**Lecture 10.**

**Some aspects of application of nanoparticles and nanodisperse systems. The basic directions of nanotechnological developments based on chemical properties of nanoparticle.**

There are a numerous and diverse aspects of the nanoparticles use in various branches of industry, agriculture, medicine and other spheres of human activity. The new directions of nanoparticle application are implementing constantly.

Features of use of nanoparticles according to Table 1 consist in:

- classification of industries associated with nanotechnology;

- presentation of nanoparticle features on the basis of their colloidal-chemical properties;

- innovative ideas about the role of nanoparticles.

Table 1 presented according to handbook of Zimon A.D., Pavlov A.N. “Colloid Chemistry of nanoparticles” [1] show the classification of applications of nanodisperse system relating to their colloidal chemical characteristics in an innovative way.

The areas and results of nanoparticle application are not limeted by data of Table 1. Since there are new practical results and field of applications of nanosystems published in considerable number today.

Table 1. – The general directions of nanotechnologies development on the basis of colloid-chemical properties of nanodispersed systems

|  |  |  |
| --- | --- | --- |
| Application area | Practical implementation | Properties of nanoparticles |
| 1 | 2 | 3 |
| Nanoelectronics | The miniaturization of the apparatus, nanoscale lasers, light-emitting diodes instead of incandescent lamps | The size effect, adhesion of nanoparticles, quantum effects |
| Transistors at the molecular level | Nanosynthesis |
| Microelectromechanical systems, combination of mechanical nanoelements, sensors and electronics based on silicon | Optical properties of nanoparticles |
|  | Microwave Electronics, Nanoscale heterostructures in radiolocation, | The size effect, adhesion of nanoparticles, quantum effects |
| communication systems |  |
| Laser technology, highly efficient lasers based on heterostructures with nanoscale layers | Surface tension of nanoparticles, surface properties of nanosystem. |
| Molecular Electronics | The use of nanoparticles as a unit cell, nanoparticles as objects of Colloid Chemistry |
| Quantum Computers | The size of circuit elements about 100 nm, size effect. |
| Medicine and pharmaceutics | Targeted delivery of medicines, genetic engineering, bactericidal preparations.  Improvement of diseases diagnosis,  transplantation of tissues and regenerative medicine nanoparticles, transportation possibility by various systems of the body. | Two-dimensional structure of nanoparticles, the excess of surface energy, synthesis of nanoparticles, size effect. |
| Nanotubes as a basis for drug delivery | Dimensions and structure of nanoparticles and nanotubes. |
| Chemical, food, processing industry | Reduction of friction. | Adhesion and friction. |
| Nanocatalysis in the oil and gas industry.  Use of wastes of food industry. | Dispersion, size effect of nanoparticles, catalytical properties. |
| Transparent nanofabric and coating with thickness 30 nm. | Dimensions and structure of nanoparticles and nanotubes. |
| Recycling,  development of products intensifying the recycling processes, creating products for biofertilizers. | Dispersion of waste. |
| High precision of surface treatment in a rocket and aircraft, the ability to control the size of the processed products to the nanometer scale. | Surface tension of nanoparticles, surface properties of nanosystem, mechanical properties, size effect. |
|  | Nanoadditives to lubricants, development of lubricants based on nanoparticles. | Surface properties of nanoparticles and their adhesion. |
| Construction materials | Creation of ultrastrong, elastic, plastic materials (alloys, ceramics, protective coatings). | Structural and mechanical properties of nanoparticles, strength, elasticity, plasticity, fluidity, hardness and parameters determining them. |
| Nanoparticles synthesis at the molecular level. | Preparation of synthetic nanoparticles with desirable properties. |
| Fabrication of nanofilms. | Compacting of nanoparticles, “bottom up” synthesis. |
| Nanoparticles dispersion in polymers. | The process of dispersion. |
| Thermal insulation materials | Highly porous materials capable to retain gaseous substances (air or other medium). | Features of structured nanosystems. |
| Reflection of light and other types of radiation. | Optical phenomena. |
| Fibrous materials | Nanofibres | Anti-ultraviolet rays, antibacterial action, resistance to moisture |
| Mechanical engineering and construction industry | Composites based on polymers, ceramics, matrix materials. | Heat-resistant, the power and magnetocapacitance materials with the inclusion of nanoparticles in a nanosized matrix, size effect. |
| Paints and films with the addition of nanoparticles. | Prevention of adhesion and contamination of surfaces, including biological overgrowth of the bottoms of ships. Waterproofing of the surface. |
|  | Nanocomponents, development of nanoscale gears, rotors, turbines. | Based on fullerenes and nanotubes. |
|  | Graphene as an open nanotube. Self-organization, strengthening of nanostructures. Foam structure based on nanoparticles. | Two-dimensional flat carbon tube, diffusion, viscosity. |
| Energetics, including nuclear power | Molecular electronics. The development of new types of energy - solar cells on Earth and in space. | Large specific surface area, the optical properties of nanoparticles. |
| Creation of engines at the molecular level. Intensification of processes in the nuclear industry. Increase in the level of nuclear fuel processing. | Fuel hydrogen elements - adsorption of hydrogen.  Diffusion enrichment of uranium.  Large specific surface area. |
| Ecology | Air and water purification, Environmental monitoring.  Membrane technology. | Nanoparticles in an aerosolized state as a way of monitoring the environment. |
| Nanofilters from graphite. | Large specific surface area. |
| Atmospheric monitoring. | Sensors based on nanoparticles. |
| Space, soldiery | Military outfit. | Anti-adhesive and non-wetted materials as personal protective equipment. |
| Creating of miniature robots. | Synthesis of nanomaterials. |
| Increasing the combustion rate and thrust of jet engines. | Nanoparticles increase the combustion rate due to the large specific surface area and the size effect |
| Bulletproof vests. | The addition of nanoparticles for strength increasing. |

As it is seen from the Table 19 the nanodevices and nanosystems possible for a variety of industrial, consumer, pharmaceutical, and biomedical applications. A variety of devices and products have been produced, and many of them are in commercial use.

Other applications of nanosystems include devices for Earth observation, space science, and missile defense applications, picosatellites for space applications, fuel cells, and many hydraulic, pneumatic, and being pursued for use in magnetic storage systems, where they are being developed for supercompact and ultrahigh-recording-density magnetic disk drives.

Nanoelectronic and mechanical systems (NEMS) are produced by nanomachining in a typical top-down approach and bottom-up approach, largely relying on nanochemistry. Examples of NEMS include microcantilevers with integrated sharp nanotips for scanning tunneling microscopy (STM) and atomic force microscopy (AFM), quantum corrals formed using STM by placing atoms one by one, AFM cantilever arrays for data storage, AFM tips for nanolithography, dip-pen lithography for printing molecules, nanowires, carbon nanotubes, quantum wires (QWRs), quantum boxes (QBs), quantum-dot transistors, nanotube-based sensors, biological (DNA) motors, molecular gears formed by attaching benzene molecules to the outer walls of carbon nanotubes, devices incorporating nm-thick films [e.g., in giant magnetoresistive (GMR) read/write magnetic heads and magnetic media] for magnetic rigid disk drives and magnetic tape drives, nanopatterned magnetic rigid disks, and nanoparticles (e.g., nanoparticles in magnetic tape substrates and magnetic particles in magnetic tape coatings).

Nanoelectronics can be used to build computer memory using individual molecules or nanotubes to store bits of information, molecular switches, molecular or nanotube transistors, nanotube flat-panel displays, nanotube integrated circuits, fast logic gates, switches, nanoscopic lasers, and nanotubes as electrodes in fuel

cells.

Bio nano- and microelectromechanical systems (BioNEMS/MEMS) are increasingly used in commercial and defense applications. They are used for chemical and biochemical analyses (biosensors) in medical diagnostics (e.g., DNA, RNA, proteins, cells, blood pressure and assays, and toxin identification), tissue engineering, and implantable pharmaceutical drug delivery.

BioNEMS/MEMS are also being developed for minimal invasive surgery, including endoscopic surgery, laser angioplasty, and microscopic surgery. Other applications include implantable drug-delivery devices (micro/nanoparticles with drug molecules encapsulated in functionalized shells for site-specific targeting applications) and a silicon capsule with a nanoporous membrane filled with drugs for long-term delivery.

Nanoscience and nanotechnology continue to move forward in production of nanodevices and nanocompounds are widely used in many spheres of industry such as agriculture, medicine, cosmetics, food industry, ecology and other fields of human activity.

Here we consider only some of them concerning to chemical properties of nanoparticles and nanodispersed systems. Obviously, there is an increasing need for a multidisciplinary, system-oriented approach to the manufacture of nanodevices. This can only be achieved through the cross-fertilization of ideas from different disciplines and the systematic flow of information and scientists. Therefore, there are many researches and publications devoted to the application of nanotechnologies.

**Revision questions:**

1. Provide some examples of nanotechnology use for solving everyday life challenges.

2. Give examples of nanoparticle implementations in areas such as nanoelectronics and construction materials.

4. What do you think about development of nanotechnologies in Kazakhstan and in the world?

5. Describe the possible dangers of nanosystems use?