

Review

Toxicity, phototoxicity and biocidal activity of nanoparticles employed in photocatalysis



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ABSTRACT

Photocatalytically active nanoparticles (PCNPs) are extensively investigated for numerous environmental and energy related applications. Independent from their photocatalytic properties, many PCNPs are established as additives for industrial materials (e.g. paintings or coatings) or even in foods, textiles and cosmetics, which leads to high production amounts. Furthermore, researchers are constantly developing new materials in order to optimize the photocatalytic efficiency and optical properties. The increasing material diversity and production amounts are accompanied by growing concerns regarding potential (eco-) toxicological hazards. This paper outlines current knowledge of nanoparticle-cell interaction and critically surveys corresponding *in vitro* and *in vivo* assays. It particularly reviews experimental work addressing photoinduced effects on cells and organisms. The work also gives a brief overview on the medical applications of PCNPs.

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Abbreviations: 2D, two dimensional; 3D, three dimensional; ATP, adenosine triphosphate; BALF, bronchoalveolar lavage fluid; CA, chromosome aberration; CB, conduction band; CHO, Chinese hamster ovary; CNT, carbon nanotube; DEPMPPO, 5-diethoxyphosphoryl-5-methyl-1-pyrroline N-oxide; DLS, dynamic light scattering; DMPO, 5,5-dimethyl-1-pyrroline N-oxide; DMSO, Dimethylsulfoxide; DNA, Deoxyribonucleic Acid; DOPAC, 3,4-dihydroxyphenylacetic acid; DOX, doxorubicin; ECIS, electric cell-substrate impedance sensing; ELISA, enzyme-linked immunosorbent assay; EPR, electronic paramagnetic resonance; FITC, fluorescein isothiocyanate; GR, glutathione reductase; GSH, reduced glutathione; HEK, human epidermal keratinocytes; ICP-MS, inductive coupled plasma mass spectrometry; ICP-OES, inductive coupled plasma optical emission spectroscopy; IL, interleukin; LDH, lactate dehydrogenase; LSPR, localized surface plasmonic resonance; MDA, malondialdehyde; MTT, 3-(4,5-Dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide; MWCNT, multi walled carbon nanotubes; NADPH, nicotinamide adenine dinucleotide phosphate; NAG, N-acetyl- β -D-glucosaminidase; NHE, normal hydrogen electrode; NIR, near infrared radiation; NOAEL, no observed adverse effect level; NP, nanoparticle; OECD, Organization for Economic Cooperation and Development; PBN, N-tert.-butyl- α -phenylnitron; PCNP, photocatalytically active nanoparticle; qPCR, quantitative polymerase chain reaction; PDT, photodynamic therapy; PEG, polyethylene glycol; PI, propidium iodide; PMN, polymorphonuclear cell; POBN, α -(4-pyridyl-1-oxide)-N-tert.-butylnitron; PS, photosensitizer; PVA, polyvinyl alcohol; QD, quantum dots; RNA, ribonucleic acid; ROS, reactive oxygen species; RT, respiratory tract; SCCNFP, Scientific Committee on Cosmetics and Non-Food Products; SCGE, single cell gelelectrophoresis; SOD, superoxide dismutase; SSA, specific surface area; SSR, simulated solar irradiation; SWCNT, single walled carbon nanotubes; TBA, thiobarbituric acid; UCNPs, upconversion nanoparticles; UV, ultra violet; VB, valence band; VOC, volatile organic compounds; WPMN, working party of manufactured nanomaterials; WST, water soluble tetrazolium; WST-8, 2-(2-methoxy-4-nitrophenyl)-3-(4-nitrophenyl)-5-(2,4-disulphophenyl)-2H-tetrazolium; XRD, X-ray diffraction.

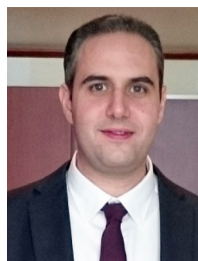
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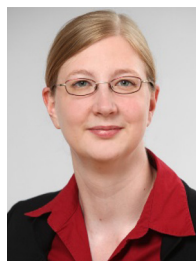
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