Chapter

The Components of Functional Nanosystems and Nanostructures

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Abstract

The science of nanosystems is used in many fields such as medicine, biomedical, biotechnology, agriculture, environmental pollution control, cosmetics, optics, health, food, energy, textiles, automotive, communication technologies, agriculture, and electronics. Nanomaterials, nanostructures, and nanosystems have recently brought the most popular and innovative approaches to our lives. This new technology is based on the production of invisible particles and the production of new materials by controlling the atomic sequence of these particles. Nanotechnological studies are based on mimicking the principle of atomic sequence in nature. Using a combination of different disciplines, it finds application in almost every field of our lives. Nanospheres, nanorobots, biosensors, quantum dots, and biochips are the main components of nanoparticles. Many new diagnostic and treatment methods are being developed nano-dimensional.

Keywords: nanospheres, nanorobots, biochips, nanosensors, biosensors, quantum dots

1. Introduction

Nanotechnology systems are rapidly becoming widespread as a technology for minimizing environmental damage and making materials advantageous. Nanotechnology has made significant improvements many application areas such as methods of obtaining solar power, the search for obtaining nuclear energy needs from solar energy, propulsion of water brought to fabrics, soil resistance, wrinkle resistance, bacterial escape, protection from UV rays, burning resistance, design of quantum computers, design of DNA computers speed, the creation of hydrogen fuel cells, the design of light space vehicles, the production of nano goods, biomolecules analysis, smart packaging in food packaging, nanosensors, and biosensors in the rapid diagnosis of diseases. **Figure 1** shows the structure of nanosystems.

2. The nanosystem unit components

2.1 Nanospheres and nanorods

Matrices, which have a particle size of 10–100 nm and which are prepared with natural or synthetic polymers and where the active substance is trapped in the particle, are called nanospheres. **Figure 2** shows the structure of the nanospheres. Polymeric nanoparticles are divided into nanocapsules and nanospheres.

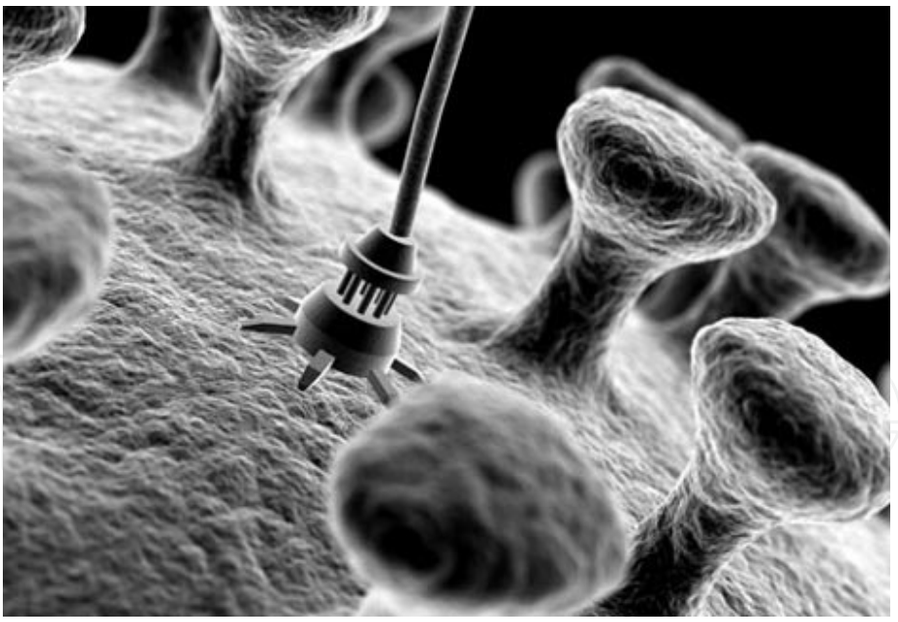

Figure 1.
Structure of nanosystems.

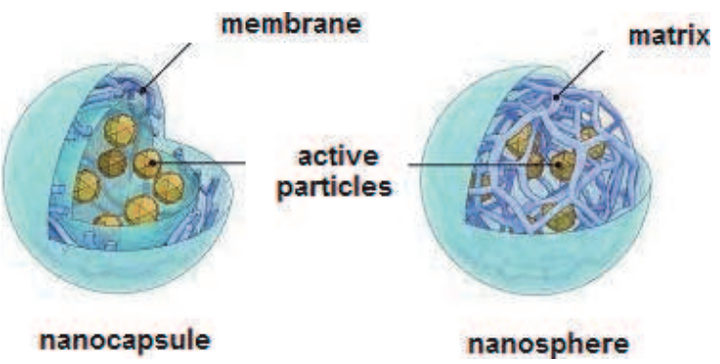

Figure 2.
The structure of nanospheres [1].

The nanospheres may be crystalline and amorphous. It is very advantageous because of its imprisonment, injection and dispersion properties [1].

Nanospheres have many advantages in their application areas. Nanospheres, especially in the field of medicine, can find a wide range of applications because they can easily pass through capillaries, penetrate tissue cavities easily, target organs, be formulated in a controlled manner, and reduce toxicity effects. Furthermore, due to the minimum particle size, they tend to agglomerate and form pellets and are challenging to obtain in liquid and solid forms. Nanospheres are obtained by polymerization, solvent displacement, salting out, controlled gelification, ionic gelation, solvent evaporation, and desolvation techniques [2–4] (**Figure 3**).

The nanorods are nanoscale materials that have unique optical properties like nanospheres. They are also expected to play an important role as both interconnects and functional units in fabricating electronic, optoelectronic, electrochemical and electromechanical nanodevices. Nanoscale materials such as fullerenes, nanorods, quantum dots and metallic nanoparticles have unique properties, because of their high surface area to volume ratio. Nanorods are used in many application fields such as dye solar cell, oligonucleotide detection, applied electric field and humidity sensitive. It should be recommended to synthesize nanorods in bulk in particular for biomedical fields. Nanorods are examined by extinction and scattering spectroscopy, DLS, TEM methods [5, 6]. Synthesis of gold nanorods has recently undergone dramatic improvements. It is possible to produce high yields of nearly

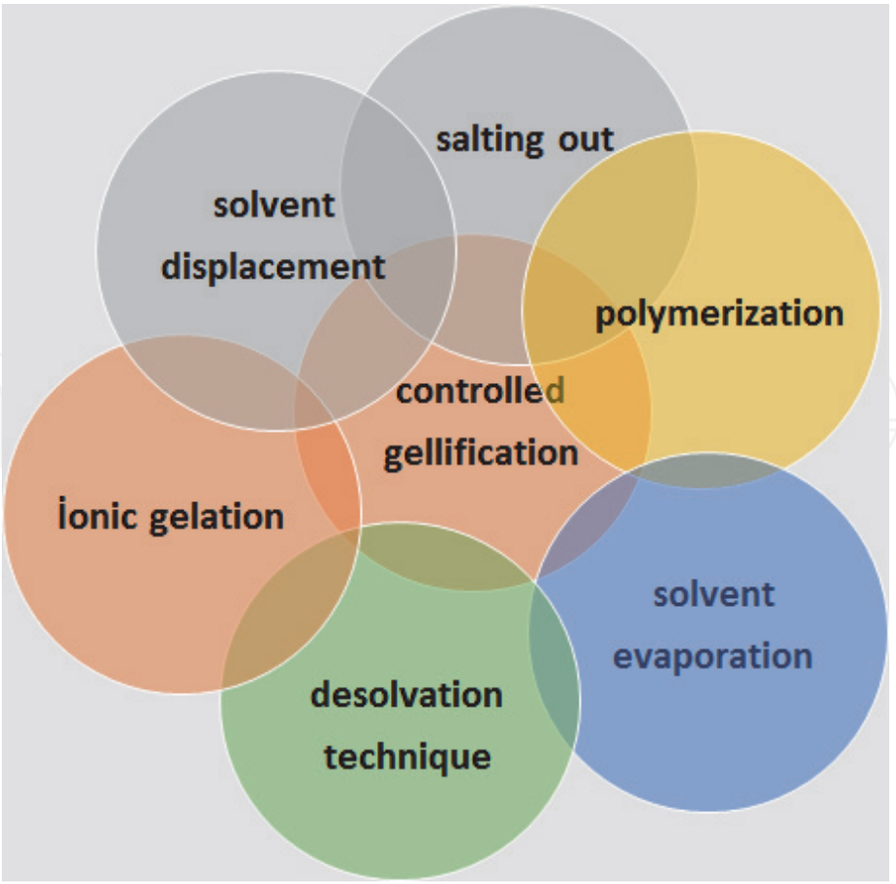

Figure 3.
The methods of obtaining nanospheres.

monodispersed short gold nanorods. The El-Sayed method of nanorod concentration determination is currently the standard way of measuring extinction coefficients (ε), and involves the coupling of bulk gold concentration, transmission electron microscopy (TEM) size analysis and absorbance data.

2.1.1 Polymerization

Emulsification polymerization is applied as a polymerization technique, and monomers are polymerized into nanospheres. Polymethylmethacrylate and poly cyanoacrylate polymers are among the most commonly used polymers for emulsification in the polymerization process. After polymerization, the active substance dissolves in the medium and is bonded with nanospheres or attached to the surface. The obtained material is purified, freeze-dried and the nanospheres are synthesized [7].

2.1.2 Ionic gelation

This method is based on the electrostatic interaction of the two aqueous phases and the nanospheres are prepared from natural polymers. Polyelectrolytes form hydrogel beads by cross-linking with counterions. These hydrogel beads are also called gelispheres. Gelispheres spreads into the polymer structure and forms a cross-linked cage. In this way, biomolecules can be trapped in this lattice structure. Examples of synthetic monomers and polymers used in this method include hydroxyethyl methacrylate, N-vinyl-2-pyrrolidone, N-isopropylacrylamide, vinyl acetate, acrylic acid, polyethylene glycol acrylate/methacrylate, polyethylene glycol diacrylate/dimethacrylate. Chitosan, gelatin, alginate fibrin, collagen, hyaluronic acid, dextran can be used as a natural polymer. Multivalent cations are generally

magnesium, sodium, calcium, potassium, ferric, aluminum, barium and zinc ions. In the experimental stage, polymer and electrolyte concentrations, pH, temperature and biomolecule concentrations are important parameters to be considered.

2.1.3 Salting out

This method is based on a salt interaction such as a polymer, organic solvent, and magnesium chloride hexahydrate or magnesium acetate tetrahydrate. An emulsification mechanism is performed. Salting out method is based on increasing hydrophobic effect as a result of electronic repulsion of dissolved anions with high-density loads. This resulting hydrophobic effect increases the uniformity of the water-soluble intermediate phase structure, reduces entropy and causes agglomeration of the solvent. This is because the presence of high-charge salts in the system decreases entropy by increasing the regularity between similar surfaces, this result is also desirable. Anions reducing water solubility; $OH^- \approx SO_4^{2-} \approx CO_3^{2-} > ClO_3^- \approx Cl^- \approx OAc^- \approx IO_3^- > Br^- \approx I^- > NO_3^-$ and the cations: $Na^+ > K^+ > Li^+ \approx Ba^{2+} \approx Rb^+ \approx Ca^{2+} \approx Co^{2+} \approx Mg^{2+} \approx Fe^{2+} \approx Zn^{2+} \approx Cs^+ \approx Mn^{2+} \approx Al^{3+} > NH4^+ > H^+$.

2.1.4 Controlled gelification

In this method, gelation is formed using calcium chloride and sodium alginate. A suitable mixture of these two compounds results in gelling. Poly-L-lysine is added to the resulting solution as a polymer and a polyelectrolyte mixture is formed by mixing. Subsequently, nanospheres are synthesized by centrifugation [8].

2.1.5 Solvent evaporation

This method is based on the principle of emulsifying the active substance in the polymer and an organic solvent and removing the solvent by reducing the temperature and pressure. In this method, polyvinylchloride or gelatin may be used as the emulsifying agent.

2.1.6 Solvent displacement

It is one of the most widely used methods for the synthesis of nanoparticles. The solvent displacement is based on the displacement of a semi-polar solvent with the polymer interface. In this method, the organic phase containing the active substance and the polymer structure in the aqueous phase is self-emulsified. The polymer and active ingredient are dissolved in an organic solvent such as water-miscible ethanol, methanol or acetone. The organic phase is injected into the aqueous phase containing the active ingredient. The nanospheres are synthesized by precipitating the polymer in which the organic phase is dispersed in the aqueous phase.

2.1.7 Desolvation technique

This method is particularly preferred for obtaining nanospheres from natural polymers. The active substance is added to the polymer and solvent, and crosslinking is performed. Crosslinking agents must be added to effect crosslinking. The suspension is lyophilized by centrifugation, and the nanospheres are synthesized [9].

The most common and advantageous method used in the synthesis of nanospheres is the solvent displacement method. This method will provide great advantages especially in controlled drug release systems. Nanospheres synthesized

by this method have more ability to convert poorly soluble and poorly absorbed drugs into better deliverables.

Particularly particle size and surface distribution properties are essential characteristic analyzes for the characterization of nanospheres. Because particle sizes and surface distributions also illuminate the properties of in vivo distribution, biological fate, toxicity and targeting ability. For the characterization of these properties, scanning electron microscopy (SEM), transmission electron microscopy (TEM), photon correlation spectroscopy methods are used. The Zeta potential analysis provides insightful information about load stability and particle collection. Zetasizer is used for this analysis. Fourier transform infrared spectroscopy (FTIR) analyses are performed to reveal the chemical bonding between the active substance and the polymers. The physical state of the active substance in the nanospheres is determined by differential scanning calorimetry (DSC) analysis after the lyophilization of the nanospheres. It can be applied many analysis methods such as in vitro drug release studies, drug release kinetics and stability study. Stability studies help to examine the effects of nanospheres on the physicochemical parameters of their formulations. In this way, suitable storage conditions are determined. Absorption and storage at room temperatures are performed for approximately 6 months and the observed changes in physicochemical parameters are recorded. Appropriate storage conditions are determined according to the results obtained. **Table 1** shows the intended use of the nanospheres synthesized according to the literature. **Figure 4** schematizes the synthesized gold nanospheres.

Nanospheres are used effectively in controlled drug delivery systems, tumor-targeted treatment methods, tumor-targeted treatment methods, epithelial cell therapy, genetic engineering studies, treatment methods targeting blood–brain barriers, cosmetics and many other areas [1].

2.2 Quantum dots

Quantum mechanics is the starting point of nanotechnology. These nano-sized semiconductor crystals are called quantum dots. Quantum dots are giant atomic structures that contain thousands of atoms. When substances are nano-sized, they

Purpose of usage	Nanospheres	References
Enhanced lithium storage properties	Ultra-small $ZnFe_2O_4$ nanosphere	[10]
Hydrogen production and photocatalytic activity	High specific surface area TiO_2 nanosphere	[11]
For lithium-ion batteries	Pyrite/carbon nanospheres	[12]
For sensing trace cysteine in HeLa cells	Gold-silver nanospheres	[13]
Water treatment and improved lubricating performance	Alkyl-capped copper oxide nanospheres	[14]
For PSA detection	Polydopamine nanospheres loaded with L-cysteine-coated cadmium sulfide quantum dots	[15]
For application in water treatment	MoO_3 nanospheres	[16]
For high-performance supercapacitors	CuS nanospheres	[17]

Table 1.
Some examples of nanospheres, according to the literature.

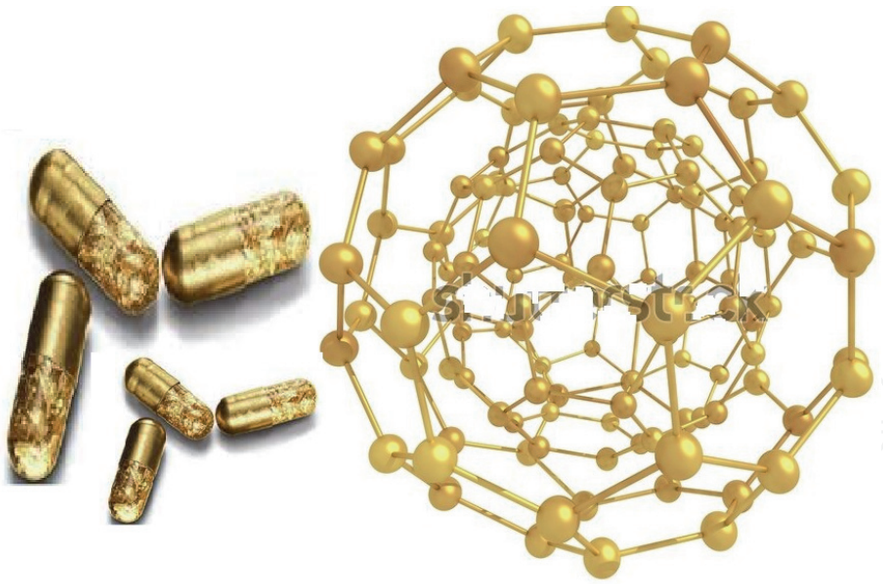

Figure 4.
The cancer treatment with gold nanospheres.

act according to quantum laws. The most preferred quantum points due to their semiconductivity, optical, and electrical properties are CdSe, InAs, CdS, GaN, InGeAS, CdTe, PbS, PbSe, ZnS. The controllable size of the quantum dots leads to outstanding optical and electrical properties, as the size of the quantum dots changes, the wavelength and color of their radiation changes. Quantum points are revealed by the stimulation of electrons [18, 19].

Quantum dots can be synthesized using methods such as plasma synthesis, viral coupling, bulk production, colloidal synthesis, fabrication, electrochemical coupling, and massive metal-free production. The parameters such as dimensions of quantum points, amount of solvent, amount of solution, amount of semiconductor metal, pH, and temperature are significant in the synthesis stage. **Figure 5** shows the wavelengths of quantum dots.

2.2.1 Fabrication

This method involves two different approaches, bottom-up and top-down. In the top-down method, small particles are formed by lithography. **Figure 6** shows quantum dots fabrication process.

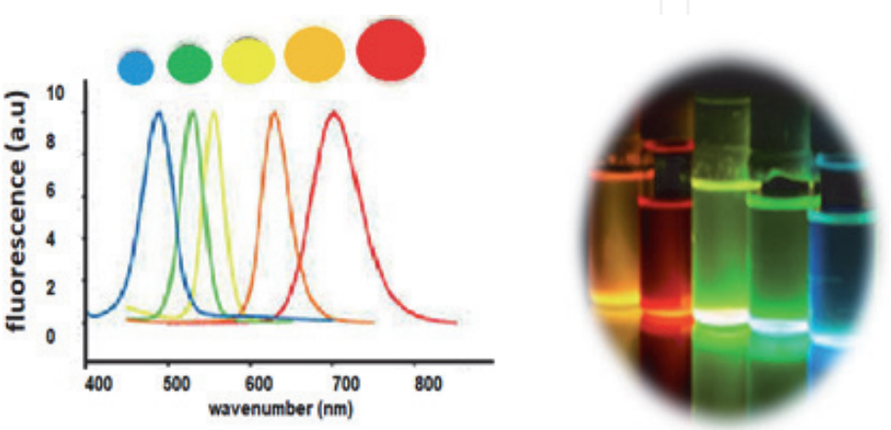

Figure 5.
The wavelengths of quantum dots [18].

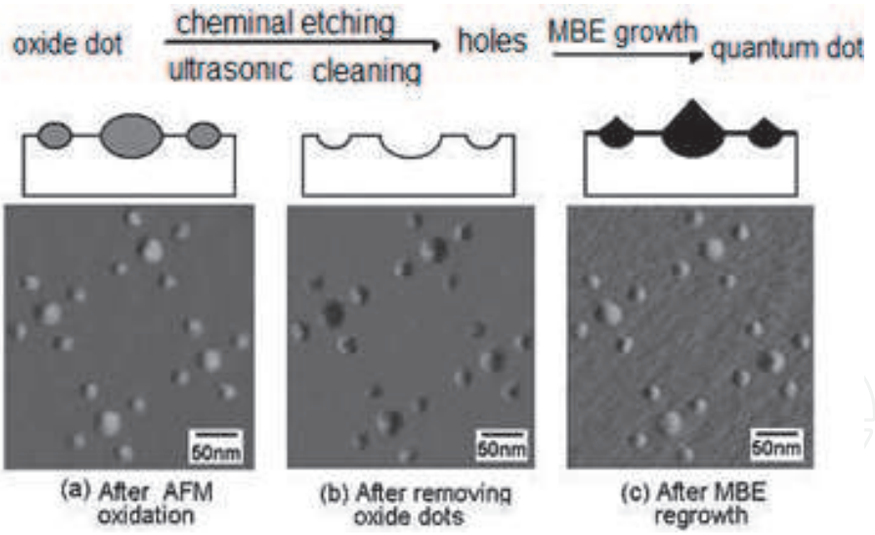

Figure 6.
Quantum dots fabrication process. (a) After AFM oxidation. (b) After removing oxide dots. (c) After MBE regrowth.

2.2.2 Colloidal synthesis

Colloidal synthesis is a practical synthesis technique where quantum dots can be synthesized easily under laboratory conditions. They consist of three main components: precursors, organic surfactants, and solvents.

2.2.3 Electrochemical coupling

Electrochemical coupling is a technique in which quantum dots can form spontaneously regularly. As a result of the ionic reaction at the electrolyte-metal interface, the nanostructures spontaneously form on the metal.

In the field of medicine, positron emission tomography and single-photon emission computed tomography are used in nuclear imaging systems, especially in the diagnosis of cancer diseases. Quantum dots can also be used in many engineering branches such as more efficient solar panels, bio-agents used for diagnostic purposes in medicine, low-energy lasers, LED lights of the desired color, low-energy, and more-lit bulbs, low-energy plasma televisions and displays. **Figure 7** shows the visualization of the quantum dots under UV light to detect different tumor cells by the addition of bioagents. Biological applications of quantum dots are examples of DNA protein sensors, sugar sensors, immunoassays, live cell imaging, bio-sensing, in vitro imaging, biological imaging, single molecule tracking, in vivo and animal

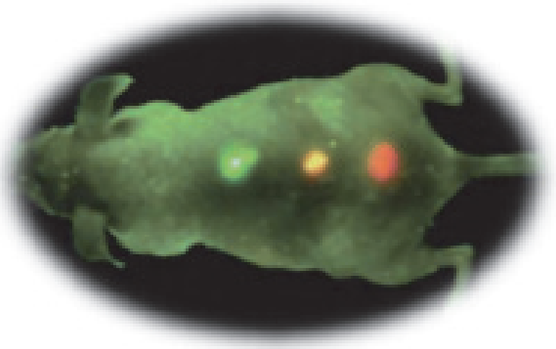

Figure 7.
Visualization of the quantum dots under UV light to detect different tumor cells by the addition of bioagents [19].

imaging. UV-vis and photoluminescence spectroscopy are generally used for characterization of quantum dots. Thanks to these methods, it is possible to perform fast, undamaged and contactless characterization. The use of photomodulated reflectance spectroscopy, an experimental method, offers a wide range of critical point advantages. The optical properties of quantum dots can be controlled by the dimensions of the dots. The size of the quantum dots can be characterized by scanning electron microscopy (SEM), transmission electron microscopy (TEM), and dynamic light scattering (DLS). Optical activity properties and particle sizes of quantum dots can be measured by photoluminescence excitation and Raman scattering spectroscopy. Atomic force microscopy (AFM), scanning tunneling microscopy (STM) and transmission electron microscopy (TEM) analysis methods are used to display the particle sizes. However, the best analysis results are obtained with AFM and TEM analysis methods.

3. Nanodevices and the complex nanostructures used in nanodevices

3.1 Nanorobotics

In order to develop nanorobots, firstly, the nanoparticles must be accurately and adequately analyzed, and the atomic arrays must be designed correctly. The essential components of nanorobots are nanocomputer. Especially in the field of health, it is vital for the rapid and accurate diagnosis and monitoring of diseases. In recent years, the need for diagnosis and treatment of cancer diseases, which is rapidly becoming widespread day by day, has significantly increased. Besides, there is an increasing need for nanorobots in environmental engineering, food technologies, gene therapy, machine design, military, and space science (**Figure 8**).

3.1.1 Biochips

As a product of the physical and biological sciences, biochips provide molecular analysis with high efficiency. Especially in gene engineering, biology, and medicine, biochips that do wonders in early diagnosis of diseases also enable gene sequencing, pharmacology and toxicology, analysis of DNA/RNA strands, and accurate identification of proteins. The most current studies are the determination of gene expression between human cells and tissue. In this way, global gene expression analysis is highly illuminating in the early detection of tumors in the living body. Application areas of biochips can be listed as a diagnostic tool in clinical medicine, quantifying

Figure 8.
The nanorobotics.

biomolecules, develop polymorphism analysis, cancer, rapid diagnostic testing, identifying, biowarfare agents [20].

Biochips provide great convenience in early and accurate diagnosis of diseases by reducing the detection time of protein sequences to less than 15 min and reducing the analysis time of nucleic acid sequences to less than 2 h. Especially in the food industry, DNA amplification of the genes of the target pathogen allows for rapid and accurate identification of pathogens. Biopharmaceuticals are also needed to identify mutations related to rifampin resistance in mycobacteria (RIF). Biochips are intended to be used to create a giant database for the narration of living and occurring events in the world soon. Biochips that can predict the health history of a person who is injured, sick or exposed to an accident, and that can give information about the food microbiota and nutritional values at every stage of food safety technologies from food production to consumption, and that can make diagnosis of diseases such as blood pressure and high blood sugar will be synthesized in the nearest future.

3.2 Nanosensors

Nanosensors are a combination of chemical, biological, and surgical sciences used to deliver nanoparticles to the world macroscopically. Nanosystems such as porous silicon, nanoparticles, nanoprobes, nanowires, nanotubes are widely used in the design of nanosensors. Examples of nanoparticles used in the design of nanosystems are MNPs magnetic nanoparticles, AuNPs gold nanoparticles, upconversion nanoparticles, QDs quantum dots, SWNTs single-wall carbon nanotubes, MWNTs multiwall carbon nanotubes, nano barcode technology and electronic nose [21]. These devices are tiny devices that can detect and respond to physical stimuli such as biological and chemical substances, displacement, motion, force, mass, acoustic, thermal and electromagnetic. In the literature studies, many nanosensors were synthesized for different purposes (**Table 2**).

Purpose of usage	Nanosensors	References
Detection of ochratoxin for real-time display of arsenic (As^{3+}) dynamics in living cells	Black phosphorene nanosensor (FRET)-based nanosensor	[22, 23]
Near-infrared imaging of serotonin release from cells	Fluorescent nanosensors	[24]
For improved dialysis treatment	microfuidic DNA-based potassium nanosensors	[25]
Development of ethanol and acetone gas sensing performance	$MgCO_2O_4$ nanosensor	[26]
Anticancer drug	SPR nanosensor	[27]
Detection of mercury ions	Multimodal nanosensor	[28]
Detection of serum albumin	Copolymer nanosensor	[29]
Detection of cysteine	Colorimetric nanosensor	[30]
Detection of cadmium ions	Quantum dots based-fluorescence nanosensörler	[31]
Emerging strategies	AuNP-based ICTS nanosensor	[32]
Detection of curcumin	Carbon-based chem nanosensor	[33]

Table 2.
Some examples of nanosensors, according to the literature.

Figure 9 shows the different uses of areas of nanosensors. The features to be considered in the design of nanosensors are selectivity, calibration requirement, reproducibility, stability, high sensitivity, wide measuring range, service life, the limit of determination, and sterilization (**Figure 10**).

Nanosensors consist of transducers and nanoparticles. Nanosensors can be designed as amperometric, voltammetric, potentiometric, colorimetric, SPR, fluorescence, optical fiber, SERS, acoustic and pieozoelectric transducer. Metallic, magnetic, quantum dots, graphene oxide, carbon nanotubes and upconversion nanoparticles are commonly used in nanosensors.

Xiang et al. [22] designed black phosphorene nanosensors for voltammetric analysis of ochratoxins. As known, ochratoxins have been identified as immunotoxic, nephrotoxic and carcinogenic in humans by the International Agency for Research on Cancer (IARC). Therefore, rapid and precise measurements are needed to determine whether ochratoxins are above the limit values in food components. Black phosphenes (BP) are widely used in the design of nanosensors because of their precise measurement capabilities. However, black phosphenes are highly reactive to water and oxygen, so they are easily affected by ambient conditions, so they lose their stable structure. In order to prevent this problem, the stability of BPs with covalent aryl diazonium, ligand surface coordination and coating materials is increased. The interaction of Ag^{+} ions and BPs in the N-methyl pyrrolidone (NMP) environment increases the super electrochemical properties considerably.

Soleja et al. [23] devised fluorescence resonance energy transfer (FRET) based nanosensors to detect arsenic metal and to determine its concentration. As it is known, arsenic is a toxic and heavy metal that has a carcinogenic effect and can cause serious health problems. Therefore, it is necessary to determine the concentration values accumulated in the living organism easily. The transcriptional repressor Arsr of the ars has an affinity for As^{3+} and the arsenic ions are thus more

Figure 9.
Different uses areas of nanosensors.

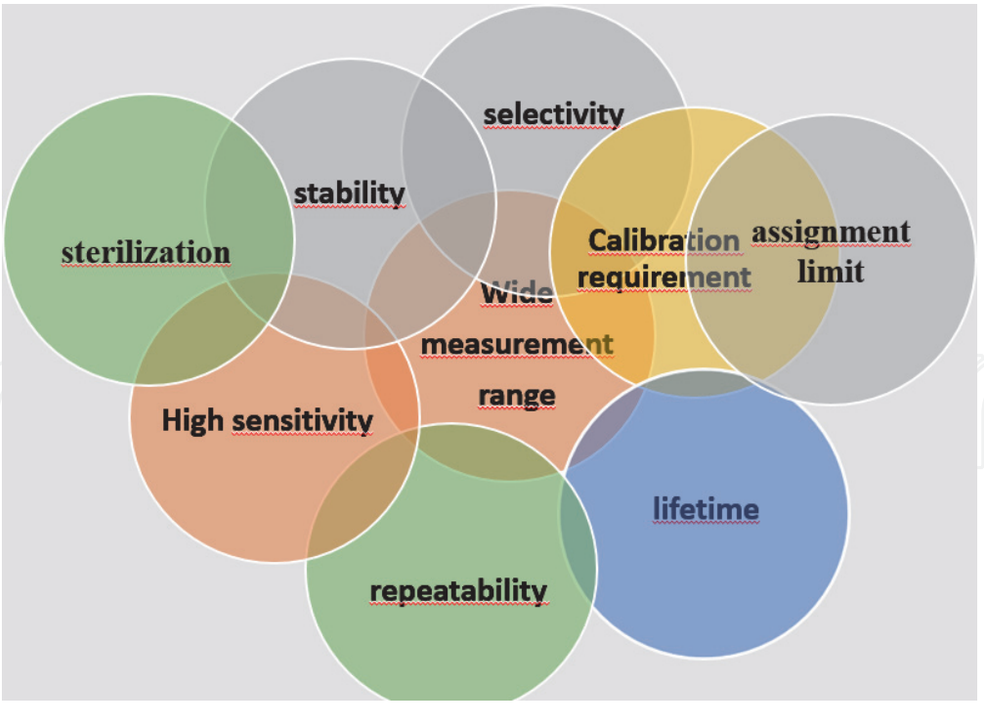

Figure 10.
The important properties of nanosensors.

easily bound. This process makes it possible to develop fluorescence resonance energy transfer (FRET) based nanosensors. The donor and acceptor perform ArsR binding with arsenic at the N- and C-terminus to obtain a recombinant protein.

Fluorescence sensors technology enables sensitive and non-destructive detection of signals in food additives and metal ions to detect environmental contamination. Fluorescence sensors have two important units: receptor and signal. As the target analyte concentrations are usually low, specific recognition for receptors is of great importance. Enzymes, aptamers and natural receptors, as well as artificial polymeric receptors or molecularly imprinted polymers, are used as receptors. Molecularly imprinted polymers are cross-linked polymers containing voids specific to analytes. These gaps support high selectivity. Comparing molecularly imprinted polymers and natural receptors, it is concluded that molecularly imprinted polymers show high chemical and physical stability, low cost and easy preparation properties. In fluorescence signal units, quantum dots, metal nanoclusters and organic dyes are often preferred as fluorescence sensors components.

Luo et al. [34] detected *E. coli* bacteria in milk by using radial flow chromatographic immunoassay (RFCI) method using gold nanoparticles as a chromatic agent. Hunter et al. [35] synthesized nanobiosensors to quickly detect pathogenic bacteria in serum with the optofluidic (surface-enhanced Raman scattering) SERS method. In this study, a hollow core photonic crystal fiber filled with microfluidics was used as the main converter. This system can be repeatedly renewed by washing with a liquid that can dissolve the analyte. The use of silver nanoparticles greatly strengthened the measuring ability of the system.

It can be said that the use of silver and gold nanoparticles in synthesized nanosensors gives very positive results in parameters such as measurement performance, sensitivity and selectivity.

Molecularly imprinted polymer receptor fluorescent sensors have several disadvantages, although they have many advantages in biology, environmental chemistry, food technology, food packaging, microbiology, pharmacology and medicine. For example, it is, unfortunately, possible to mention environmental harm properties for quantum dots in the presence of heavy metals.

3.3 Biosensors

Biosensors are formed as a result of combining the receptor and transformer components. Receptors have a biomolecular structure. Physical signals are measured by combining selectively interacting analytes, biological sensors (enzymes, antibodies, immuno-agents, nucleic acids, microorganisms, cells, tissues), and physicochemical transducers (electrodes, transistors, thermistors, optical fibers, piezoelectric crystals). Electrical signals are obtained from these measured physical signals [36]. The working principles of biosensors are based on this basis. **Figure 11** schematizes biosensors. **Table 3** summarizes the literature studies.

There are some crucial advantages of using nanotechnology in the construction of biosensors. Nanoelectronic particles increase the memory and processing capabilities of biosensors and facilitate analysis. Besides, it facilitates the identification of microorganisms, provides high selectivity and long life. It also offers the possibility to work without damaging living cells [36]. **Table 3** shows the use of some biosensors according to the literature. **Figure 12** shows some examples of biosensor technology.

Liang et al. [37] synthesized biosensors for the detection of hydrogen peroxide using carbonization with graphene nanoplates derived from ficus fruits. As is known, hydrogen peroxide is an intermediate commonly used in biological test steps, clinical diagnoses, enzymatic and many other chemical reaction environments. Since it is used so often, it is of great importance to quantitatively analyze hydrogen peroxide. It is usually analyzed by colorimetric, photochemical and electrochemical techniques. The most advantageous technique among these techniques is the electrochemical technique. Because electrochemical techniques allow fast, cheap and real-time measurements. The carbon sources are commonly used as active substances in many kinds of research.

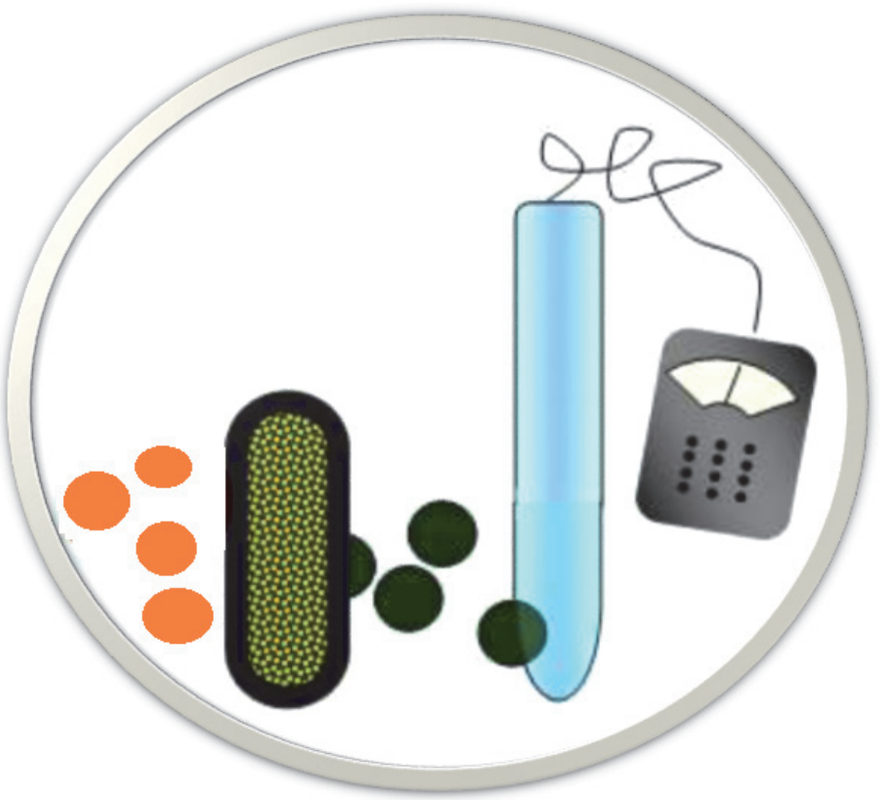

Figure 11.
Schematic representation of biosensors.

Purpose of usage	Biosensors	References
For the detection of single-nucleotide variant	Biosensor based on triplex DNA-templated Ag/Pt nanoclusters	[38]
Green synthesis of porous graphene-like nanosheets	High-sensitivity nonenzymatic hydrogen peroxide biosensor	[37]
Detection of single nucleotide polymorphism of tumor	Gold probe with lateral flow strip biosensor	[39]
For simultaneous imaging of P53 and P21 mRNA in living cells	An RGONS-based biosensor	[40]
Detection of lysozyme	Aptamer-based electrochemical biosensors	[41]
Detection of arsenic and mercury	Metallothionein-based biosensor	[42]
Detection of malachite green	Free microcantilever based biosensor	[43]
Refractive index sensor	A single-layer guided-mode resonant optical biosensor	[44]
The determination of 3-methylquinoxaline-2-carboxylic acid	Surface plasmon resonance biosensor	[45]
Detection of escherichia coli	Label-free amperometric biosensor	[46]
Electrochemical detection of the human cancer biomarker	Autocrine motility factor-phosphoglucose isomerase' based on a biosensor	[47]
Naked-eye detection of aflatoxin b1	Label-free colorimetric biosensor	[48]

Table 3.
Some examples of biosensors according to the literature.

Figure 12.
Some examples of biosensor technology.

Ma et al. [39] synthesized gold probe-based strip biosensors to diagnose liver cancer tumors. Liver cancer is the most common type of cancer in the world and is highly affected by environmental and genetic factors. Early diagnosis is vital because in some cases the patient may lose his liver only a few months after being diagnosed. In this literature study, single nucleotide polymorphism (SNP) was used as a genetic marker for gene diagnosis of the disease. Thanks to the colloidal gold strip nanoparticles, the SNP diagnosis makes exceptionally accurate diagnoses in just a few minutes. Colloidal gold strips are of great interest in the environment, food safety and medicine as they offer a fast, precise, high selectivity and inexpensive method.

Fana et al. [40] also synthesized reduced graphene oxide-based biosensors to diagnose liver cancer. Graphene oxides are preferred as nanoparticles due to their electronic, mechanical and thermal stability. However, in-vitro assays should be kept in limited amounts for use in living cells due to their toxic effects.

Khan et al. [41] synthesized aptamer-based electrochemical biosensors for lysozyme determination. These biosensors are electronic and disposable biosensors. They used the inkjet-printing method for the detection of lysozyme which is a biomarker in the diagnosis of diseases. Carbon nanotubes and the single-stranded DNA were used for aptamer immobilization on the electrode. Thus, inks containing a mixture of carbon nanotube-aptamer complexes were synthesized. Generally, the main reasons for the use of aptamers in biosensor syntheses are resistance to environmental conditions, thermal and chemical stability, and increasing the binding efficiency. In addition to these advantages, it is possible to synthesize inexpensive biosensors, have a long shelf life and can be reproduced.

Zhong et al. [49] synthesized fluorescence biosensor to detect *Pseudomonas aeruginosa* bacteria in food products. They performed the synthesis step using the copolymer points of dual-aptamer-labeled polydopamine-polyethyleneimine. According to the study of this article, it is seen that dual-aptamer biosensors enable more sensitive and accurate measurements than single-aptamer biosensors. Therefore, it has been concluded that the use of dual-aptamer-labeled polydopamine-polyethyleneimine copolymer points can be used in different alternative methods. Zhang et al. [50] synthesized colorimetric sensors for the detection of *Escherichia coli* and *Staphylococcus aureus* bacteria. It is based on the principle of separating and detecting bacteria from the medium using aptamer-based magnetic beads. Quantitative measurements of the growth kinetics of bacteria were measured by measuring the conductivity changes occurring in the environment depending on time. However, it was emphasized that the synthesized biosensor should be supported with different methods in sensitivity measurements. For this, methods such as changes in analyte volume and prolongation of incubation are recommended. Li et al. [51] used multiple amplification reactions and electrochemical methods to detect *E. coli* bacteria. First, the target sequences extracted from *E. coli* O157: H7 were converted to executive DNA and amplified. Next, a large number of transformed nucleic acid sequences were amplified by the RCA reaction. Then, DNA sequences were immobilized and electrochemical signals were measured with the help of electrochemical indicators. As a result, it is suggested that more effective results can be obtained in detecting pathogenic bacteria in living organism by developing multiple amplification methods.

Zhan et al. [52], synthesized aptasensors with the amplification method for the colorimetric detection of *Listeria monocytogenes*. In this study, enzyme dependent aptasensors were developed by rotary circle amplification (ELARCA) analysis. The study is based on the selectivity race between an aptamer specific for the bacteria of the *Listeria monocytogenes* and the biotin probe and the RCA probe. Adding bacteria to the environment prepares the medium suitable for the RCA probe, which starts the RCA process (rolling circle amplification), and causes the biotin probe to be exposed. In the presence of RCA buffer, multiple DNA copies are formed by binding to the biotin probe. In the presence of the enzyme substrate in the medium, (horse radish peroxidase), the chromophore group produced by HRP enables colorimetric measurement analysis.

As a result, it is thought that the determination of more specific aptamers for bacteria may be more developer for measurement accuracy and accuracy in the study that allows successful measurements.

4. Conclusion

Nanosystems and nanoparticles are based on the foundations of quantum physics that upset the laws of classical physics. Quantum mechanics makes it possible

that nano-sized particles can be given unique and extraordinary abilities. This new technology is pushing dreams together and even promises to go beyond the borders of a futuristic imagination. Nanotechnology, which opens the door to extraordinary innovations in many engineering applications and medicine, brings many definitions such as nanoparticles, quantum dots, nanosensors, biosensors, nanospheres and nanorobots to our lives. The toxicities of quantum dots are very important for in-vivo experiments in agricultural applications. The best way to solve this problem is to secure it by bioconjugating it with coatings, proteins and peptides to protect and stabilize the surface of quantum dots. In addition, the choice of rounded quantum dots called colloidal in biosensing solutions can prevent possible problems. Using a non-toxic titanium dioxide compound can also solve the toxicity problem in in vitro applications.

Biological recognition systems connected to a transducer are effective in the specificity and selectivity of biosensors. Therefore, the most important part in a biosensor mechanism is bioreceptor synthesis. In the literature searches, biosensors for the detection of many diseases, viruses and bacteria were synthesized. However, in the applied methods, dual-aptamer biosensors generally give more precise and accurate measurements than single-aptamers. Multiple amplification reactions with fluorescence, colorimetric or electrochemical methods give better results. The more specific aptamers are used, the greater the measurement accuracy. The use of silver and gold nanoparticles in biosensor synthesis greatly increases the measuring ability of the system. Therefore, the repeatability properties of the probes will also be supported. In addition, metal organic framework compounds greatly increase the measuring ability due to their large surface areas, especially in the modification of electrodes for biosensor synthesis based on the measurement of electrochemical signals.

Even though this new technology enables rapid, inexpensive, reliable, reproducible, high-precision measurement, diagnosis and analysis in many scientific fields, the studies to be carried out in this field in the coming years will provide meaningful grounds for solving existing problems or developing more advanced technologies. It should be noted that nanotechnological systems have a significant effect on polymers. Because polymers enable easy sterilization of synthesized nanoparticles. It also increases the loading capacity of the active substance and allows the synthesis of non-toxic particles, which can be degraded and decomposed in a physiological environment. Thanks to these advantages, it supports controlled release systems and bioavailability. It makes the world of the future a candidate for the dream of the future.

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