AN OVERVIEW ON USES OF ZINC OXIDE NANOPARTICLES

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ABSTRACT

Nanotechnology is a very fresh field of research in 21st century. Due to distinctive properties Nanoparticles (NPs) are used in different fields. Out of all other Metal nanoparticles zinc oxide nanoparticles are most important, as these are used in biomedical, gas sensors, drug-delivery systems, biosensors, cosmetics and agriculture etc. Current research shows that the nanoparticles are used in waste water management, textile and medicine also. In this review paper an attempt has been made to elaborate the uses of Zinc oxide nanoparticles.

KEYWORDS: Nanoparticles, ZnO, Cancer, Anti microbial activity.

INTRODUCTION

Nanotechnology deals with nanoparticles that are atomic or molecular aggregates characterized by size less than 100 nm. These are actually modified form of basic elements derived by altering their atomic as well as molecular properties of elements [Wang, Z. L. 2004 and Suchea, M, et al., 2006]. The application of nanotechnology in medical applications, commonly referred as “nanomedicine”, seeks to deliver a new set of tools, devices and therapies for treatment of human disease. Nanomaterials that can act as biological mimetic, “nanomachines”, biomaterials for tissue engineering, shape-memory polymers as molecular switches, biosensors, laboratory diagnostics and nanoscale devices for drug release, are just a few of the applications being explored [Wagner V, et al., 2006 ; Ferrari M. 2005 and Panchal RG 1998 ].

ZnO nanoparticles are systemically absorbed, which elevates the zinc level in the liver, adipose tissue and pancreas [Umran and Paknikar, 2014]. The cytotoxicity of ZnO nanoparticles on antioxidant enzyme activities and mRNA expression in the co-cultured C2C12 and 3T3-L1 cells [Muthuraman et al., 2015] and the dose-dependent effect of ZnO...
nanoparticles on oxidative stress and antioxidant enzyme activity in adipocytes [Muthuraman 
et al., 2014]. Muthuraman Pandurangan and Doo Hwan Kim, 2015 reported that the indution of oxidative stress is the vital part of the cytotoxicity of ZnO nanoparticles. In summary, ALT, AST, ALP and LDH enzyme mRNA expressions and their activities were significantly increased in a dose-dependent manner. The present study showed that the ZnO nanoparticles significantly produced cytotoxicity in C2, C12 cells.

**Chemistry of ZnO nanoparticles**

In ZnO nanoparticles Zn atom have atomic no. 30 and belongs to d-block and O have atomic no.8 belonging to p-block in periodic table. ZnO is described as a functional, strategic, promising and versatile inorganic material with a broad range of applications. [Y.G. Gertrude Neumark and I. Kuskovsky 2007]. The electrostatic characteristics of ZnO nanoparticles are another useful feature for biomedical applications. Zinc oxide nanoparticles typically have neutral hydroxyl groups attached to their surface, which plays a key role in their surface charge behaviour [Qu F. and Morais P. C. 1999; Qu F. and Morais P. C. 2001]. In aqueous medium and at high pH, the chemisorbed protons (H⁺) move out from the particle surface leaving a negatively charged surface with partially bonded oxygen atoms (ZnO⁻). At lower pH, protons from the environment are likely transferred to the particle surface, leading to a positive charge from surface ZnOH₂⁺ groups. The isoelectric point of 9–10 [Degen A and Kosec M. 2000] indicates that ZnO nanoparticles will have a strong positive surface charge under physiological conditions. zinc oxide nanoparticles are used considerably for its catalytic, electrical, optoelectronic and photochemical properties [Brida, D et al. 2002; Wang, Z L 2004; Suchea, M, et al., 2006 and Ashour, A et al., 2006].

ZnO nanostructures have a great advantage to apply to a catalytic reaction process due to their large surface area and high catalytic activity [Huang et al. 2006]. One-dimensional nanostructures exhibit interesting electronic and optical properties due to their low dimensionality leading to quantum confinement effects [Baruah, S. and Dutta, J. 2009]. Cancer cells frequently contain a high concentration of anionic phospholipids on their outer membrane and large membrane potentials [Abercrombie M and Ambrose EJ. 1962; Bockris JOM and Habib MA. 1982 and Papo N et al., 2003], interactions with positively charged ZnO nanoparticles are expected to be driven by electrostatic interactions, thereby promoting cellular uptake, phagocytosis and ultimate cytotoxicity.
The concentration of various chemical groups \((-\text{ZnOH}_2^+, -\text{ZnOH}, -\text{ZnO}^-)\) on the surface of ZnO nanoparticles is pH dependent [Nagao M. 1971]. The availability of chemical reactive groups lends ZnO nanoparticles to antibody/protein functionalization via N-hydroxysuccinimide/1-ethyl-3-(3-dimethyl-aminopropyl) carbodiimide (NHS/EDC) coupling chemistry [Grabarek Z and Gergely J. (1990)], as well as other standard coupling approaches, which can further improve cancer cell targeting. ZnO nanoparticles have also been shown to exhibit strong protein adsorption properties, which can be used to modulate cytotoxicity, metabolism or other cellular responses [Horie M et al., 2009].

Another important feature of ZnO nanoparticles is the relatively straightforward process that allows their size and size distribution to be controlled. Studies demonstrate that the cytotoxic properties of ZnO nanoparticles against cancerous cells is directly related to size, with smaller nanoparticles exhibiting greater toxicity [Guo D, et al., 2008; Nair S, et al., 2009 and Hanley C, et al., 2009]. By tailoring nanoparticle size, it is possible to take the greatest advantage of the EPR/enhanced permeation and retention effect for increasing intra-tumour concentrations. Another important consideration is that hydrophilic nanoparticles of 100 nm size or less tend to remain in circulation considerably longer and are more likely to avoid clearance by macrophages and rapid serum clearance by the reticule endothelial system. In contrast, particles with a preponderance of hydrophobic surfaces tend to be preferentially taken up by the liver, followed by the spleen and lungs [Brannon-Peppas L and Blanchette JO. 2004]. The ability to modify the surface and electrostatic characteristics (zeta-potential) of ZnO nanoparticles is a desirable feature, as well as their spherical morphology which is well suited for removal from the blood stream by the kidneys to help avoid build up of these materials in the liver. The zeta potential of metal oxide nanoparticles can be varied from $-30$ mV in uncoated samples to $+50$ mV when coated with cationic surfactants such as CTAB (cetyltrimethyl ammonium bromide), by using different anionic, cationic and non-ionic surface groups including polymethyl methacrylate, sodium dodecyl sulfate, bovine serum albumin and by varying reaction medium and chemical precursors [Gorelikov I and Matsuura N. 2008; Brayner R, et al., 2006].

**Reactive oxygen species**

ZnO nanoparticles, have the ability to induce reactive oxygen species (ROS) generation, which can lead to cell death when the antioxidative capacity of the cell is exceeded [Xia T, et al., 2006; Ryter SW, et al., 2007; Long TC, Saleh N, et al., 2006; Lovric J, et al., 2005;
Lewinski N, et al. 2008]. The ability of ZnO nanoparticles to generate ROS is related to their semiconductor properties. Unlike metals, which have a range of electronic states, the electrons in semiconductors can have energies only within certain bands. The void region which extends from the top of the filled valence band to the bottom of the vacant conduction band is called the band gap and is ~3.3 eV for crystalline ZnO [Lany S, et al., 2007]. Consequently, light of certain wavelengths (i.e. UV) contains sufficient energy to promote electrons ($e^-$) to the conduction band to leave behind electron holes ($h^+$), or unoccupied states in the valence band. Electrons and holes often recombine quickly, but can also migrate to the nanoparticle surface where they react with adsorbed species enabling 1) electrons to react with oxygen and 2) holes to react with hydroxyl ions or water to form superoxide and hydroxyl radicals. Such photo-oxidations by ZnO have been traditionally used for photo catalytic oxidation of organic and inorganic pollutants, and sensitizers for the photo destruction of cancer cells [Y. Kubota, et al., 1994; Cai R, et al., 1991; Cai R, et al., 1992] and bacteria [Nair S, et al., 2009] via oxidative damage.

However, for nanoscale ZnO, large numbers of valence band holes and/or conduction band electrons are thought to be available to serve in redox reactions even in the absence of UV light [Yang H, et al., 2009]. One of the reasons is that as ZnO nanoparticle size decreases, so does the nanocrystal quality, which results in increased interstitial zinc ions and oxygen vacancies and possibly donor/acceptor impurities [Sharma S, et al., 2009]. These crystal defects can lead to a large number of electron-hole pairs ($e^- - h^+$). The holes are powerful oxidants and can split water molecules derived from the ZnO aqueous environment into $H^+$ and $OH^-$. The conduction band electrons are good reducers and can move to the particle surface to react with dissolved oxygen molecules to generate superoxide radical anions ($O_2^{•−}$), which in turn react with $H^+$ to generate (HO$_2^•$) radicals. These HO$_2^•$ molecules can then produce hydrogen peroxide anions (HO$_2$) following a subsequent encounter with electrons. Hydrogen peroxide anions can then react with hydrogen ions to produce hydrogen peroxide (H$_2$O$_2$) [Salem IA. 2000 and Padmavathy N and Vijayaraghavan R. 2008]. The relative positions of the band edges for the conduction and valence band for ZnO and the redox potential for adsorbed substances provides a sufficiently large over potential (voltage differences) to drive redox reactions and ROS generation in cellular environments [Matsunaga T, et al.,1985; Kamat PV and Meisel D. 2003; Hoffman AJ, et al.,1994]. The various ROS molecules produced in this fashion can trigger redox-cycling cascades in the
cell, or on adjacent cell membranes, leading to depletion of endogenous cellular reserves of antioxidants such that irreparable oxidative damage to cells occurs.

The doping of ZnO nanoparticles with transition metal ions has been demonstrated [Lany S, et al., 2007; Hays J, et al., 2007; Sun L, Rippon JA, et al., 2009] and may be another approach to improve their therapeutic potential as transition metals can potentiate redox-cycling cascades. It is postulated that incorporation of Fe$^{+3}$ into the ZnO crystal lattice enhances the particle’s ability to generate ROS by catalyzing the dissociation of H$_2$O$_2$ to a hydroxyl radical and hydroxide ion, or to a hydrogen ion and hydroperoxy radical following the Fenton’s reaction [Pirkanniemi KAMS. 2002 and Choi W and et al. 1994]. In support of this, recent studies have shown that Fe$^{+3}$ supported on bulk ZnO improves catalytic activity for H$_2$O$_2$ production [Salem IA. 2000] and introduction of free transition metal ions can induce protein oxidation and redox state within cells [Petit A, et al., 2005]. Although a conflicting report suggests iron-doping of ZnO may not function in this manner [George S, et al., 2010], recent data from our laboratory is consistent with increased ROS capacity and may reflect differences in nanoparticle synthesis resulting in variations in surface structure and charge. Thus, the engineering of metal oxide nanoparticles to incorporate metal dopants may be a means to enhance ROS generation leading to improved cancer cell killing.

**ZnO nanoparticles as a biomarker in Cancer Treatment**

Recent studies have shown that ZnO nanoparticles exhibit a high degree of cancer cell selectivity with the ability surpass the therapeutic indices of some commonly used chemotherapeutic agents in similar ex vivo studies [Hanley C, et al., 2008 and Wang H, et al., 2009]. Current anticancer chemotherapies based on alkylating agents, anti metabolites, biological agents and natural products frequently fail to produce a complete anti-cancer response due to the development of drug resistance or their failure to effectively differentiate between cancerous and normal cells. This indiscriminate action frequently leads to systemic toxicity and debilitating adverse effects in normal body tissues including bone marrow function suppression, neurotoxicity, and cardiomyopathy, which greatly limits the maximal allowable dose of the chemotherapeutic drug [Nie S, et al., 2007 and Bosanquet AG and Bell PB. 2004].

The principal factors believed to cause properties of nanomaterials to differ from their larger micron-sized bulk counterparts include an increase in relative surface area, a greater percentage of atoms at the material’s surface, quantum effects which can affect chemical
reactivity and other physical and chemical properties [Nel A, et al., 2006 and Lanone S and Boczkowski J. 2006]. One of the advantages of this approach is that the enclosure of the expression plasmid or conjugation/absorption of the nucleic acid to the nanoparticle surface ensures safe and efficient gene delivery to the desired tissue. Another advantage relies on the capability of nanoparticles to be taken up by specific cells and internalized to the nucleus according to their surface chemistry. The feasibility of this approach has been validated by a growing number of studies including the reported in vivo studies demonstrating inhibition of metastasis in melanoma tumour bearing mice treated with poly-L-lysine modified iron oxide nanoparticles carrying the NM23-H1 gene [Li Z, et al., 2009].

The size of nanoparticles can facilitate their entry into tumour tissues, and their subsequent retention, by a process recognized as the enhanced permeation and retention (EPR) effect. Therapeutic approaches making use of the EPR effect are now recognized as the “gold-standard” in the design of new anti-cancer agents. The EPR phenomena can be described as a combination of “leaky” tumour blood vessels due to alterations in angiogenic regulators, enlarged gap junctions between endothelial cells, and compromised lymphatic drainage in the tumour microenvironment. This localized imbalance allows nanoparticles of certain sizes [Cho K, et al. 2008] to readily enter, but to be passively retained within the tumour interstitial space, thereby improving therapeutic potential. ZnO and other metal oxide nanomaterials for use as biomarkers for cancer diagnosis, screening and imaging. Recent studies have shown that ZnO nanoparticle cores capped with polymethyl methacrylate are useful in the detection of low abundant biomarkers [Shen W, et al. 2008]. Using another approach, a ZnO nanorod-based cancer biomarker assay has been developed for high-throughput detection of ultra low levels of the telomerase activity for cancer diagnosis and screening [Dorfman A, et al., 2008].

Use for Biomedical Applications
Zinc oxide (ZnO) nanopowders are available as dispersions and powders. These nanoparticles, exhibit antifungal, anti-corrosive, antibacterial and anti-corrosive properties.

Antimicrobial activity (anti fungal and anti bacterial) Antiallergic
Increased outbreaks and infections of pathogenic strains, bacterial antibiotic resistance, emergence of new bacterial mutations, lack of suitable vaccine in underdeveloped countries, and hospital-associated infections, are global health hazard to human, particularly in children. For example, infections by Shigella flexneri cause 1.5 million deaths annually, due to contaminated food and drinks by these bacteria [K. Kotloff, 1999].
Research on ZnO-NPs as antibacterial agent has become interdisciplinary linking physicists, biologists, chemists and medicine, hence it is the wide spread of their applications. One of these essential applications is in food industry as an antibacterial agent in food packaging and towards food borne pathogen. Nanomaterials possess great concern in food technology for their high reactivity, enhanced bioavailability and bioactivity and have creative surface possessions [M.L.M. Francisco Javier Gutierrez, et al., 2012]. Some of the main benefits of using NPs in food nanotechnology are the addition of NPs onto food surfaces to inhibit bacterial growth, also using of NPs as intelligent packaging materials and for nano-sensin [Q. Chaudhry and L. Castle 2011].

P. Kaur 2011 and P. Narayanan, et al., 2012 Studied that ZnO-NPs can inhibit and kill common as well as major food borne pathogens. the bactericidal activity of ZnO-NPs (8–10 nm size) against E. coli DH5a and S. Aureus was examined and found to be effective at 80 and 100 gm L-1. These concentrations disrupted the cell membrane causing cytoplasmic leakage. They tested the antibacterial activity of ZnO nanoparticles against some human pathogens such as P. aeruginosa, E. coli, S. aureus and E. faecal. They reported that ZnO-NPs have strong antibacterial activity toward these human pathogens. The liberation of the NPs, which acts as bacteriostatic or bactericidal agents onto the food surface where bacteria reside, halts the growth and thus prevents food from spoilage [H. de Azeredo, 2013]. This type of active packaging is also called antimicrobial packaging, where direct interaction occurs between the product and the NPs leading to the killing or inhibition of bacterial growth on food surfaces [N. Soares et al. 2009].

The applications of nanoparticles are wide and diverse: interactions of nanomaterials with living cells and tissues, researches in polymer nanocoupling, creation of biohybrid systems (artificial muscles), regenerative medicine (proto metrocytes and nervous cells, bone tissue), nanomedicine (drug delivery, cell therapy) and others [Meshalkin Yu.P. and Bgatova N.P. 2008 and Mikityuk M.V. 2011]. The direct addition of highly concentrated antibacterial to a packed food is not recommended. The inclusion of antibacterial agents assists either bacteriostatic or bactericidal materials to gradually diffuse into the food matrix. Hence, reducing the possibility of pathogen contamination and thus a safe product with an extended shelf life was obtained towards P. aeruginosa and E. coli which were isolated from mint leaf extract and frozen ice cream and ZnO was prepared using wet chemical method. Both bacteria showed decreased growth rate at the highest concentration 100 IL and they explained
the growth inhibition as a result of cell membrane damage through penetration of ZnO-NPs. ZnO-NPs synthesized by wet chemical method are potential antibacterial agents is due to its inherent ability to absorb UV irradiation and optical transparency. ZnO nanoparticles are used in the cosmetic industry, typically in sunscreens and facial creams [Nohynek GJ, et al., 2007].

ZnO nanoparticles have recently shown promise as cholesterol biosensors, dietary modulators for hydrolase activity relevant to controlling diabetes and hyperglycaemia, as well as cell imaging [Wang H, et al., 2009; Dhobale S, et al., 2008]. ZnO nanoparticles show promise in modulating allergic reactions via inhibition of mast cell degranulation [Yamaki K and Yoshino S. 2009]. ZnO nanowires have been shown to be biodegradable and to eventually dissolve into ions that can be adsorbed by the body and become part of the nutritional cycle, and thereby proposed for in vivo biosensing and biodetection applications [Zhou J, et al. 2006] One of the primary advantages for considering ZnO nanoparticles for use in cancer is the inherent preferential cytotoxicity against cancer cells in vitro [Hanley C, et al., 2008 and Wang H, et al., 2009].

ZnO nanoparticles have also been shown to exhibit strong protein adsorption properties, which can be used to modulate cytotoxicity, metabolism or other cellular responses [Horie M, et al., 2009]. Another important consideration is that hydrophilic nanoparticles of 100 nm size or less tend to remain in circulation considerably longer and are more likely to avoid clearance by macrophages and rapid serum clearance by the reticulo endothelial system [Papo N, et al., 2003]. One more feature of ZnO nanoparticles, as stated earlier, is their ability to induce reactive oxygen species (ROS) generation, which can lead to cell death when the antioxidative capacity of the cell is exceeded [Xia T, et al. 2006; Ryter SW et al., 2007; Long TC, et al., 2006; Lewinski N, et al., 2008].

The antibacterial mechanism of ZnO NPs involves the direct interaction between ZnO nanoparticles and cell surfaces affecting cell membrane permeability; afterwards these nanoparticles enter and induce oxidative stress in bacterial cells, which results in the inhibition of cell growth and eventually cell death; the demonstrated antibacterial activity of ZnO NP recommends its possible application in the food preservation field. It can be applied as a potent sanitizing agent for disinfecting and sterilizing food industry equipment and containers against the attack and contamination with food borne pathogenic bacteria. The NPs of ZnO showed both toxicity on pathogenic bacteria (e.g., Escherichia
coli and Staphylococcus aureus) and beneficial effects on microbes, as Pseudomonas putida, which has bioremediation potential and is a strong root colonizer [M. A. Molina, *et al.*, 2006]. ZnO NPs have attracted intensive research efforts for their unique properties and versatile applications in transparent electronics, ultraviolet (UV) light emitters, piezoelectric devices, chemical sensors and spin electronics [K. Nomura, *et al.*, 2003; T. Nakada, *et al.*, 2004].

ZnO is nontoxic; it can be used as photocatalytic degradation materials of environmental pollutants. Bulk and thin films of ZnO have demonstrated high sensitivity for many toxic gases [H.-W. Ryu, *et al.*, 2003]. Amna Sirelkhatim concluded that the potential use of ZnO-NPs for antibacterial activity. Extensive discussion was centered on the antibacterial activity of ZnO-NPs coupled with a number of influenced factors impacting the activity. Mainly, by improving factors like UV illumination, ZnO particle size, concentration, morphology, and surface modification, powerful antibacterial results would be obtained [Amna Sirelkhatim, *et al.*, 2015].


**Antidiabetic activity**

Zinc, an essential metal, is an activator for more than three hundred enzymes in the body [Haase *et al.*, 2008] and plays a key role in different metabolic pathways including glucose metabolism. Zinc promotes hepatic glycogenesis through its actions on the insulin pathways and thus improves glucose utilization [Jansen *et al.*, 2009]. Zinc is also known to keep the structure of insulin [Sun *et al.*, 2009] and has a role in insulin biosynthesis, storage and secretion [Chausmer, 1998].

Ali Alkaladi, *et al.*, (2014) ZnO NPs elucidated as anti diabetic agents. They reported that ZnO NPs are more powerful in their effect than silver nanoparticles. ZnO NPs lead to reduction of blood glucose, increased insulin level and expression, increased GK activity and expression and improved expression level of IRA, GLUT-2 in diabetic rats. Rinku D Umranì & Kishore M Paknikar (2013) reported that Oral administration of zinc oxide nanoparticles resulted in significant antidiabetic effects – that is, improved glucose tolerance,
higher serum insulin (70%), reduced blood glucose (29%), reduced non-esterified fatty acids (40%) and reduced triglycerides (48%). Nanoparticles were systemically absorbed resulting in elevated zinc levels in the liver, adipose tissue and pancreas. Increased insulin secretion and superoxide dismutase activity were also seen in rat insulinoma (RIN-5F) cells. They further concluded that Zinc oxide nanoparticles are a promising antidiabetic agent.

**Role of ZnO Nanoparticles in Agriculture**

Nanotechnology has a dominant position in transforming agriculture and food production. Nanotechnology has a great potential to modify conventional agricultural practices. Most of the agrochemicals applied to the crops are lost and do not reach the target site due to several factors including leaching, drifting, hydrolysis, photolysis and microbial degradation. Nanoparticles and nanocapsules provide an efficient means to distribute pesticides and fertilizers in a controlled fashion with high site specificity thus reducing collateral damage. Farm application of nanotechnology is gaining attention by efficient control and precise release of pesticides, herbicides and fertilizers. Nanosensors development can help in determining the required amount of farm inputs such as fertilizers and pesticides. Nanosensors for pesticide residue detection offer high sensitivity, low detection limits, super selectivity, fast responses and small sizes. They can also detect level of soil moisture and soil nutrients. Plants can rapidly absorb nanofertilizers. Nano encapsulated slow release fertilizers can save fertilizer consumption and minimize environmental pollution. Zinc oxide NPs have potential to boost the yield and growth of food crops. Peanut seeds were treated with different concentrations of zinc oxide nanoparticles. Zinc oxide nanoscale treatment (25 nm mean particle size) at 1000 ppm concentration was used which promoted seed germination, seedling vigor, and plant growth and these zinc oxide nanoparticles also proved to be effective in increasing stem and root growth in peanuts [T. N. V. K. V. Prasad, et al., 2012]. The colloidal solution of zinc oxide nanoparticles is used as fertilizer. This type of nanofertilizer plays an important role in agriculture. Nanofertilizer is a plant nutrient which is more than a fertilizer because it not only supplies nutrients for the plant but also revives the soil to an organic state without the harmful factors of chemical fertilizer. One of the advantages of nanofertilizers is that they can be used in very small amounts. An adult tree requires only 40–50 kg of fertilizer while an amount of 150 kg would be required for ordinary fertilizers. Nanopowders can be successfully used as fertilizers and pesticides as well [V. N. Selivanov and E. V. Zorin, 2001 and O. P. Raikova et al., 2006]. The yield of wheat plants grown from seeds which were treated with metal nanoparticles on average increased by 20–
25% [L. M. Batsmanova, et al. 2013]. colloidal solution of ZnO NPs is used in nanofertilizers [Sidra Sabir, et al., 2014].

ZnO nanoparticles play a significant role in agriculture, where colloidal solution of ZnO NPs is used in nanofertilizers. Application of these nanoparticles to crops increases their growth and yield. As food demand is increasing day by day the yield of staple food crops is much low. So it is need of the hour to commercialize metal nanoparticles for sustainable agriculture [Sidra Sabir, et al., 2014].

Use in water treatment

Nanoparticles are expected to play a crucial role in water purification [Stoimenov, et al., 2002]. The environmental fate and toxicity of a material are critical issues in materials selection and design for water purification. No doubt that nanotechnology is better than other technique used in water treatment but today the knowledge about the environmental fate, transport and toxicity of nanomaterials [Colvin and V.L., 2003] is still in infancy. Advances in nanoscale science and engineering suggest that many of the current problems involving water quality could be resolved or greatly diminished by using nonabsorbent, nanocatalysts, bioactive nanoparticles, nanostructured catalytic membranes, submicron, nanopowder, nanotubes, magnetic nanoparticles, granules, flake, high surface area metal particle supramolecular assemblies with characteristic length scales of 9-10 nm including clusters, micromolecules, nanoparticles and colloids have a significant impact on water quality in natural environment [Mamadou, et al., 2005].

Nanotechnology used for detection of pesticides [Nair, et al., 2004] chemical and biological substances including metals (e.g. Cadmium, copper, lead, mercury, nickel, zinc), Nutrients (e.g. Phosphate, ammonia, nitrate, nitrite), Cyanide Organics, Algae (e.g. Cyanobacterial toxins) Viruses, Bacteria, Parasites, antibiotics and Biological agents are used for terrorism. Innovations in the development of novel technologies to desalinate water are among the most exciting and seem to have promis [Diallo, et al., 2005]. Photo catalytic processes has been considered because of its simplicity, low cost, ease of controlling parameters and its high efficiency in degrading organic and inorganic substances in aqueous systems and being increasingly utilized. It has been found that CPC is readily and rapidly degraded in aqueous solution by UV/ZnO NPs in a relatively short time of about 60 min after selection of desired operational parameters (pH=8.0, ZnO NPs=40mg/100mL, [AB]= 9.0 x 10-5, [H2O2]= 8 x 10-5mol dm-3). [Asthana Shrishti, et al., 2014].
CONCLUSION
Zinc Oxide Nanoparticles are beneficial for treatment of diseases like cancer and are used against bacterial infection in agriculture in water treatment and in cosmetics.

REFERENCES


