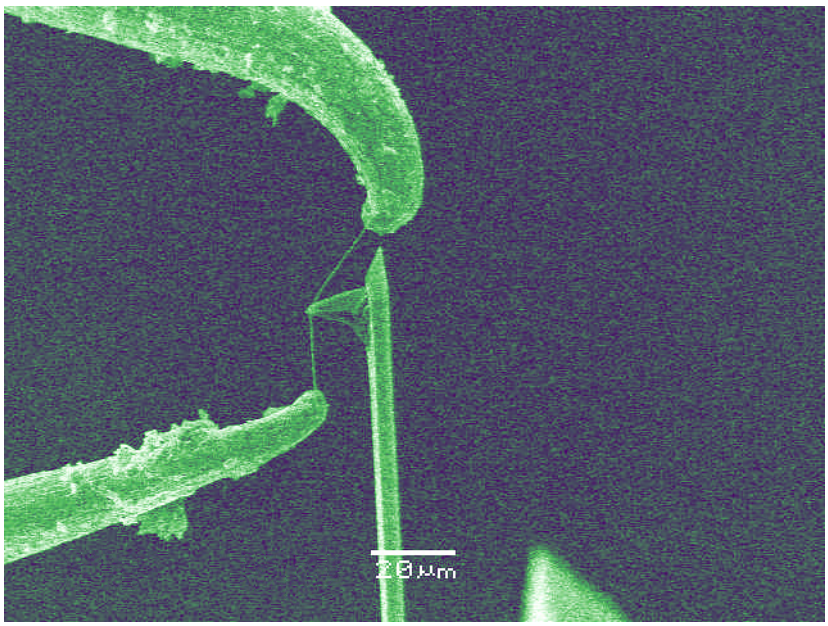

Fig. 2. Nano-knife [4].

robots, programmed to attack the molecular structure of the cancer cells and to destroy them.

Medical devices

A nano-knife (Fig. 2) is a carbon nanotube-based prototype compression cutting tool intended for sectioning of biological cells [3]. Working principle is like that of a 'cheese slicer', a nanometer-thin individual carbon nanotube strung between two tungsten needles would allow sectioning of very thin slices of biological matter for imaging under an electron microscope. A successful development of this new tool will allow scientists and biologists to make 3D images of cells and tissues for electron tomography, which typically requires samples less than ~300 nanometres in thickness [4] (Fig. 2).

Nanofibers

Nanofibers are fibers with diameters in the nanometre range (typically, between 1 nm and 1 μm). They are synthetic polymers, consisting of single strands of nanofibers and they are being used for treating brain and spinal cord injuries. Medical applications of nanofibers include the use of materials for wound dressings, surgical textiles, implants and components of artificial organs.

DNA manipulation

Ligands, mostly binding to proteins to form complexes and catalyse chemical reactions, can serve as drug and probe molecules, as well as sensing elements. DNA nanotechnology can integrate the high editability of DNA nanostructures and the biological activity of ligands into functionalized DNA nanostructures in a manner of controlled ligand stoichiometry, type, and arrangement, which provides significant advantages for targeted therapeutics and diagnostics [5].

Robotics

Nanorobotics is the study of robotics at the nanometre scale and includes robots that are nanoscale in size and large robots capable of manipulating objects that have dimensions in the nanoscale range with nanometre resolution (Fig. 3). Scientists at the Technical University of Zurich have developed an elastic "nanophile" in the form of nanotubes that can move through biological fluid at a speed of 15 micrometres per second. Nanofilaments can be adapted to deliver drugs to target cancer cells. Molecular motors are nano-sized machines that can rotate when energy is applied to them. The main characteristic of molecular motors is the repetitive unidirectional rotational motions that occur when energy is applied. Chemical, light and electron tunnelling methods are used to deliver energy.

In addition, to molecular motors, nano-electric ones are also being created, the principle of operation of which is based on the use of quantum effects. Water-powered nanomotors are also being created that would not pollute the environment.

Fig. 3. Nanorobot [6].

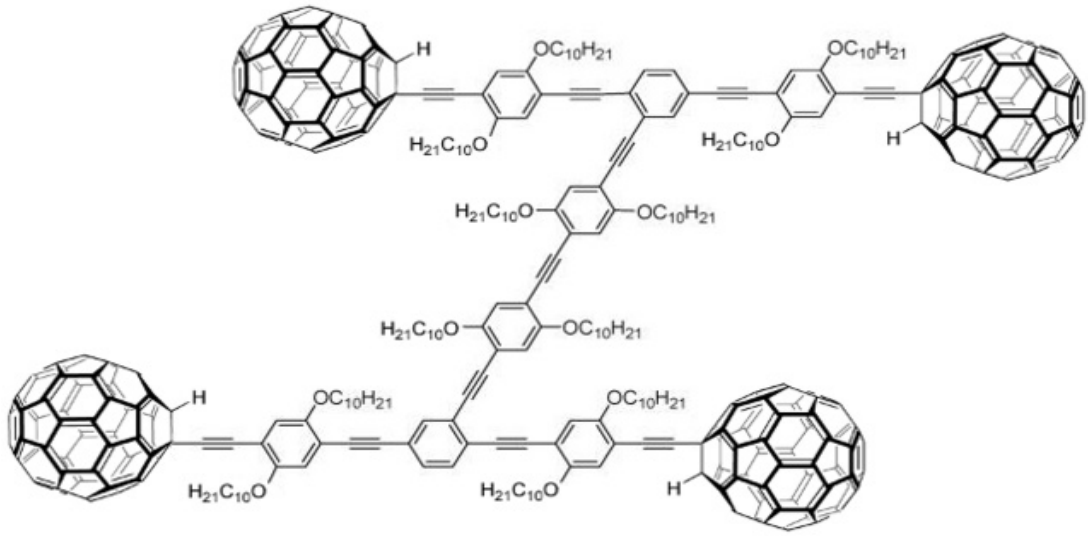

Fig. 4. Nanocar [5].

A nano-mobile is the simplest nanorobot consisting of one or several molecules capable of independent movement. The power source is an externally supplied electric current. The first nanocar races in history took place in 2017 (Fig. 4) [5].

Several groups of researchers have recently built a high-speed version of remotely controlled nanoscale rockets by combining nanoparticles with biological molecules. Scientists hope to develop a rocket that can operate in any environment, for example, to deliver medicine to the affected area of the body.

Nanorobots could play an important role in developing a more efficient renewable energy system. They could make our current machines more efficient by using less energy, but still operate with the same efficiency.

Microelectronics and computers

In 2007, Intel announced the development of a new processor in which the smallest structural element measures 45 nm, with the company aiming to reach sub-5 nm processors.

In 2005, an antenna-oscillator with size of 1 μm was created in the laboratory of Boston University. This device is capable of oscillating at a frequency of 1.49 GHz, which allows the transmission of a large amount of information.

In 2007, Albert Firth and Peter Grünberg received the Nobel Prize in Physics for the discovery of the giant magnetoresistance effect, which allows data to be recorded on hard disks with atomic recording density.

Nanotechnology in computers solves the problem of overheating by providing more processor power at lower temperatures.

Nanotechnology in the energy sector

One of the areas of significant develop-ment is in the field of renewable energy. Nanotechnology plays a crucial role in increasing the efficiency of solar cells [7,8]. Nanomaterials, such as quantum dots and nanofibers, can be engineered to capture and convert sunlight into electricity more efficiently. In addition, advances in the field

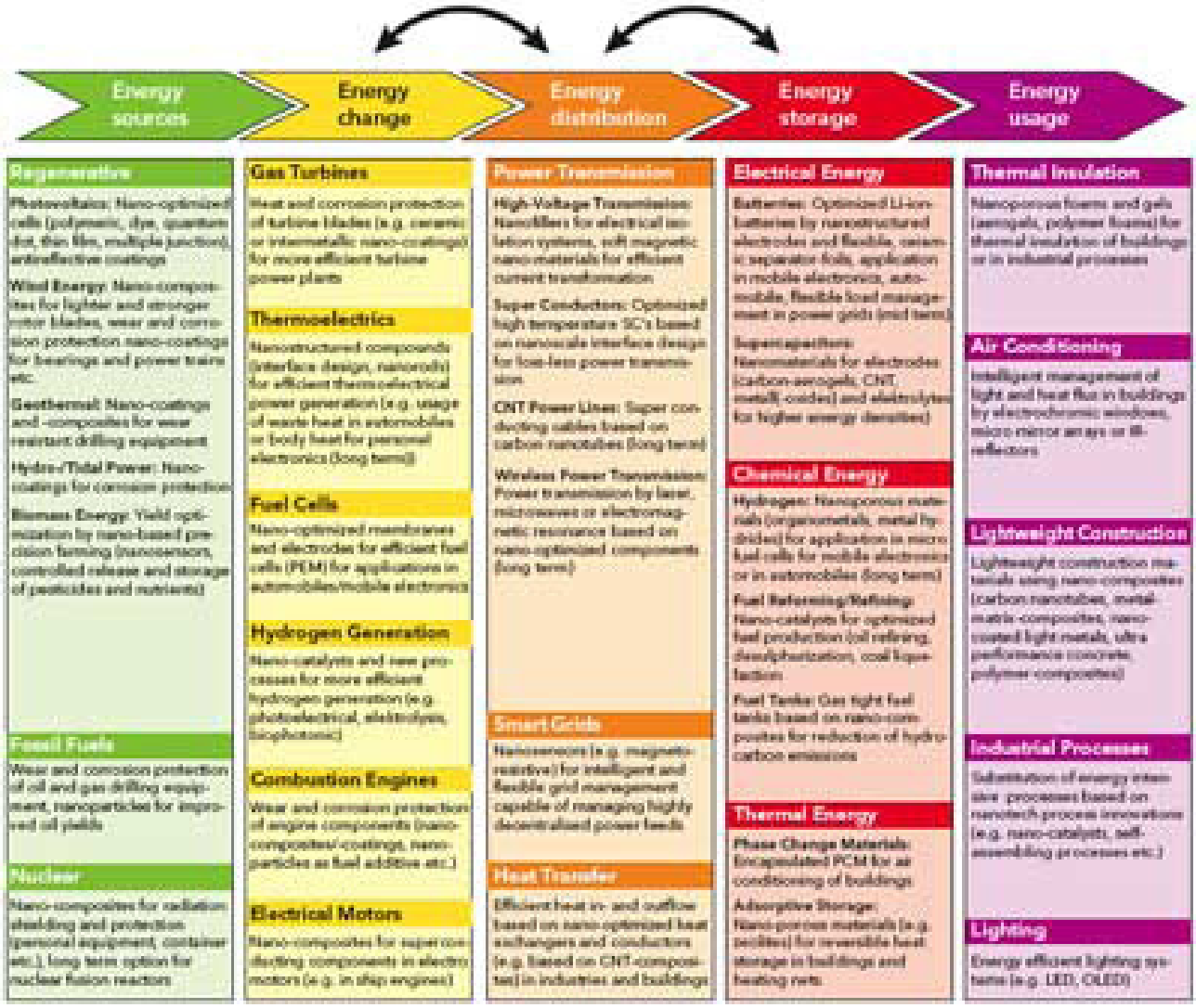

Fig. 5. Solar cells [8].

of nanomaterials contribute to the development of flexible and lightweight solar panels, which paves the way for new applications of solar energy. (Fig. 5).

In the field of energy storage, nanotechno-logy is making progress in improving the performance of batteries and supercapacitors. Cartograph and nanotube nanomaterials are being investigated to improve the conductivity and capacity of energy storage devices. This could lead to longer lasting and more efficient batteries for electric vehicles and grid energy storage, which would reduce dependence on fossil fuels.

Industry

Scientists have announced that they have developed a super-efficient alternative to fluorescent lights. The new lighting fixtures not only eliminate unpleasant flickering and noise, but also provide a more pleasant light and are

at least twice as efficient as compact fluorescent lamps. The new bulbs use FIPEL technology, based on a nanopolymer matrix that covers the inner side of the light bulbs. When charged, it emits white light with spectral characteristics like those of natural daylight.

Environmental protection

Despite the promising future of nanotechnology, we cannot ignore its harm to the environment. Improper use of some nanomaterials, such as carbon nanotubes and nanoparticles of some metals, may pose a risk to human health. Some nanoparticles with high surface reactivity can interact with biological systems, thus making them toxic. The potential toxicity of some nanomaterials is being actively investigated, such as by these studies, some nanoparticles can enter food chains through plants and affect different organisms.

Mining and processing to produce nanomaterials are very energy-intensive processes that can be hazardous to the environment. Because of this, the researchers develop safe ways of their synthesis, based on the principle of sustainability. This includes designing nanomaterials with minimal harm and understanding the potential risks.

The main concerns are that the production and use of nanomaterials in commercial products may have effects on human health and the environment. Some technologies already developed show so-called unintended consequences. Scientists have discovered that bacteriostatic silver nanoparticles used in socks to reduce odour are released when washed. Discharged into wastewater, they can destroy bacteria important to the ecosystem

The Organization for Economic Co-operation and Development has published a study on the benefits and risks of the application of nanotechnology in practice. The conclusions are that science, and industry must develop fundamental knowledge about the possible risks and develop necessary measures.

The indicated small part of the applications of nanotechnology is enough to prove the fact that they are changing people's lives and will be more frequently used in the future. Therefore, heading to this interdisciplinary field, young people will apply a complex of knowledge and contribute to the development of nanotechnology.

CONCLUSIONS

The research done on the application of nanotechnology enriches the students' knowledge and increases their natural science literacy. The information obtained is a step towards the formation of new competences in the field of chemistry. These can be supplemented and developed by those students who choose to study chemistry at higher universities.

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