NANOTECHNOLOGY AND SILVER NANOPARTICLES

Damla ARSLAN[1], Ulaş ACARÖZ[2], Osman ARİF[3], Halil Ozancan ARSLAN[4]
[1]*Department of Animal Nutrition and Nutritional Disease, Graduate School of Health Science, Ankara University, 06110, Diskapi-Ankara, Turkey.*
[2]*Department of Food Hygiene and Technology, Graduate School of Health Science, Ankara University, 06110, Diskapi-Ankara, Turkey.*
[3]*Faculty of Veterinary Medicine, Trakia University, 6000, Stara Zagora, Bulgaria.*
[4] *Faculty of Veterinary Medicine, Kirikkale University, 6000, Kirikkale, Turkey.*

ABSTRACT

Nanotechnology is a multidisciplinary science, in which physics, chemistry, engineering and biology work together. In various fields, nanoscience and nanotechnology take places in our life quickly. For instance, nanoscience and nanotechnology is applied by computer, electronic, communication, producing energy, food industry, nutrition, agriculture and medicine. Forthcoming 10-15 years nanotechnology is believed to be a new technological revolution.

In animal nutrition, antibiotic usage causes development of antibiotic resistant microorganisms. On this account, in many countries antibiotic based growth promoters are banned. Silver and ions has known to have antibacterial content. Silver nanoparticles (nanobiotic-Ag) are synthesized by various techniques. This nanoparticles posses good biocapability and also have low toxicity. Thus nanotechnology is used by animal nutrition and it is developing day by day.

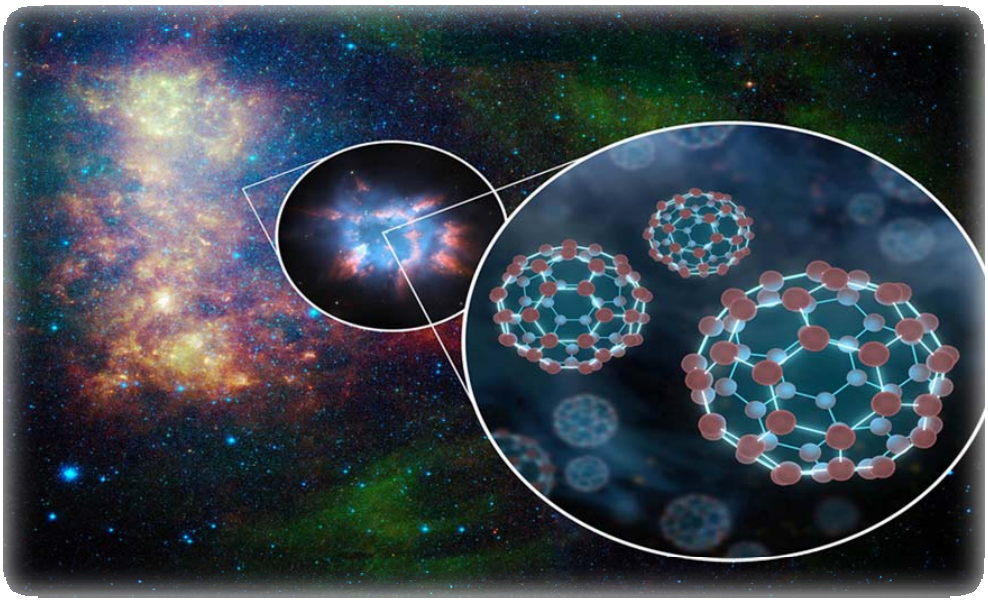
In world trade, nanotechnological product's market share is increasing rapidly. Countries are racing against each other to increase their market share. In Turkey, this technology and science is developing, researchs are doing and institutes are established.

Keywords: *Nanotechnology, Silver nanoparticle, Antibacterial*

INTRODUCTİON

What is Nanotechnology and Terminology of Nanotechnology?

Nature has been performing nanotechnological success for millions of years by arrangement of atoms and molecules. Nano usually refers to size between 1 and 100 nanometers (nm). In nanometric scale (one millionth of a millimeter), nanotechnology contains physical, chemical and biologic events' understanding and control. Nanotechnology; allows us to manipulate at atomic and molecular level **(picture-5)**. Nanotechnology processes materials which are measured by nanometers. Nanotechnology works with various research areas. Nanotechnology is a multidisciplinary technology. 'Nanoscience' is interested in this technology and when this science is applied to medicine it is called 'Nanomedicine' [1].

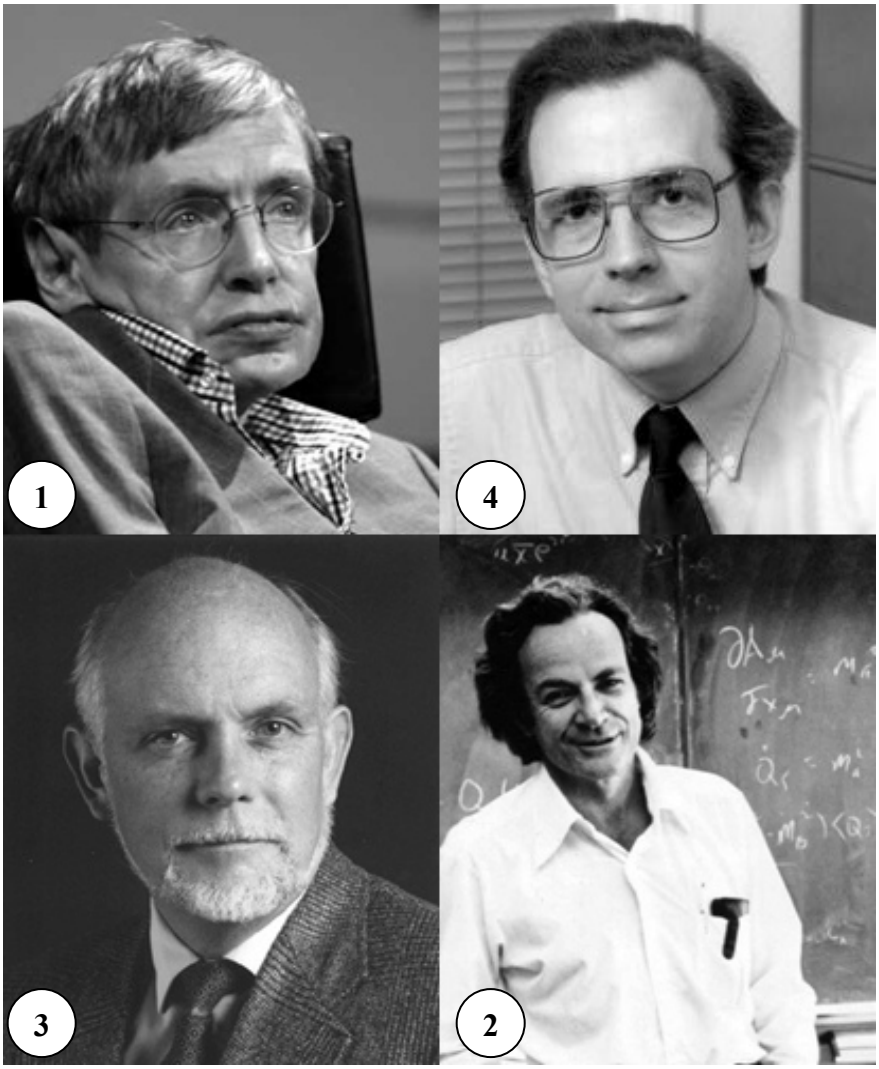


Picture-5: Nanotechnology; allows us to manipulate at atomic and molecular level, [1]

Nanoprocessing term means processing product in atomic level. Today's technology has started to process this product and discover the unknown parts of it. Nanotechnology has enabled us to produce high quality, low price materials. In this technology, such as communication, medicine, agriculture and food industry can produce better-built, safer and long lasting materials [2]. Nanotechnology is broad and interdisciplinary area of research and past few years it has developed so rapidly [3].Nanoscale materials are nanocrystals, nanoparticles, nanowires, nanotubes and nano films. This materials have potential to have different characteristics and functionality than they normally have [4, 5]. Nanosized inorganic particles shows unique phsical and chemical properties. These are increasingly important material [6-9]. In scientific world nanotechnology has revolution potential [10].

History Of Nanotechnology

In a speech Stephan Hawking **(picture-1)** said that today's science fiction generally tomorrow's science reality. In ancient Greek Nano term derive from "nanos" which means dwarf. Physicist Richard Feynman **(picture-2)** who was awarded by Nobel Prize talk presented in American Physical Society in 29 December 1959. This date is initial day for nanotechnology [11]. Eric Drexler **(picture-4)** was the first who used nanotechnology term. He was interested in moleculer production, moleculer screening and nanofabrication [12]. Richard Feynman, Eric Drexler and Richard Smalley **(picture-3)** played an important role developing of nanotechnology [13].



How To Get Nanoparticles?

Nanoparticles are generally different from other commercial products and also have superior characteristics **(Figure-1)**. Nanoparticles have great surface atom characteristic and very high surface/ volume ratio. Recently, it is possible to produce nucleus-crust, alloyed, sandwich, cavity, spherical, rod shape nanoparticles [14].Generally for producing nanoparticles two methods are used. This are 'Top Down' and 'Bottom Up'. For producing metals or oxide nanoparticles, chemical steam intensification, hydrogen reduction, inert gas intensification and ultrasonic sprey pyrolysis methods are used. In Top Down method, energy is given to material by mechanical or chemical prosedure. During this method aim is to get nano size from material. For this method very high energy is consumed. In Bottom-Up method, through chemical reaction atomic or moleculer size structures are expanded. Commonly used reductants are citrate, ascorbate and elemental hydrogen [15-18].

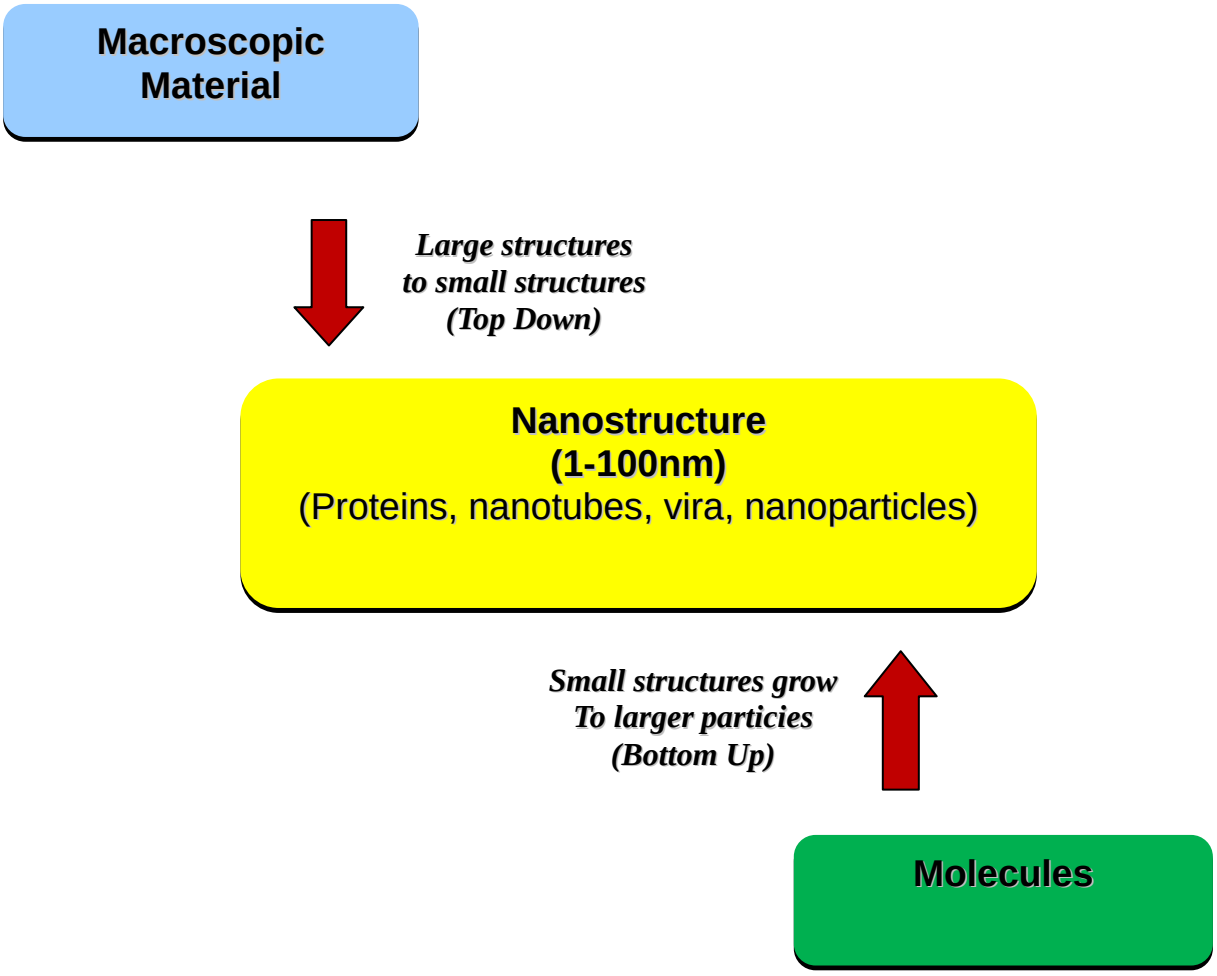


Figure-1: Nanoparticles are generally different from other Commercial products and also have superior characteristics

Silver Nanoparticles (Ag NPs) and Their Antibacterial Effects

Most of nanoperticles is in the form of metalic silver nanoparticles. Remaining silver is in ionic form. Surface area of silver is maxized, it results the highest effect per unit of silver [19]. Ionic silver becomes silver chloride in the stomach or bloodstream. Solubility of silver chloride is low. The silver-chloride is less effective than metalic one. There are many processes to synthesize silver nanoparticles. For instance, electrochemical reductin and irradiation [20-25]. Silver enter body throuh various ways like ingestion, inhalation of dust of fumes which contains silver [26, 27]. For centuries, silver has been in use for threatment of burns and wounds [28, 29]. In 1700 for venereal diseases and perianal abscesses silver nitrate was used [30, 31]. After penicilin was introduced, usage of silver for bacterial infections treatments minimized [32-34]. Moyer introduced the use of 0.5% silver nitrate for the treatment of burns. He proposed that it posses antibacterial property against Staphylococcus aureus, Pseudomonas aeruginosa and Escherichia coli [35, 36]. Silver's antimicrobal property is raleted to the amount of silver and the rate of its releasing. Silver in the form of metalic state is inert. When it reacts with the moisture in the skin and the fluid, it get ionized. Ionized silver is highly reactive. It binds to tissue proteins and makes structural changes in the bacterial cell wall. These processes lead to cell distortion and death [31, 37]. Mechanism of silver action is linked with silver interaction with thiol group compounds found in the respiratory

enzymes of bacterial cells. Silver binds to bacterial cell wall and cell membrane than inhibits the respiration [38]. Compared to other salts nanoparticles show efficient antimicrobial property. Because of their large surface area. Large surface area provides better contact with microorganism. Nanoparticles attach the bacterial cell membrane and tha penetrate inside the bacteria. Bacterial cell membrane contains sulfur containing proteins. Silver nanoparticles interact with these proteins and also phosphorus containing compounds. DNA is also phosphorus containing compound. When silver nanoparticles enter the bacteria, it forms a low molecular weight region. Bacteria conglomerates and protect the DNA from silver ions. Nanoparticles preferably attack the respiratory chain. This event causes cell death [39-42].

REFERENCES

1. ETC Group(action group on erosion, technology and concentration)., Down on the Farm, (http ://www.etcgroup.org/documents/ETC-DOTFarm2004.pdf), the arriving of date: 14.02.2011
2. Fu L. Cao L. Liu Y., Molecular and nanoscale materials and devices in electronics, Adv Colloid Interface Sci, 2004; 111:133–57.
3. Kulzer F. Orrit M., 'Single-Molecule Optics' , Annual Review of physical Chemistry, 2004; Vol. 55, 585-611
4. Goldstain A., Handbook of Nanophase Materials, 1997; Marcel Dekker Inc, New York.
5. Rao C.N.R. Müller A. Cheetham A.K., The Chemistry of Nanomaterials Volume 1, 2005; WILEY-VCH Verlag GmbH & Co. KgaA, Weinheim.
6. Chan W.C.W. Maxwell D.J. Gao X. Bailey R.E. Han M. Nie S., Curr. Opin. Biotechnol. 13 (2002) 40.
7. Wu X. Liu H. Liu J. Haley K.N. Treadway J.A. Larson J.P. Ge E. Peale F. Bruchez M.P., Nat. Biotechnol. 21 (1993) 41.
8. Brigger I. Dubernet C. Couvreur P., Adv. Drug Deliver. Rev. 54 (2002) 631.
9. Forestier F. Gerrier P. Chaumard C. Quero A.M. Couvreur P. Labarre C.J., Antimicrob. Chemother. 30 (1992) 173.
10. Roco M.C. Williams R.S. Alivasatos P., Eds. Nanotechnology Research Directions: IWGN Workshop Report, Kluwer Academic Publishers: Norwell, MA, 1999.
11. Feynman R.P., There's plenty of room at the bottom an invitation to enter a new field of physics, 1959; http://www.zyvex.com/nanotech/feynman.html, the arriving of date: 05.02.2011
12. Drexler K.E., Engines of creation:the coming era of nanotechnology. New York: Anchor Pres/ Doubleday 1986:99-129.
13. Fanfair D. Desai S. Kelty C., The early history of nanotechnology, 2007; http://cnx.org/content/m14504/1.1/
14. Liveri V.T., Controlled Synthesis of Nanoparticles in Microheterogeneous Systems, Springer Science+Business Media, Inc., New York, 2006.
15. Wolfgang L., Bottom-up Methods for Making Nanotechnology Products. <http://www.azonano.com/details.asp? ArticleID=1079>. Access 22 October 2007.
16. Sergeev B.E., Nanochemistry, Elsevier B.V., Amsterdam, Netherlands, 2006.
17. Stephen W. Richard J. Alison G., Physics at the Nanoscale, and Nanotechnology Production Methods with Special Focus on Biology, 2003, <http://www.azonano.com/Details. asp? ArticleID=1207>. Access 22 Ekim 2007.
18. Zaki A., Processing and Synthesis Techniques for the Preparation of Nanomaterials. <http://www.azonano.com/details.asp?ArticleID= 1710>. Access 22 October 2007.
19. Alt V. Bechert T. Steinrucke P. Wagener M. Seidel P. Dingeldein E. Domann E. Schnettler R., An in vitro assessment of the antibacterial properties and cytotoxicity of nanoparticulate silver bone cement, Biomaterials 25:4383-4391, 2004.

20. Sergeev M.B. Kasaikin A.V. Litmanovich A.E. Cryochemical synthesis and properties of silver nanoparticle dispersions stabilised by poly (2-dimethylamino ethyl methacrylate). Mendeleev Commun. 9:130–132, 1999.

21. Sun Y. Xia Y., Shape controlled synthesis of gold and silver nanoparticles. Science 298:2176–2179, 2002.

22. Zhang Y. Chen F. Zhuang J., Synthesis of silver nanoparticles via electrochemical reduction on compact zeolite film modifiedelectrodes. Chem. Commun. (Camb.) 7:2814–2815, 2002.

23. Pyatenko A. Shimokawa K. Yamaguchi M., Synthesis of silver nanoparticles by laser ablation in pure water. J. Appl. Phys. A: Mater. Sci. Proces. A79:803–806, 2004.

24. Bogle K.A. Dhole S.D. Bhoraskar V.N., Silver nanoparticles: synthesis and size control by electron irradiation. Nanotechnology 17:3204–3208, 2006.

25. Chen X. Schluesener H.J., Nanosilver: A nanoproduct in medical application. Toxicol. Lett. 176:1–12, 2007.

26. Phalen R.F. Morrow P.E., Experimental inhalation of metalic silver. Health Phys. 24:509-518, 1973.

27. Furchner J.E. Richmond C.R. Dranke G.A., Comparative metabolism of radionuclides in mammals-IV. Retention of silver-110m in the Mouse, rat, monkey and dog. Health Phys. 15:505-14, 1968.

28. Richard J.W. Spencer B.A. McCoy L.F. Carina E, Washington J. Edgar P., Acticoat versus silverlon: the truth. J Burns Surg Wound Care 2002;1:11–20.

29. Castellano J.J. Shafii S.M. Ko F. Donate G. Wright T.E. Mannari R.J., Comparative evaluation of silver-containing antimicrobial dressings and drugs. Int Wound J 2007; 4(2):114–22.

30. Klasen H.J., A historical review of the use of silver in the treatment of burns. Part I early uses. Burns 2000; 30:1–9.

31. Landsdown A.B.G., Silver I: its antibacterial properties and mechanism of action. Jwound Care 2002; 11:125–38.

32. Hugo W.B. Russell A.D., Types of antimicrobial agents. In: Principles and practice of disinfection, preservation and sterilization. Oxford, UK: Blackwell Scientific Publications; 1982. p. 106. 8.

33. Demling R.H. DeSanti L., Effects of silver on wound management. Wounds 2001;13:4.

34. Chopra I., The increasing use of silver-based products as antimicrobial agents: a useful development or a cause for concern? J Antimicrob Chemother 2007; 59:587–90.

35. Moyer C.A. Brentano L. Gravens D.L. Margraf H.W. Monafo W.W., Treatment of large human burns with 0.5% silver nitrate solution. Arch Surg 1965; 90:812–67.

36. Bellinger C.G. Conway H., Effects of silver nitrate and sulfamylon on epithelial regeneration. Plast Reconstr Surg 1970; 45:582–5.

37. Castellano J.J. Shafii S.M. Ko F. Donate G. Wright T.E. Mannari R.J., Comparative evaluation of silver-containing antimicrobial dressings and drugs. Int Wound J 2007; 4(2):114–22.

38. Klasen H.J., A historical review of the use of silver in the treatment of burns. Part I early uses. Burns 2000;30:1–9.

39. Feng Q.L. Wu J. Chen G.Q. Cui F.Z. Kim T.N. Kim J.O., A mechanistic study of the antibacterial effect of silver ions on Escherichia coli and Staphylococcus aureus. J Biomed Mater 2000;52(4):662–8.

40. Sondi I. Salopek-Sondi B., Silver nanoparticles as antimicrobial agent: a case study on E. coli as a model for gram-negative bacteria. J Colloid Interface 2007; 275:177–82.

41. Morones J.R. Elechiguerra J.L. Camacho A. Ramirez J.T., The bactericidal effect of silver nanoparticles. Nanotechnology 2005;16:2346–53.

42. Song H.Y. Ko K.K. Oh L.H. Lee B.T., Fabrication of silver nanoparticles and their antimicrobial mechanisms. Eur Cells Mater 2006;11:58.