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Fabrication of nanomaterials using nanotechnology and biotechnology

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Abstract

Nanobiotechnology, Bio nanotechnology and Nano biology these are all emerging progressive technological fields which are originated by the collaboration of two research-oriented fields i.e. Biotechnology and Nanotechnology. Now a days a lot of new research are being conducted to develop more advanced devices for molecular biological purposes which are used to perform more sensitive and highly accurate diagnosis. So, there is an interference between Biotechnology and Nanotechnology which have potential for such tremendous discoveries. In following review article that interface between these two fields is drawn which describes about the subfields of these two fields and areas of their implication. In Addition, a brief overview is also discussed about how nanomaterials are fabricated using different economic methods.

Introduction

In modern era, every biologist is familiar with the term Biotechnology as it covers a wide area of biology including genetic engineering, genomics, applied immunology and numerous pharma therapies and diagnosis, which deals with biological systems and organisms to make valuable products to serve the humanity[1]. The basic concepts behind the Biotechnology are to deal with living objects, modify these entities in sake of human benefits. Biotechnology has enormous domains depends on fields as molecular biology, cell biology, biochemistry and genetics. Bioengineering is also lies under the broad range of biotechnology as in bioengineering, basic principles of engineering are applied on living cells, tissues and organisms (pharma engineering, tissue culture engineering and genetic engineering) [2].

Nanotechnology is known as the manipulation of matter at an atomic level with at least one-dimensional size ranges between 1 to 100 nanometers. Nanotechnology is a field comprising on organic chemistry, surface science, energy storage and microfabrication. Nanotechnology has helped to control mater at nanometer scale which enhanced the efficiency [3].

Future implications of nanotechnology may include creation of many new devices and materials which are more efficient as compared to classic ones. Nano electronics, nanomedicine, consumer products and biomaterials energy production are futuristic goals of nanotechnology [4]. Similar to other emerging fields, nanotechnology might have some issues including toxicity and environmental hazards however not yet proved. Hence, nanotechnology has to prove more economic potential as compare to other emerging technologies [3].

Biotechnology and nanotechnology have the potential to take the whole World into a new era of technology. Many collaborating fields of nanotechnology and biotechnology have been introduced to get more efficient results [5]. Many subfields like Bio nanotechnology, Nano biotechnology and nanotechnology are introduced recently which are employing the collaboration of both the techniques. Various logical results are reported by applying these subfields [6].

In this review, an interface between Biotechnology and Nanotechnology has been summarized as the number of emerging research fields and new applications are being applied by the collaboration of both the fields. The applications of Nano biotechnology are also being discussed in this review and the applications of nanotechnology to get more efficient biological products by applying more accurate procedures which are more sensitive than classic ones. Lab-On-a-Chip technology is being used for more accurate and sensitive diagnosis. Similarly, Nano sensors and Point-of-Care diagnosis are also being used which works upon the principles of Nano biotechnology. As Nanomaterials have much interest to be used in different industries and also in Biotechnological experimentations. Different approaches are being used for this purpose [7-9].

Interface between Biotechnology and Nanotechnology

There are a number of research fields in the interference between Biotechnology and Nanotechnology which are being applied and many applications of these subfields are useful in industry as well as health sectors (**Fig. 1**) [10].

Nanobiotechnology

Nanobiotechnology is a merging field lies between the interference of Nanotechnology and Biotechnology having Nano technological principles and techniques applied in biotechnology. Nanomaterials are being used to grow artificial organs outside the living organisms and transplanted in the body. The cultured bladders are transplanted in three American patients and studies were being conducted to culture the artificial uterus outside the body. In addition, metabolite detection studies were also reported by using Nano biotechnological based Nano spheres coated with fluorescent polymers. The diagnosis and treatment of diseases at nanometer scale as Nano Biotech Pharma have done successful treatment against Nano bacteria [11].

Nanobiotechnology is an interdisciplinary field as it is a combining edge of chemical properties, physical principles and biological parameters. Nanobiotechnology is offering new tools to biology for advanced diagnosis and treatments.

Bio nanotechnology

DNA nanotechnology is used to compose valuable materials of DNA. The synthetic membranes are being synthesized using the properties of the biological membranes. The programmable nanomaterials are being synthesized following

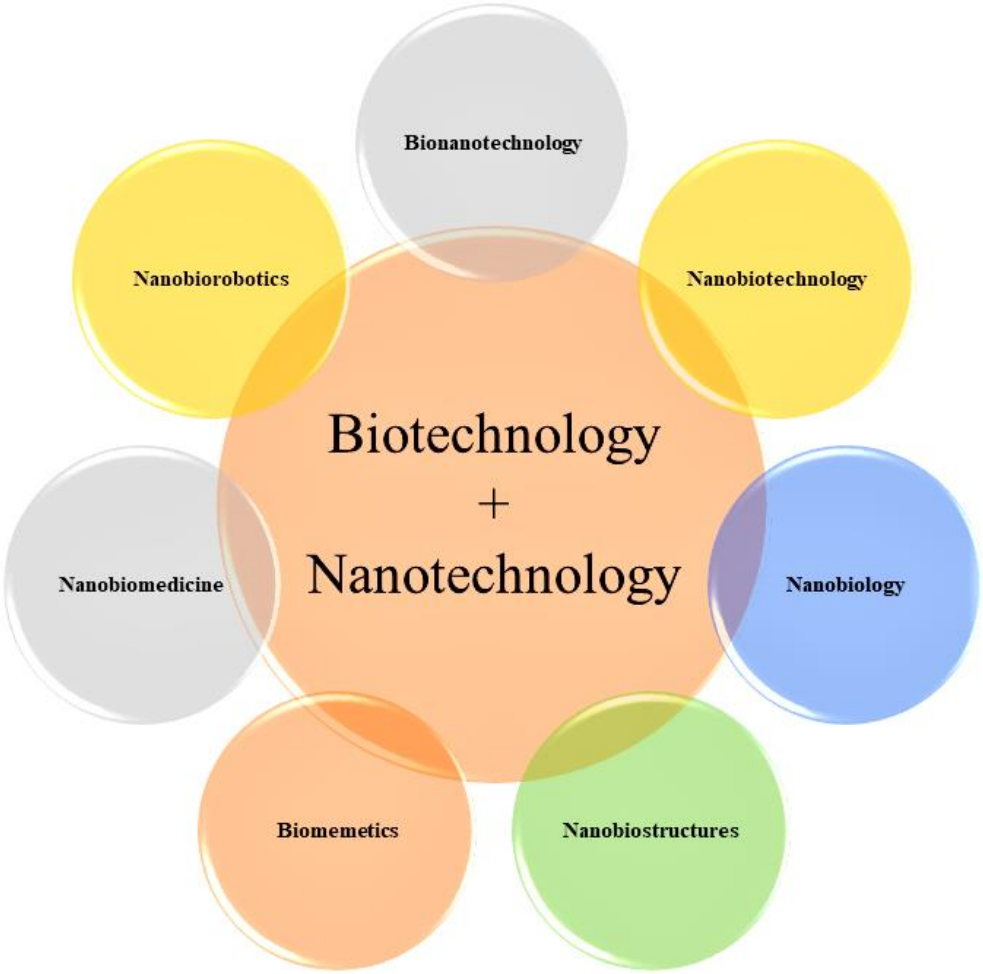

Fig. 1: Subfields of the collaboration between Nano and Biotechnology, explaining the interference of both the fields

principles of self-assembling proteins. The protein models themselves into specific supramolecular configurations. Another example for Bio nanotechnology applications is the development of amyloids-based nanomaterials which can be programmed according to different properties. Lipid nanotechnology is also an interface between both the fields [12-14].

Nanobiology

Nanobiology lies on the intersecting edge of Biology and nanotechnology. In this research area, Nano tools are being applied in biological processes and Biosystems. Many new BioNanotools are being devised in using Nano biology approach such as peptide Nano sheets and programmable biological membranes. Number of areas is known where applications of Nanobiology are being applied such as use of cantilever array sensors and Nano photonics

for manipulation of molecular phenomenon in the living cells [15, 16].

Nano biostructures

Nano biotechnology is an interdisciplinary field focused to develop different techniques and processes for building nanostructures at nanometer level. Different Nano biostructures are being developed such as, DNA nanostructures as DNA is the most important unit for any living entity so it's being used as a point target of interest for Nano biotechnological research and Peptide structures as peptides are self-assembling structures so these can be used as programmable Nano biostructures [17, 18].

Nano biomedicines

This is an emerging field of health sciences which is truly based upon nanotechnology and biotechnology combination i.e. nanobiorobots and bio machines. New paths for diagnosis and treatments have been determined by this area of research just because of nanobiorobots. As we all know that some target sites are impossible to be targeted for a drug but Nanobiotechnology have increased the efficiency of biomolecules to be targeted towards those sites as these biomolecules are used along with nanomaterials which have high penetration rate as compare to normal biomolecules i.e. Carbon nanotube along with a DNA strand wrapped around this tube, similarly a Nano rod after enzyme immobilization can be used as more efficient biosensor [7, 19].

Nanobiorobotics

Nanobiorobotics is an emerging interface between biotechnology and nanotechnology which deals with advanced nanorobotics which are used to diagnose and detect biological processes within biological systems. Technology has driven the era from micro technology to nanotechnology. There is a number of natural bio machines which exist naturally like potassium gates etc., Nanobiorobotics enable us to devise these naturally present bio machines artificially. Nanobiorobotics are highly targetable so one can use these nanobiorobots for drug delivery purposes as they can reach up to highly smaller (nanometer scale) targets more efficiently [20-22].

These all disciplines are at the interface edge of Biotechnology and Nanotechnology and example of interface between Biotechnology and Nanotechnology is drawn in (**Fig. 2**).

Fabrication of nanomaterials

Firstly, we have to that what are nanomaterials, these are substances with at least one of their dimensions within Nanoscale. So, they can refer as 1D, 2D and 3D with one, two and all of their dimensions within nanometer scale respectively. Nanofibers have two dimensions within nanometer scale, Nano sheets, nanoparticles etc. all are examples of nanomaterials [23, 24]. Nanomaterials can be driven by different sources i.e. they can be engineered or manufactured by humans using technological techniques such as titanium dioxide nanoparticles and carbon black nanomaterials, nanomaterials also got as byproduct for some biological as well as mechanical process examples for such nanoparticles are fullerenes and some other nanoparticles. Next we can obtain nanomaterials from natural source i.e. capsid of viruses. So we can say that nanomaterials can be divided into three types by the means of their sources: engineered, incidental and natural [18, 25, 26].

Basically two main approaches are being applied for the NPs fabrication, (I) Bottom up (smaller to larger) as name indicates in bottom up approach small atoms and molecules are assembled into specific nanostructures and (II) Top down (larger to smaller) in this approach comparatively larger molecules are subjected to some mechanical force or laser and then broke up into nanomaterials [27-29].

Nanomaterials can be synthesized physically, chemical or can be extracted from a natural living source. So we can divide the methods for fabrication of nanomaterials into three type's i.e. physical, chemical and biological fabrication (**Fig. 3**) [30].

1. High Energy Ball Milling (HEBM) was introduced in 1970 by John Benjamin. HEBM involves very high temperature and pressure conditions and thus also considered as a Physical fabrication process [31].
2. Solovothermal technique is just like hydrothermal method only the main difference is diversity of solvents other than water can be used for this procedure. This procedure involves the use of solvent under reasonable to high pressure and temperature which ease the communication of pioneers throughout mixture [32, 33].
3. Chemical Vapor Deposition (CVD) technique is used to fabricate high-performance and high-quality solid materials. The reaction temperature, the reaction rate, and the absorption of the pioneers are the main parameters on which the excellence of the deposited materials powerfully rest on. Constant coating of the nanoparticles is a main benefit of this approach [34, 35].
4. Sol gel method is used to fabricate solid materials from smaller molecules that are appropriate for formulating diverse layers. It includes transformation of small molecules (precursors) into a colloidal solution (sol) and then into a combined system (gel) containing of either separate atoms or network polymers. This procedure contains

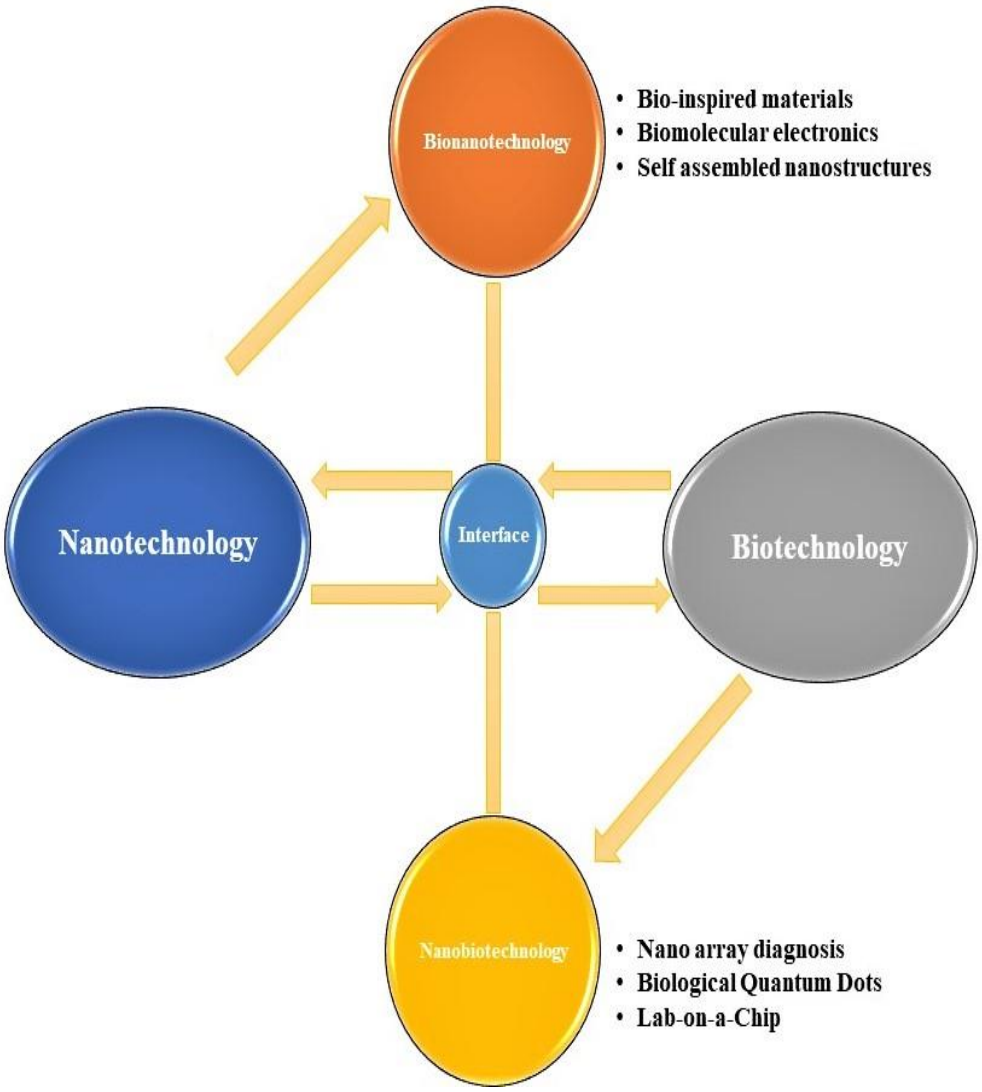

Fig. 2: Arrows shows the applications flow of one field into other i.e. when Biotechnology techniques are being applied in Nanotechnology it is referred as Bio nanotechnology and vice versa for Nanobiotechnology.

four phases: Hydrolysis, Condensation and Development of partials. Sol gel technique occasionally known as chemical solution deposition technique. Benefit of the sol–gel technique is it is an informal and inexpensive process to the preparation of metal oxides and additional benefit is it can be organized in order to get the compulsory oxide with a high degree of consistency and transparency [36, 37].

5. Pure doped metallic nanomaterials can be fabricated by metal alkoxides and salts by applying high energy by heat using Thermal Decomposition and Pulsed Laser Ablation. Properties for these produced nanomaterials depends upon precursor concentrations such as TiO_2 nanoparticles are synthesized with diameter less than 30nm using this technique. This method is comparatively costly method and require highly professional expertise [38, 39].
6. NPs are also being synthesized using template method in which materials with similar morphological features also known as template. So, it is possible to fabricate new nanomaterials with controlled morphological properties. Such as, number of templates are being studied to fabricate titanium nanomaterials [40].

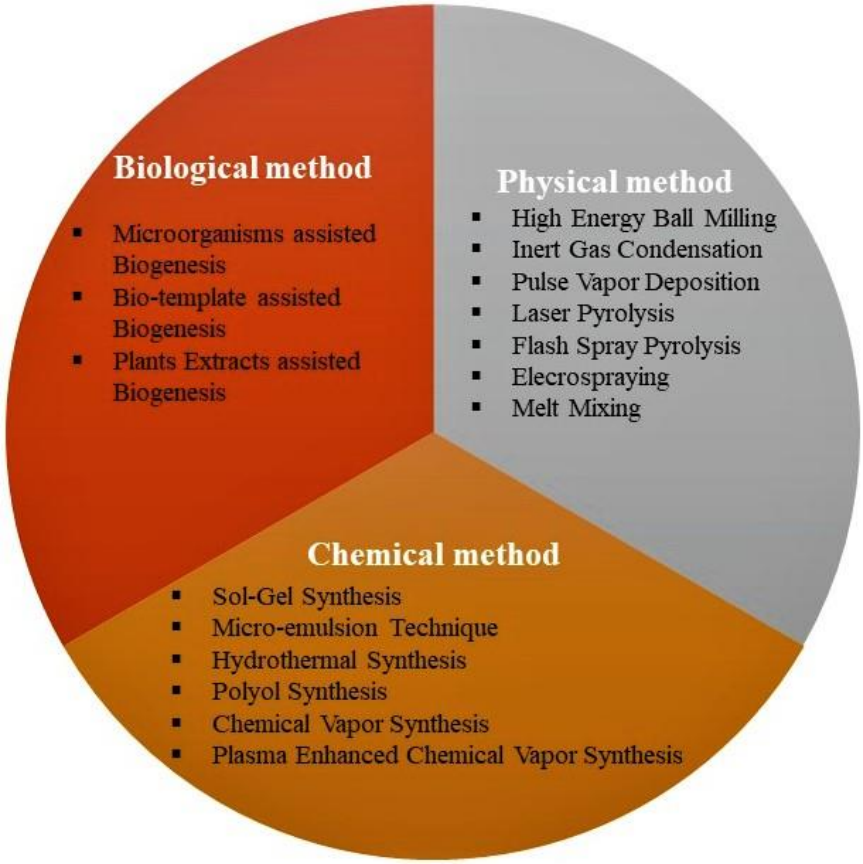

Fig. 3: All methods for the fabrication of Nanomaterials

7. Another method is also of great interest for NPs fabrication is Combustion based synthesis which are used to synthesize crystalline particles. In this method solution containing redox groups is heated rapidly at almost 650°C for one to two minutes for crystal nanoparticles synthesis [41].
8. Just like CVD, Physical vapor deposition (PVD) is a method used to produce NPs. PVD comprises three basic stages: (I) Solid material is vaporized, (II) Transportation of vaporized substance and (III) generation of thin films and NPs. Such as, Sputtering, Electron beam evaporation, Pulsed laser deposition and Vacuum arc are some techniques used for this purpose [42].
9. Green nanotechnology is also a subfield of Nanotechnology which deals with the extraction of Nanomaterials from Natural sources like Plants and use of nanoparticles for agriculture purposes i.e. Nano fertilizers. Examples for this type of fabrication are Synthesis of Silver Nanoparticles from Aqueous Extract *Impatiens balsamina* and *Lantana camara*, Synthesis of Gold Nanoparticles using Plant Extract etc. [43-45].

Conclusion

Nontechnology is a highly interdisciplinary emerging field which have roots and applications in almost every kind of research field. Collaboration of Nanotechnology and Biotechnology is a hot topic now a days. This collaboration has variety of applications and have a very bright future ahead may led the whole world into a new era.

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Conflict of interest

Authors have no conflict of interest.

References

[1] Stewart GA. Biotechnology: an introduction. Am Pharm. 1986;NS26:31-4.

[2] Pohlscheidt M, Kiss R, Gottschalk U. An Introduction to "Recent Trends in the Biotechnology Industry: Development and Manufacturing of Recombinant Antibodies and Proteins". Adv Biochem Eng Biotechnol. 2018;165:1-8.

[3] Campos EVR, de Oliveira JL, Abrantes DC, Rogerio CB, Bueno C, Miranda VR, et al. Recent Developments in Nanotechnology for Detection and Control of Aedes aegypti-Borne Diseases. Front Bioeng Biotechnol. 2020;8:102.

[4] Agoramoorthy G, Chakraborty C. Re: introduction to nanotechnology: potential applications in physical medicine and rehabilitation. Am J Phys Med Rehabil. 2007;86:1031-2; author reply 2.

[5] Barabadi H, Alizadeh Z, Rahimi MT, Barac A, Maraolo AE, Robertson LJ, et al. Nanobiotechnology as an emerging approach to combat malaria: A systematic review. Nanomedicine. 2019;18:221-33.

[6] Gellert MR, Kim BJ, Reffsin SE, Jusuf SE, Wagner ND, Winans SC, et al. Nanobiotechnology for the Environment: Innovative Solutions for the Management of Harmful Algal Blooms. J Agric Food Chem. 2018;66:6474-9.

[7] Chen S, Liang XJ. Nanobiotechnology and nanomedicine: small change brings big difference. Sci China Life Sci. 2018;61:371-2.

[8] Giraldo JP, Wu H, Newkirk GM, Kruss S. Nanobiotechnology approaches for engineering smart plant sensors. Nat Nanotechnol. 2019;14:541-53.

[9] Krishnan Y, Seeman NC. Introduction: Nucleic Acid Nanotechnology. Chem Rev. 2019;119:6271-2.

[10] Tan A, Alavijeh MS, Seifalian AM. Next generation stent coatings: convergence of biotechnology and nanotechnology. Trends Biotechnol. 2012;30:406-9.

[11] Zadegan RM, Norton ML. Structural DNA nanotechnology: from design to applications. Int J Mol Sci. 2012;13:7149-62.

[12] Borjesson K, Lundberg EP, Woller JG, Norden B, Albinsson B. Soft-surface DNA nanotechnology: DNA constructs anchored and aligned to lipid membrane. Angew Chem Int Ed Engl. 2011;50:8312-5.

[13] Ghaffari S, Alihosseini F, Rezayat Sorkhabadi SM, Arbabi Bidgoli S, Mousavi SE, Haghighat S, et al. Nanotechnology in Wound Healing; Semisolid Dosage Forms Containing Curcumin-Ampicillin Solid Lipid Nanoparticles, in-Vitro, Ex-Vivo and in-Vivo Characteristics. Adv Pharm Bull. 2018;8:395-400.

[14] Mashaghi S, Jadidi T, Koenderink G, Mashaghi A. Lipid nanotechnology. Int J Mol Sci. 2013;14:4242-82.

[15] Kroll A. Nanobiology--convergence of disciplines inspires great applications. Cell Mol Life Sci. 2012;69:335-6.

[16] Xia T, Rome L, Nel A. Nanobiology: particles slip cell security. Nat Mater. 2008;7:519-20.

[17] Deal BR, Ma R, Ma VP, Su H, Kindt JT, Salaita K. Engineering DNA-Functionalized Nanostructures to Bind Nucleic Acid Targets Heteromultivalently with Enhanced Avidity. J Am Chem Soc. 2020.

[18] Li L, Wang P, Shao Q, Huang X. Metallic nanostructures with low dimensionality for electrochemical water splitting. Chem Soc Rev. 2020.

[19] Bianco A. Peptides in nanotechnology. Introduction. J Pept Sci. 2008;14:117.

[20] DNA nanorobot signals cancer cells to die. Cancer Discov. 2012;2:292.

[21] Fu J, Yan H. Controlled drug release by a nanorobot. Nat Biotechnol. 2012;30:407-8.

[22] Patel GM, Patel GC, Patel RB, Patel JK, Patel M. Nanorobot: a versatile tool in nanomedicine. J Drug Target. 2006;14:63-7.

[23] Garnett E, Mai L, Yang P. Introduction: 1D Nanomaterials/Nanowires. Chem Rev. 2019;119:8955-7.

[24] Tang JL, Zheng YX. [Introduction to World Health Organization Guidelines on Protecting Workers from Potential Risks of Manufactured Nanomaterials]. Zhonghua Yu Fang Yi Xue Za Zhi. 2018;52:782-4.

[25] Cronin JG, Jones N, Thornton CA, Jenkins G, Doak SH, Clift MJD. Nanomaterials and innate immunity: A perspective of the current status in nanosafety. Chem Res Toxicol. 2020.

[26] Patel DK, Kim HB, Dutta SD, Ganguly K, Lim KT. Carbon Nanotubes-Based Nanomaterials and Their Agricultural and Biotechnological Applications. Materials (Basel). 2020;13.

[27] Nguyen VQ, Schaming D, Martin P, Lacroix JC. Nanostructured Mixed Layers of Organic Materials Obtained by Nanosphere Lithography and Electrochemical Reduction of Aryldiazonium Salts. Langmuir. 2019;35:15071-7.

[28] Prosa M, Bolognesi M, Fornasari L, Grasso G, Lopez-Sanchez L, Marabelli F, et al. Nanostructured Organic/Hybrid Materials and Components in Miniaturized Optical and Chemical Sensors. Nanomaterials (Basel). 2020;10.

[29] Venditti I. Nanostructured Materials Based on Noble Metals for Advanced Biological Applications. Nanomaterials (Basel). 2019;9.

[30] Penades S, Davis BG, Seeberger PH. Glycans in Nanotechnology. In: rd, Varki A, Cummings RD, Esko JD, Stanley P, Hart GW, et al., editors. Essentials of Glycobiology. Cold Spring Harbor (NY)2015. p. 743-53.

[31] Xing T, Sunarso J, Yang W, Yin Y, Glushenkov AM, Li LH, et al. Ball milling: a green mechanochemical approach for synthesis of nitrogen doped carbon nanoparticles. Nanoscale. 2013;5:7970-6.

[32] Durai L, Kong CY, Badhulika S. One-step solvothermal synthesis of nanoflake-nanorod WS2 hybrid for non-enzymatic detection of uric acid and

quercetin in blood serum. Mater Sci Eng C Mater Biol Appl. 2020;107:110217.
[33] Li JY, Cao ZM, Hua Y, Wei G, Yu XZ, Shang WB, et al. Solvothermal Synthesis of Novel Magnetic Nickel Based Iron Oxide Nanocomposites for Selective Capture of Global- and Mono-Phosphopeptides. Anal Chem. 2020;92:1058-67.
[34] Aljumaily MM, Alsaadi MA, Das R, Hamid SBA, Hashim NA, AlOmar MK, et al. Optimization of the Synthesis of Superhydrophobic Carbon Nanomaterials by Chemical Vapor Deposition. Sci Rep. 2018;8:2778.
[35] Qi X, Qin C, Zhong W, Au C, Ye X, Du Y. Large-Scale Synthesis of Carbon Nanomaterials by Catalytic Chemical Vapor Deposition: A Review of the Effects of Synthesis Parameters and Magnetic Properties. Materials (Basel). 2010;3:4142-74.
[36] Jayaprakash J, Srinivasan N, Chandrasekaran P, Girija EK. Synthesis and characterization of cluster of grapes like pure and Zinc-doped CuO nanoparticles by sol-gel method. Spectrochim Acta A Mol Biomol Spectrosc. 2015;136 Pt C:1803-6.
[37] Subban CV, Zhou Q, Hu A, Moylan TE, Wagner FT, DiSalvo FJ. Sol-gel synthesis, electrochemical characterization, and stability testing of Ti(0.7)W(0.3)O2 nanoparticles for catalyst support applications in proton-exchange membrane fuel cells. J Am Chem Soc. 2010;132:17531-6.
[38] Ganesan PG, McGuire K, Kim H, Gothard N, Mohan S, Rao AM, et al. ZnO nanowires by pulsed laser vaporization: synthesis and properties. J Nanosci Nanotechnol. 2005;5:1125-9.
[39] Neumeister A, Jakobi J, Rehbock C, Moysig J, Barcikowski S. Monophasic ligand-free alloy nanoparticle synthesis determinants during pulsed laser ablation of bulk alloy and consolidated microparticles in water. Phys Chem Chem Phys. 2014;16:23671-8.
[40] Aisu K, Suzuki TS, Nakamura E, Abe H, Suzuki Y. AAO-template assisted synthesis and size control of one-dimensional TiO2 nanomaterials. Journal of the Ceramic Society of Japan. 2013;121:915-8.
[41] Nersisyan HH, Yoo BU, Lee TH, Lee JH. Combustion based synthesis of AlN nanoparticles using a solid nitrogen promotion reaction. Journal of the American Ceramic Society. 2015;98:3740-7.
[42] Sharma RK, Kumar P, Reddy G. Synthesis of vanadium pentoxide (V2O5) nanobelts with high coverage using plasma assisted PVD approach. Journal of Alloys and Compounds. 2015;638:289-97.
[43] Makarov V, Love A, Sinitsyna O, Makarova S, Yaminsky I, Taliansky M, et al. “Green” nanotechnologies: synthesis of metal nanoparticles using plants. Acta Naturae (англоязычная версия). 2014;6.
[44] Iravani S. Green synthesis of metal nanoparticles using plants. Green Chemistry. 2011;13:2638-50.
[45] Kumar V, Yadav SK. Plant-mediated synthesis of silver and gold nanoparticles and their applications. Journal of Chemical Technology & Biotechnology: International Research in Process, Environmental & Clean Technology. 2009;84:151-7.