



e-ISSN: 2319-8753 | p-ISSN: 2347-6710

IJRSET

International Journal of Innovative Research in
SCIENCE | ENGINEERING | TECHNOLOGY

INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 12, Issue 4, April 2023

ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA

Impact Factor: 8.423

9940 572 462

6381 907 438

ijirset@gmail.com

www.ijirset.com

NANOTECHNOLOGY : A New Tool to Agriculture , Medicine and Environment

SHAILY SAINI

U.G Student, Department of Pharmacy, SRMS College of Engineering and Technology, Bareilly, Uttar Pradesh, India.

ABSTRACT : Nanotechnology has the potential to revolutionise agricultural systems, biomedicine, environmental engineering, safety and security, water resources, energy conversion, and numerous other areas. Nanotechnology is working with the smallest possible particles which raise hopes for improving agricultural productivity through encountering problems unsolved conventionally. In the management aspects, efforts are made to increase the efficiency of applied fertiliser with the help of nano clays and zeolites and restoration of soil fertility by releasing fixed nutrients. Various polymers have been used in the formulation of nanoparticles for drug delivery research to increase therapeutic benefit, while minimising the side-effects. This review article presents the most outstanding contributions in the field of nanotechnology as a drug delivery system. Pharmaceutical nanotechnology based systems, methods of preparation, applications, advantages and disadvantages.

KEYWORDS: Nanotechnology, Nanoparticles, Nano-systems, Nanodevices, Nanotubes, Nanofertilizer, Nano Herbicide

I. INTRODUCTION

“Nano” means one-billionth, thus nanotechnology deals with materials measured in a billionth of a metre. A nanometer is 1/80,000 the diameter of a human hair or approximately ten hydrogen atoms wide. Nanotechnology is the science of very small things. But nanotechnology is not just involved with small things. Nanotechnology is a multi-disciplinary science. It includes knowledge from biology, chemistry, physics and other disciplines. Joseph and Morrison, (2006) defined Nano technology as the manipulation or self assembly of individual atoms ,molecules or molecular clusters into structures to create materials devices with new or vastly different properties.(1,2)

Given the high production and broad feasibility of nanomaterials, the application of Nanotechnology includes the use of engineered nanomaterials (ENMs) to clean-up polluted media such as soils, water, air, groundwater and wastewaters, and is known as nanoremediation. Contamination by hazardous substances in environmental matrices, including landfills, oil fields, and manufacturing and industrial sites, represents a global concern and needs to be remediated, since it poses a serious risk for the environment and human health. Particular attention should also be focused on the use of medical devices and recent developments in the use of nanoparticles expressed as drug delivery systems designed to treat a wide variety of diseases.

This Special Issue, “Nanotechnology for Environmental and Biomedical Research”, is characterised by this double role, and is aimed at facing the use of nanotechnology for environmental and human health. It aims at collecting a compilation of articles that strongly demonstrate the continuous efforts in developing advanced and safe nanomaterial-based technologies for nanoremediation, as well as for drug delivery and other biomedical applications.(3)

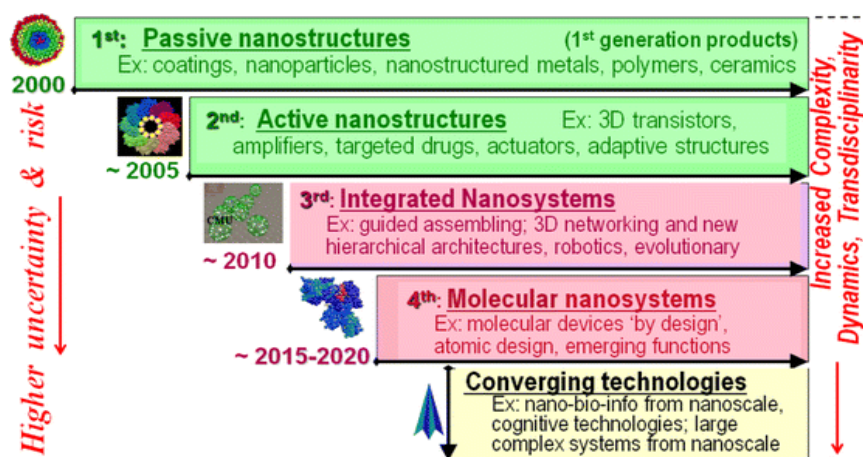


Fig.1 Representation of generations of nanotechnology

Interest in nanotechnology is strong because standard silicon techniques have nearly reached their limit-CPU's and similar products can't get much smaller with current technology because manufacturers can't keep stuffing more and more transistors in the same space. However nanotechnology may allow this. We could develop a new manufacturing technology, which will let us inexpensively build computer systems with mole quantities of logic elements that are molecular in both size and precision and are interconnected in complex and highly idiosyncratic patterns.

Nanostructures are made by Lithography and Self Assembly- Physical or chemical. Lithography is a top-down fabrication technique where a bulk material is reduced in size to a nanoscale pattern.(4-6)

The concept of molecular self-assembly prepares small molecules of almost any structure and assembles these single molecules into supramolecular assemblies consisting of many molecules arranged in a well defined manner. They automatically arrange themselves into some useful conformation through a bottom-up approach.

In nanomanufacturing we are integrating "bottom up" self assembly with "top down" lithography called Hierarchical Manufacturing.

Basic theme of nanotechnology

At nanoscale the role of quantum mechanics, statistical mechanical effects, comes into play. The rules of quantum mechanics are very different from classical physics, which means that the behaviour of substances at the nanoscale can sometimes contradict common sense. This effect does not come into play by going from macro to micro dimensions. However, it becomes dominant when the nanometer size range is reached. Additionally, a number of physical (mechanical, electrical, optical, etc.) properties also change when compared to macroscopic systems(7-9) Also an increase in surface area to volume ratio, at nanoscale; alters the mechanical, thermal and catalytic properties of materials. For example, due to an increase in surface area , Melting points can change, opaque substances become transparent (copper); inert materials become catalysts (platinum); stable materials turn combustible (aluminium); solids turn into liquids at room temperature (gold); insulators become conductors (silicon). A material such as gold, which is chemically inert at normal scales, can serve as a potent chemical catalyst at nanoscales.

II. NANOMATERIAL

Nanomaterials are materials with morphological features smaller than a one tenth of a micrometre in at least one dimension. Nanomaterials exhibit unique physical and electrochemical properties, thereby enabling the manufacture of stronger, harder, more wear-resistant materials(10). Interface and Colloid science has given rise to many materials which may be useful in nanotechnology, such as carbon nanotubes, other fullerenes, various nanoparticles and nanorods. Members of the fullerene family are a major subject of research falling under the nanotechnology umbrella.

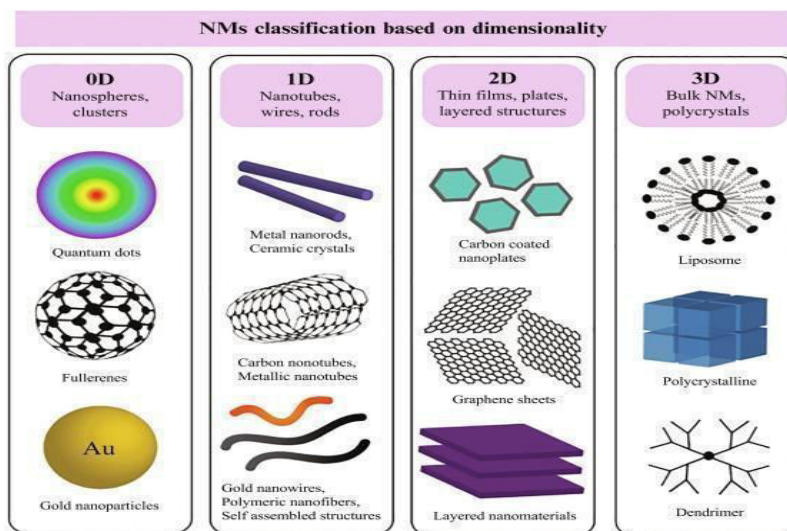


Fig.2 Nanomaterials representation

Approaches used in nanotechnology

Bottom-up approach:

In the "bottom-up" approach, materials and devices are built from molecular components which assemble themselves chemically by principles of molecular recognition. Simply put, these seek to arrange smaller components into more complex assemblies(11).

Top-down approach:

In the "top-down" approach, nano-objects are constructed from larger entities without atomic-level control. Or simply put, these seek to create smaller devices by using larger ones to direct their assembly.

III.NANOPARTICLES – Essential Component of Nanotechnology

Nanotechnology is concerned with development and utilisation of structures and devices with organisational features at the intermediate scale between individual 2 molecules and about where novel properties occur as compared to bulk materials. It implies the capability to build up tailored nanostructures and devices for given functions by control at the atomic and molecular levels. Nanotechnology is recognized as an emerging enabling technology for the 21st century, in addition to the already established areas of information technology and biotechnology. This is because of the scientific convergence of physics, chemistry, biology, materials and engineering at nanoscale, and of the importance of the control of matter at nanoscale on almost all technologies. These include hard disks in computers, photographic systems, dispersions with novel optoelectronic properties, information recording layers, bio-detectors, advanced drug delivery systems, chemical–mechanical polishing, a new generation of lasers, chemical catalysts, nanoparticle reinforced materials, ink jet systems, colourants, and nanosystems on a chip, to name some of the most important. Assemblies of nano-particles, droplets, bubbles, fibres and tubes with an interstitial medium are defined here as ‘ultradispersions’(12-15).This term will mark the difference as compared to ordinary dispersions because of the specific properties and phenomena developed at nanoscale (dispersed phase dimension or interstitial gap).

IV. NANO-AGRICULTURE

In December 2002, the United States Department of Agriculture (USDA) drafted the world’s first “roadmap” for applying nanotechnology to agriculture and food. Agriculture, according to the new nano-vision, needs to be more uniform, further automated, industrialised and reduced to simple functions. In our molecular future, the farm will be a wide area biofactory that can be monitored and managed from a laptop and food will be crafted from designed substances delivering nutrients and calories efficiently to the body(16-19).

Nano biotechnology will increase agriculture’s potential to harvest feed stocks for industrial processes. Mean while tropical agricultural commodities such as rubber, cocoa, coffee and cotton – and the small-scale farmers who grow them - will find themselves quaint and irrelevant in a new nano economy of “flexible matter” in which the properties of industrial nanoparticles can be adjusted to create cheaper, “smarter” replacements(20).Just as Genetically Modified

(GM) agriculture led to new levels of corporate concentration all along the food chain, so proprietary nano technology, deployed from seed to stomach, genome to gullet, will strengthen the grasp of agribusiness over global food and farming at every stage – all, ostensibly, to feed the hungry, safeguard the environment.

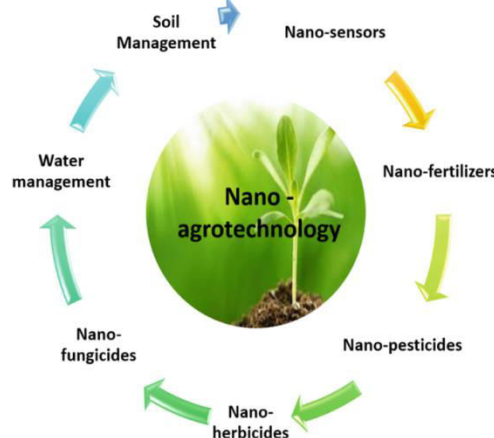


Fig.3 Representation of Nano-Agriculture

For two generations, scientists have manipulated food and agriculture at the molecular level. Agro-nano connects the dots in the industrial food chain and goes one step further down. With new nanoscale techniques of mixing and harnessing genes, GM plants become atomically modified plants. Pesticides can be more precisely packaged to knock-out unwanted pests and add artificial flavourings and natural nutrients engineered to please the palate. Visions of an automated, centrally-controlled industrial agriculture can now be implemented using molecular sensors, molecular delivery systems and low-cost labour.

The European Union’s (EU) vision is of a “knowledge-based economy” and as part of this; it plans to maximise the potential of biotechnology for the benefit of the EU economy, society and the environment. There are new challenges in this sector including a growing demand for healthy, safe food; an increasing risk of disease and threats to agricultural and fishery production from changing weather patterns(21-23). However, creating a bioeconomy is a challenging and complex process involving the convergence of different branches of science. Nano technology has the potential to revolutionise the agricultural and food industry with new tools for the molecular treatment of diseases, rapid disease detection, enhancing the ability of plants to absorb nutrients etc.

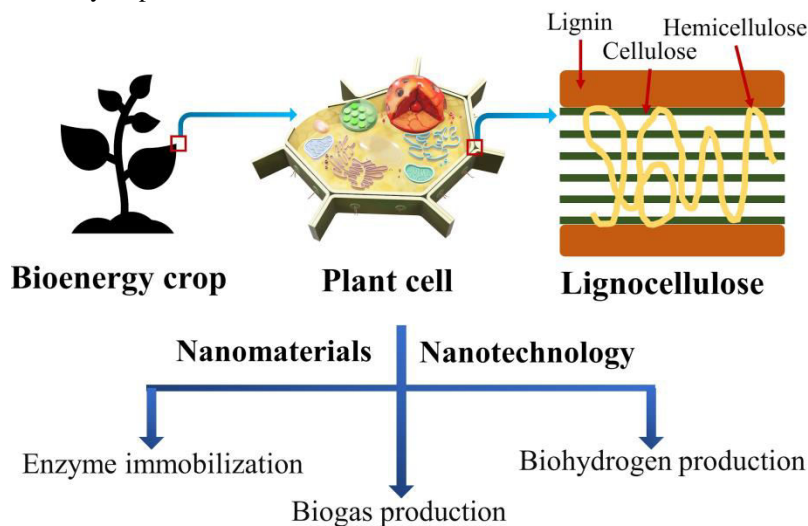


Fig.4 Use of Nanoparticles and Nanotechnology

V. NANO-MEDICINE (24)

Nanomedicine is the medical application of nanotechnology. Nanomedicine ranges from the medical applications of nanomaterials and biological devices, to nanoelectronic biosensors, and even possible future applications of molecular nanotechnology such as biological machines. Current problems for nanomedicine involve understanding the issues related to toxicity and environmental impact of nanoscale materials (materials whose structure is on the scale of nanometers, i.e. billionths of a metre).

Functionalities can be added to nanomaterials by interfacing them with biological molecules or structures. The size of nanomaterials is similar to that of most biological molecules and structures; therefore, nanomaterials can be useful for both in vivo and in vitro biomedical research and applications(25,26). Thus far, the integration of nanomaterials with biology has led to the development of diagnostic devices, contrast agents, analytical tools, physical therapy applications, and drug delivery vehicles.

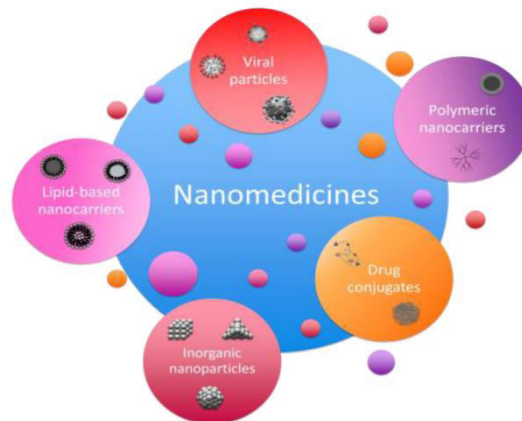


Fig.5 Representation of Nanomedicine

Nanomedicine seeks to deliver a valuable set of research tools and clinically useful devices in the near future. The National Nanotechnology Initiative expects new commercial applications in the pharmaceutical industry that may include advanced drug delivery systems, new therapies, and in vivo imaging.(27) Nanomedicine research is receiving funding from the US National Institutes of Health Common Fund program, supporting four nanomedicine development centres.

VI. GENERAL APPLICATION

Sunscreen:

Many sunscreens contain nanoparticles of zinc oxide or titanium oxide. Older sunscreen formulas use larger particles, which is what gives most sunscreens their whitish colour. Smaller particles are less visible, meaning that when you rub the sunscreen into your skin, it doesn't give you a whitish tinge(28)

Ingredients like zinc oxide can leave a white shine behind. But sunscreens with zinc oxide nanoparticles rub on clear.

Self-Cleaning Glass:

A company called Pilkington offers a product they call Activ Glass, which uses nanoparticles to make the glass photocatalytic and hydrophilic.

Clothing:

Scientists are using nanoparticles to enhance clothing. By coating fabrics with a thin layer of zinc oxide nanoparticles, manufacturers can create clothes that give better protection from UV radiation. Some clothes have nanoparticles in the form of little hairs or whiskers that help repel water and other materials, making the clothing stain-resistant.

Scratch-Resistant Coatings:(29)

Engineers discovered that adding aluminium silicate nanoparticles to scratch resistant polymer coatings made the coatings more effective, increasing resistance to chipping and scratching. Scratch-resistant coatings are common on everything from cars to eyeglass lenses.

Antimicrobial Bandages:

Scientist Robert Burrell created a process to manufacture antibacterial bandages using nanoparticles of silver. Silver ions block microbes' cellular respiration. In other words, silver smothers harmful cells, killing them.

Swimming Pool Cleaners and Disinfectants:

EnviroSystems, Inc. developed a mixture (called a nanoemulsion) of nano-sized oil drops mixed with a bactericide. The nano sized oil particles adhere to bacteria, making the delivery of the bactericide more efficient and effective.

Tennis:

Nanotechnology is making a big impact on the tennis world. They made the racket with carbon nanotube-infused graphite, meaning the racket was very light, yet many times stronger than steel. Meanwhile, tennis ball manufacturer Wilson introduced the Double Core tennis ball. These balls have a coating of clay nanoparticles on the inner core. The clay acts as a sealant, making it very difficult for air to escape the ball.

Cure of cancer:

The delivery of any drug at the right time and in the target where it is needed and at the level that is required is essential to realise the full potential of therapeutic molecules. These requirements are more important in the case of cancer chemotherapies due to their high toxicity which could lead to serious side-effects. In the last few years, a great number of drug delivery technologies have been optimised including the micro and the nano-systems as well as polymer conjugation.

Some new products:

New products incorporating nanotechnology are coming out every day. Wrinkle Resistant fabrics, deep-penetrating cosmetics, liquid crystal displays (LCD) and other conveniences using(30)nanotechnology have already been developed. Before long, we'll see dozens of other products that take advantage of nanotechnology ranging from Intel microprocessors to bionano batteries, capacitors only a few nanometers thick.

VII. ACKNOWLEDGEMENT

The authors would like to acknowledge the management of Shri Ram Murti Smarak College of Engineering and Technology (Pharmacy), Bareilly, Uttar Pradesh, for supporting the basic research ideas and also for the resources provided.

VIII. CONFLICTS OF INTEREST

The authors declare no conflict of interest.

IX. CONCLUSIONS

1. By taking advantage of quantum-level properties, Molecular Nanotechnology MNT allows for unprecedented control of the material world, at the nanoscale, providing the means by which systems and materials can be built with exacting specifications and characteristics.
 2. The use of Nanotechnology is continuously transforming daily use products, making consumer goods plentiful, inexpensive and highly durable.
 3. The medicine will take a quantum leap forward, with the use of nanotechnology.
 4. Single molecule transistor technology has got scope in chemical and biological sensing. DNA-based logic gates that could carry out calculations inside the body have been constructed for the first time.
 5. Space travel and colonisation will become safe and affordable with the advances that nanotechnology is bringing in aerospace materials.
 6. With continuous use of nanotechnology, the global lifestyles will change radically.
 7. Nanotechnology will have a drastic impact on human behaviour and society.
- The use of nanomaterials for delivery of pesticides and fertilisers is expected to reduce the dosage and ensure controlled slow delivery. A main contribution anticipated is the application of nanoparticles to stabilise biocontrol

preparations that will go a long way in reducing the environmental hazard. A major hurdle in the removal of harmful field, which was costly with conventional methods. Nanotechnology, by exploiting the unique properties of nanomaterials, has developed nanosensors capable of detecting pathogens at levels as low as parts per billion.

REFERENCES

1. Orive, G., Hernandez, R.M., Gascon, A.R. and Pedraz, J.L. (2005) 'Micro and nano drug delivery systems in cancer therapy', *Cancer Therapy*, Vol.3, pp.131-138.
2. Liu, Z., Tabakman, S., Welscher, K. and Dai, H. (2009) 'Carbon nanotubes in biology and medicine: In vitro and in vivo Detection, Imaging and Drug Delivery', *Nano Research*, Vol. 2, pp.85-120.
3. Virji, S., Kojima, R., Fowler, J.D., Villanueva, J.G., Kaner, R.B. and Weiller, B.H. (2009) 'Polyaniline Nanofiber Composites with Amines: Novel Materials for Phosgene Detection', *Nano Research*, Vol. 2, No. 2, pp.135-142.
4. Wang, Z.L. (2008) 'Energy Harvesting for SelfPowered Nanosystems', *Nano Research*, Vol. 1, pp.1-8.
5. Ferrari, M. (2005) 'Cancer Nanotechnology: Opportunities and Challenges', *Nature Reviews Cancer*, Vol. 5, pp.161-171.
6. Wang, D., Xie, T. and Li, Y. (2009) 'Nanocrystals: Solution-Based Synthesis and Applications as Nanocatalysts', *Nano Research*, Vol. 2, pp.30-46.
7. Norton, M.G., McIlroy, D.N., Corti, G., Miller, M.A. (2009) 'Silica Nanosprings – A Novel Nanostructured Material for Hydrogen Storage', *Nanotech Conference and Expo*, May 3-7, 2009, Houston, Texas, US.
8. Zhihong Chen, Yu-Ming Lin, Michael J. Rooks, Phaedon Avouris (2007), 'Graphene nano-ribbon electronics', IBM T. J. Watson Research Center, Yorktown Heights, NY 10598, USA.
9. Vladimir V. Mitin, Viatcheslav A. Kochelap, Michael A. Strosio (2007), 'Introduction to Nanoelectronics', Cambridge University Press.
10. Jain NK, *Advances in Controlled and Novel Drug Delivery*. . CBS publisher New Delhi, 2001, Allemann E., Gurny R. and Doelker E. (1992) *International Journal of Pharmaceutics*, 87, 247 Bailey, R. E., Smith, A.M., Nie S. Quantum dots in biology and medicine. *Physica E* (2004), 25, 1–12 Bertling W. M., Garies M., Paspaleeva V., Zimer A., Kreuter J., 12. Numborg E. and Harrer P. (1989) *Biotechnol. Appl. Biochem.* 13, 390 Bindschaedler C., Gurny R. and Doelker E. (1990) US patent 4, 968, 350.
13. Hari Singh Nalwa and Thomas Webster (editors), *Cancer Nanotechnology: Nanomaterial for Cancer Diagnosis and Therapy*, American Scientific Publishers, USA, 2007 Controlled novel drug delivery. Jain NK, editor. 2nd ed. CBS publisher New Delhi, 2002 Dinauer N, Balthasar S, Weber C, Kreuter J, Langer K, Von 14. Briesen H (2005). Selective targeting of antibody-conjugation nanoparticles to leukemic cells and primary T-lymphocytes. *Biomaterials*, 26:5898-5906. De Jaeghere F., Doelker E., and Gurny R. (1999) In: 15. *Encyclopedia of controlled drug delivery*, Mathiowitz, E. (Ed.), vol II, John Wiley and sons, New York, 641. Ferrari, M. *Cancer nanotechnology: opportunities and challenges*. *Nature Reviews/Cancer*. (2005) 5, 161-171. Fessi H., Puisieux F., Devissaguet J.P., Ammoury N. and Benita S. (1989). *International Journal of Pharmaceutics*. 55, R1. Gupta P.k, Hung C.T, Lam F.C. and Perrier D.G. (1987b) 16. *International Journal of Pharmaceutics*, 43, 167. Gupta P.k, Gallo J. M, Hung C.T and Perrier D.G. (1987a) *Drug Development and Industrial Pharmacy*. 13, 1471. http://crnano.typepad.com/crnblog/2006.03/new_risks_new_f.html. <http://www.ninger.com/dendrimer/01.gif>. http://www.gkss.de/templates/images_d/werkstoff/micelle.jpg. http://nanoengineer_1.com/contents/index.php? Ibrahim H., Bindschaedler C., Doelker E., P. and Gurny R. (1992) 17. *International Journal of Pharmaceutics*, 87, 239. Jain, K.K. The role of nanotechnology in drug discovery. 18. *Drug Discovery Today* (2005) 10 (21), 1435-1442. Jain S., Jain N.K. Liposomes as drug carrier, In: Jain NK, editor. *Controlled and novel drug delivery*, 2nd edition, CBS publisher, New Delhi, 2002, 304-52. J. 19. Kreuter and I. Haenzel, *Infect. Immun.*, *Journal of pharmaceutical sciences* 19667 (1978). Kreuter J. (1991) *Journal of controlled Release*, 16, 169. Kreuter J. (1983) *International Journal of Pharmaceutics*, 14, 43. Kreuter J. (1994) 20. *European Journal of Drug metabolism and Pharmacokinetics*, 19, 253. Kreuter and Speiser, 1976. *Journal of Pharmaceutical sciences* 65, 1624. Khopde AJ, Jain, NK. Dendrimer as potential delivery system for bioactive In: Jain NK, editor. *Advances in controlled and novel drug delivery*. CBS publisher, New Delhi, 2001, 361-80. Kubik, T. Bogunia-Kubik K., 21. Sugisaka M. *Nanotechnology on Duty in Medical Applications*, *Current Pharmaceutical Biotechnology*. (2005) 6, 17-33. Li V. H., Wood R. W., Kreuter J., Harmia T. And Robinson J. R. (1986) *Journal of Microencapsulation*. 3, 213 Labhasetwar V., Song C. X., Humphrey W.R., Shebuski R.J. (1995), *Proceedings of International Symposia, Control Release 22. Bioactive Materials*, 22, 182. Labhasetwar V, Song C. X. and Levy R. *Journal of Advanced Drug Delivery*, Review article, 24, 63. Langer K. (1996) *International Journal of Pharmaceutics*, 137,



23. Lukowski G., Muller R.H., Muller B.W. and Dittgen M. (1992) International Journal of Pharmaceutics, 84, 23. Molpeceres J., Guzman M., Aberturas M.R., 24. Chacon M. and Berges L. (1996) Journal of Pharmaceutical Sciences. 85, 206. Maincent P., Marchal-Heussler I., Sirbat D., Thouvenot. 25. Hoffman M. and Vallet J.A. (1992), Proceedings of International Symposia, Control Release Bioactive Materials, 18, 226. Nanoparticles: From Theory to Application. Edited by Gunter Schmid, Wiley-Vch Verlag GmbH & Co.KGAA, Weinheim, 2004 Nahar M, Dutta T, Murugesan S, Asthana A, Mishra D, 26. Rajkumar V, Tare M, Saraf S, Jain NK. Functional polymeric nanoparticles: an efficient and promising tool for active delivery of bioactives. Critical Reviews in Therapeutic Drug Carrier Systems. (2006) 23(4), 259-318. Journal of Applied Pharmaceutical Science 01 (02); 2011: 08-16 Quintanar-Guerrero D, Fessi H, Alleman E. and Doelker E. (1996) International Journal of Pharmaceutics, 143, 133. Senthilkumar M, Subramanian G, 27. Ranjit Kumar A, Nahar M, Mishra P, Jain N.K. PEGylated Poly (Lactide-co-Glycolide) (PLGA) nanoparticulate delivery of Docetaxel: synthesis of diblock copolymers, optimization of preparation variables on formulation characteristics and in vitro release studies. Journal of 28. Biomedical Nanotechnology, (2007) 1, 52-60. Sinha N, Yeow J.T.W. Carbon Nanotubes for Biomedical Applications. IEEE transactions on nanobioscience. 2005 4(2) 180195. Song C.X., Labhassetwar V., Guzman L., Topol E. and Levy R.J. (1995), Proceedings of 29. International Symposia, Control Release Bioactive Materials, 22, 444. Schroder U. and Sthal A. (1984) J Immunol Methods, 70, 127 Targeted and controlled drug delivery S.P.Vyas and R.K.Khar. Wickline S.A, Lanza G.M. Molecular Imaging, Targeted 30. Therapeutics, and Nanoscience. J Cell Biochem, Supplement (2002)39, 90-97. Widder K, Flouret G and Senyei A. (1979) Journal of Pharmaceutical Sciences, 68, 79.



INNO SPACE
SJIF Scientific Journal Impact Factor
Impact Factor: 8.423



ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

9940 572 462 **6381 907 438** **ijirset@gmail.com**



www.ijirset.com

Scan to save the contact details