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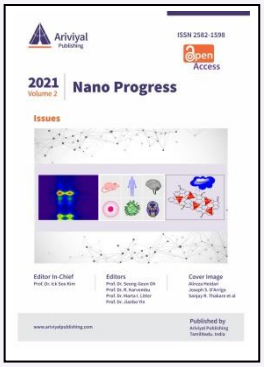

Nano toxicology for Safety Assessment of Sophisticated Nanomaterials

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Abstract: Nano toxicology, examines the conceivable harmfulness of nanoparticles, with a strong prerequisite for a drew in assessment program facilitated towards totally understanding the association of size and surface area on the assertion, development, and toxicity of nanoparticles. To work with progress of inclination in this multidisciplinary area, Nano toxicological data should be exchanged through virtual associations that facilitate toxicologists, material analysts, researchers, physicists, and clinical trained professionals to acknowledge the risks attained from nanotechnology. Therefore, nanotechnology to the economy and to our future success is past talk, but its potential opposing impacts ought to be focused also.

Keywords: Physicochemical; Polysaccharide chitosan; Fullerenes; Super paramagnetic; Nanotubes

1. Introduction

Nanotechnology covers the inspection and control of particles at the Nano scale (1–100 nm) level, normally known as nanoparticles.[1] Nanoparticles have fascinating mechanical and physicochemical properties as a result of their extended relative surface area and quantum impacts, inclining toward their usage in various applications.[2] In the earlier decade, the area of nanotechnology has evolved due to its wide implementation in biotechnology, avionics and biomedical industries.[3] Even more lately, nanotechnology is furthermore applied to the field of Nano medicine, which covers nanotechnology-based diagnostics, treatment and identification of human contaminations like threat, dealing with human prosperity and success.[4] In addition, nanoparticles play a significant role in targeted drug delivery in Nano medicine.[5] They can be arranged into carrier molecules like polymers, inorganic nanoparticles and metallic nanoparticles, for instance, polysaccharide chitosan nanoparticles (CS-NPs) work in drug transport in light of their ability to work with both proteins and prescription formulations.[6,7] The polymer-protein structures update protein steadfastness anyway decreases immunogenicity, while the polymer-drug structures show further developed vulnerability and support impacts.[8] Even more, the polymeric nanoparticle poly-lactic-co-glycolic corrosive (PLGA) has in like manner been used as a nanocarrier for drug transport across blood due to its biocompatibility and biodegradability, thus ensuring safe treatment.[9,10] On the other hand, inorganic nanoparticles like silica, titania and alumina are moreover typically being used for drug delivery on account of their porous nature, regardless of the way that their applications are confined in view of their non-biodegradable nature.[11,12] Metallic nanoparticles, including super paramagnetic iron oxide nanoparticles, gold shell nanoparticles and titanium dioxide (TiO_2) nanoparticles, are consistently used for resonation imaging contrast development,[13] while silver nanoparticles (AgNPs) are being researched as antibacterial experts for treatment of overwhelming microbe associated ailments.[14] Amazingly, carbon nanoparticles, such as fullerenes and nanotubes, are the most extensively used materials for drug transport purposes due to their compatible structural conformation and nanotubes offer high electrical conductivity and strength.[15,16] Nanoparticles have been used as an instrument for the identification of disease biomarkers in both invivo and exvivo applications, accordingly provoking a movement of proteomics and genomics progressions.[17] For example, streptadivin-covered fluorescent polystyrene Nano spheres offer more unmistakable affectability in the acknowledgment of epidermal advancement factor receptor (EGFR) in human carcinoma cells, hence giving a more sensitive device to biomarker divulgence.[18] Besides, an ultrasensitive nanoparticle-based analyser for the identification of prostate-unequivocal antigen

(PSA) in the serum was made, which can offer up to six huge degrees higher affectability than the standard measure.[19] Subsequently, nanoparticles have moreover obtained noticeable eminence in the field of sub-nuclear examination and imaging such as in appealing resonation imaging (MRI), fluorescence imaging, figured tomography imaging and ultrasound techniques, on account of their ideal physicochemical properties of nanoparticle size, flexibility of surface covering and up gradation.[20,21] Gadolinium based paramagnetic nanoparticles targeting fibrin in atherosclerotic plaques considered seriously convincing imaging agents when diverged from the usually used separation subject matter experts; subsequently progressing early disclosure of frail plaques.[22,23] Particularly, nanoparticle definitions passing on antagonistic to harmful development drugs, including paclitaxel, 5-fluorouracil and doxorubicin, have been believed to be more capable prescription transport structures, by updating the cytotoxic effects of the medicine while reducing dubious centering of normal cells.[24,25]

2. Toxicity of Nanoparticles

Regardless of the uprising acclaim of nanotechnology in the field of medicine, their applications have been bound in light of their normal destructiveness and long stretch discretionary antagonistic effects.[26] Nano toxicology involves the investigation of Nanomaterials toxicity to comprehend and evaluate the overwhelming utilization of nanoparticles.[27] The physicochemical properties of nanoparticles though favour their utilization in Nano medicine, but have additionally been found to add to their improved toxicological incidental effects as well.[28] In particular, molecule size and surface region are viewed as significant components that contribute straightforwardly and altogether to the toxicity of nanoparticles.[29] Aside from size, construction and state of the nanoparticle likewise add to Nano toxicity for instance, concentrates with carbon nanofibers, single- nanotubes (SWCNTs) and multi- nanotubes (MWCNTs), have uncovered that the harmfulness of carbon material with high-viewpoint proportion is controlled by molecule structure and measurements.[30,31] In addition, the nanoparticle surface directs the adsorption of particles and biomolecules, in this manner affecting the cell reactions evoked, and consequently adding to nanoparticle instigated toxicity.[32] Individuals can be introduced to Nanomaterials through a couple courses like internal breath, implantation, oral ingestion and the dermal course.[33] Specifically, the respiratory structure, gastrointestinal plot, the circulatory structure similarly as the central tangible framework are known to be inimically impacted by nanoparticles.[34] In vivo studies have uncovered that carbon nanotubes are found to cause segment subordinate epithelioid granulomatous wounds in the lung and vigorous interstitial irritation on steady transparency.[35] In addition, nanoparticles, typically used for drug transport, have been represented to show oxidative strain/cytotoxic development in the lungs, liver, heart, and brain, similarly as have teratogenic/disease causing impacts.[36] Just as causing horrible respiratory effects, nanoparticles constrained through implantation have been shown to enter the crucial spread, causing discretionary intricacies in the circulatory structure and further access the central tactile framework.[37] Carbon nanoparticles and nanotubes were found to provoke the amassing of platelets in vitro, and the effect of SWCNTs was packed in cell models of human kidney and bronchi, where they supposedly prompted cell apoptosis and reducing cell grasp through either up regulating quality related with cell downfall or down regulating characteristics related with cell increase and perseverance.[38,39] Besides the effect of TiO_2 nanoparticles were found to frustrate cell perseverance rates in a piece subordinate way, with over the top effects, for instance, blood-frontal cortex deterrent obliteration, cell oedema and brain tissue rottenness.[40] Besides, Nano-manganese dioxide (MnO_2) was moreover found to cause dopaminergic neuronal brokenness and astrocyte inception, subsequently affecting the learning limits of rodents.[41] Thus, the collection of nanoparticles in different organs and antagonistic incidental effects have upset their utilization in the field of Nano medication, and have stopped full misuse of their potential in sub-atomic diagnostics and as medication conveyance frameworks.[42] A superior comprehension of the systems engaged with Nano toxicity might give hints to going around the toxicological impacts of nanoparticles and may assist with advancing create/abuse nanoparticles in the field of Nano medicine.[43] Silica nanoparticles (SNPs) are undeniably used in added substances to excellence care items, drugs, printer toners, stains, and food.[44] Additionally, SNPs are used in biomedical and biotechnological applications like therapy, DNA transfection, drug movement, and compound immobilization.[45] Ultrafine particles (<0.1 µm) have been displayed to cause more conspicuous combustible responses and lung sicknesses than fine particles (<2.5 µm) per given mass.[46] Nanoparticles may incite provocative or immunological responses when enter the blood or the central tactile framework, where they might potentially clearly impact cardiovascular and cerebral limits.[47]

3. Conclusions

Therefore, Nano toxicology should be portrayed to address openings in data and to expressly resolve the extraordinary issues inclined to be achieved by nanoparticles. A discipline of Nano toxicology would make a huge obligation to the headway of a conservative and safe nanotechnology.

Conflicts of Interest

The authors declare no conflict of interest.

References

1 Poole Jr C.P.; Owens F.J. Introduction to Nanotechnology. John Wiley & Sons, 2003. [Link]
2 Bhushan B. Springer Handbook of Nanotechnology Berlin: Springer. 2007, **2**. [Link]
3 McNeil S.E. Nanotechnology for the Biologist. *J. Leukoc. Biol*., 2005, **78**, 585-594. [CrossRef]
4 Vo-Dinh T. Nanotechnology in Biology and Medicine: Methods, Devices, and Applications. *CRC Press,* 2007. [CrossRef]
5 Kim B.Y.; Rutka J.T.; Chan W.C. Nanomedicine. *N. Engl. J. Med*., 2010, **363**, 2434-2443. [Link]
6 Lemarchand C.; Gref R.; Couvreur P. Polysaccharide-Decorated Nanoparticles. *Eur. J. Pharm. Biopharm*., 2004, **58**, 327-341. [CrossRef]
7 Pan Y.; Li Y.J.; Zhao H.Y.; Zheng J.M.; Xu H.; Wei G.; Hao J.S. Bioadhesive Polysaccharide in Protein Delivery System: Chitosan

Nanoparticles Improve the Intestinal Absorption of Insulin in Vivo. *Int. J. Pharm*., 2002, **249**, 139-147. [CrossRef]
8 Janes K.A.; Calvo P.; Alonso M.J. Polysaccharide Colloidal Particles as Delivery Systems for Macromolecules. *Adv. Drug Deliv. Rev*., 2001, **47**, 83-97. [CrossRef]
9 Danhier F.; Ansorena E.; Silva J.M.; Coco R.; Le Breton A.; Preat V. PLGA-based Nanoparticles: an Ooverview of Biomedical Applications. *J. Control. Release*, 2012, **161**, 505-522. [CrossRef]
10 Makadia H.K.; Siegel S.J. Poly Lactic-co-glycolic Acid (PLGA) as Biodegradable Controlled Drug Delivery Carrier. *Polymers*, 2011, **3**, 1377-1397. [CrossRef]
11 Xu Z.P.; Zeng Q.H.; Lu G.Q.; Yu A.B. Inorganic Nanoparticles as Carriers for Efficient Cellular Delivery. *Chem. Eng. Sci*., 2006, **61**, 1027-1040. [CrossRef]
12 Nie Z.; Petukhova A.; Kumacheva E. Properties and Emerging Applications of Self-Assembled Structures Made from Inorganic Nanoparticles. *Nat. Nanotechnol*., 2010, **5**, 15-25. [CrossRef]
13 Na H.B.; Song I.C.; Hyeon T. Inorganic Nanoparticles for MRI Contrast Agents. *Adv. Mater*., 2009, **21**, 2133-2148. [CrossRef]
14 Rai M.; Yadav A.; Gade A. Silver Nanoparticles as a New Generation of Antimicrobials. *Biotechnol. Adv*., 2009, **27**, 76-83. [CrossRef]
15 Melanko J.B.; Pearce M.E.; Salem A.K. Nanotubes, Nanorods, Nanofibers, and Fullerenes for Nanoscale Drug Delivery. In Nanotechnology in drug delivery, 2009, 105-127. Springer, New York, NY. [CrossRef]
16 Li Y.; Liao K.; Lee S. A Comparative Study of Antioxidant-Loaded Carbon Nanoparticles as Drug Delivery Vehicles. *RSC Adv*., 2014, **4**, 56992-56997. [CrossRef]
17 Geho D.H.; Jones C.D.; Petricoin E.F.; Liotta L.A. Nanoparticles: Potential Biomarker Harvesters. *Curr. Opin. Chem. Biol*., 2006, **10**, 56-61. [CrossRef]
18 Shi D.; Cho H.S.; Chen Y.; Xu H.; Gu H.; Lian J.; Wang W.; Liu G.; Huth C.; Wang L.; Ewing R.C. Fluorescent Polystyrene–Fe3O4 Composite Nanospheres for in Vivo Imaging and Hyperthermia. *Adv. Mater*., 2009, **21**, 2170-2173. [CrossRef]
19 de la Escosura-Muniz A.; Ambrosi A.; Merkoçi A. Electrochemical Analysis with Nanoparticle-based Biosystems. *TrAC Trends Anal. Chem*., 2008, **27**, 568-584. [CrossRef]
20 Kim E.H.; Lee H.S.; Kwak B.K.; Kim B.K. Synthesis of Ferrofluid with Magnetic Nanoparticles by Sonochemical Method for MRI Contrast Agent. *J. Magn. Magn. Mater*., 2005, **289**, 328-330. [CrossRef]
21 Bogart L.K.; Pourroy G.; Murphy C.J.; Puntes V.; Pellegrino T.; Rosenblum D.; Peer D.; Levy R. Nanoparticles for Imaging, Sensing, and Therapeutic Intervention. *ACS Nano*, 2014, **8**, 3107-3122. [CrossRef]
22 Ghaghada K.B.; Ravoori M.; Sabapathy D.; Bankson J.; Kundra V.; Annapragada A. New Dual Mode Gadolinium Nanoparticle Contrast Agent for Magnetic Resonance Imaging. *PloS one*, 2009, **4**, 7628. [CrossRef]
23 Taupin F.; Flaender M.; Delorme R.; Brochard T.; Mayol J.F.; Arnaud J. Perriat P.; Sancey L.; Lux F.; Barth R.F.; Carriere M. Gadolinium Nanoparticles and Contrast Agent as Radiation Sensitizers. *Phys. Med. Biol*., 2015, **60**, 4449. [Link]
24 Robidoux A.; Buzdar A.U.; Quinaux E.; Jacobs S.; Rastogi P.; Fourchotte V.; Younan R.J.; Pajon E.R.; Shalaby I.A.; Desai A.M.; Fehrenbacher L. A Phase II Neoadjuvant Trial of Sequential Nanoparticle Albumin-Bound Paclitaxel Followed by 5-Fluorouracil/Epirubicin/Cyclophosphamide in Locally Advanced Breast Cancer. *Clin. Breast Cancer*, 2010, **10**, 81-86. [CrossRef]
25 Joseph N.M.; Sharma P.K. Nanoparticle: Drug Delivery System for Cancer Therapy. *Asian J. Pharm.*, 2014, **2**. [CrossRef]
26 Zoroddu M.A.; Medici S.; Ledda A.; Nurchi V.M.; Lachowicz J.I.; Peana M. Toxicity of Nanoparticles. *Curr. Med. Chem*., 2014, **21**, 3837-3853. [CrossRef]
27 Bahadar H.; Maqbool F.; Niaz K.; Abdollahi M. Toxicity of Nanoparticles and an Overview of Current Experimental Models. *Iran. Biomed. J*., 2016, **20**, 1. [CrossRef]
28 Fard J.K.; Jafari S.; Eghbal M.A. A Review of Molecular Mechanisms Involved in Toxicity of Nanoparticles. *Adv. Pharm. Bull*., 2015, **5**, 447. [CrossRef]
29 Huang Y.W.; Cambre M.; Lee H.J. The Toxicity of Nanoparticles Depends on Multiple Molecular and Physicochemical Mechanisms. *Int. J. Mol. Sci.*, 2017, **18**, 2702. [CrossRef]
30 Kobayashi N.; Izumi H.; Morimoto Y. Review of Toxicity Studies of Carbon Nanotubes. *J. Occup. Health*, 2017, 17-0089. [CrossRef]
31 Liu Y.; Zhao Y.; Sun B.; Chen C. Understanding the toxicity of carbon nanotubes. *Acc. Chem. Res*., 2013, **46**, 702-713. [CrossRef]
32 Khalid P.; Hussain M.A.; Suman V.B.; Arun A.B. Toxicology of Carbon Nanotubes-a Review. *Int. J. Appl. Eng. Res*., 2016, **11**, 148-157. [Link]
33 Aydın A.; Sipahi H.; Charehsaz M. Nanoparticles Toxicity and their Routes of Exposures. *Recent Advances in Novel Drug Carrier Systems*, 2012, 483-500. [Link]
34 Elsaesser A.; Howard C.V. Toxicology of Nanoparticles. *Adv. Drug Deliv. Rev*., 2012, **64**, 129-137. [CrossRef]
35 De Matteis V. Exposure to Inorganic Nanoparticles: Routes of Entry, Immune Response, Biodistribution and in Vitro/in Vivo Toxicity Evaluation. *Toxics*, 2017, **5**, 29. [CrossRef]
36 Ostiguy C.; Lapointe G.; Trottier M.; Menard L.; Cloutier Y.; Boutin M.; Antoun M.; Normand C. Health Effects of Nanoparticles. 2006. [Link]
37 Aitken R.J.; Creely K.S.; Tran C.L. Nanoparticles: An Occupational Hygiene Review, 2004, 41-44. London: HSE books. [Link]
38 Magrez A.; Kasas S.; Salicio V.; Pasquier N.; Seo J.W.; Celio M.; Catsicas S.; Schwaller B.; Forro L. Cellular Toxicity of Carbon-Based Nanomaterials. *Nano Lett.*, 2006, **6**, 1121-1125. [Link]
39 Panessa-Warren B.J.; Warren J.B.; Wong S.S.; Misewich J.A. Biological Cellular Response to Carbon Nanoparticle Toxicity. *J. Phys: Condens. Matter*, 2006, **18**, S2185. [Link]
40 Dar G.I.; Saeed M.; Wu A. Toxicity of TiO_2 Nanoparticles. TiO_2 Nanoparticles: Applications in Nanobiotechnology and Nanomedicine, 2020, 67-103. [CrossRef]
41 Mate Z.; Szabo A.; Paulik E.; Papp A. Experimental Neurophysiological Alterations Caused By Combined Nano-Manganese Exposure. Editorial Board, 2011, 17. [Link]
42 El-Ansary A.; Al-Daihan S. 2009. On the Toxicity of Therapeutically used Nanoparticles: An Overview. *J. Toxicol*., 2009. [CrossRef]
43 Jeevanandam J.; Barhoum A.; Chan Y.S.; Dufresne A.; Danquah M.K. Review on Nanoparticles and Nanostructured Materials: History, Sources, Toxicity and Regulations. *Beilstein J. Nanotechnol*., 2018, **9**, 1050-1074. [Link]
44 Slowing I.I.; Vivero-Escoto J.L.; Trewyn B.G; Lin V.S.Y. Mesoporous Silica Nanoparticles: Structural Design and Applications. *J. Mater. Chem*., 2010, **20**, 7924-7937. [Link]
45 Wang Y.; Zhao Q.; Han N.; Bai L.; Li J.; Liu J.; Che E.; Hu L.; Zhang Q.; Jiang T.; Wang S. Mesoporous Silica Nanoparticles in Drug Delivery and Biomedical Applications. *Nanomed.: Nanotechnol. Biol. Med*., 2015, **11**, 313-327. [CrossRef]
46 Kim I.Y.; Joachim E.; Choi H.; Kim K. Toxicity of Silica Nanoparticles Depends on Size, Dose, and Cell Type. *Nanomed.: Nanotechnol. Biol. Med*., 2015, **11**, 1407-1416. [CrossRef]
47 Chen L.; Liu J.; Zhang Y.; Zhang G.; Kang Y.; Chen A.; Feng X.; Shao L. The Toxicity of Silica Nanoparticles to the Immune System. *Nanomedicine*, 2018, **13**, 1939-1962. [CrossRef]