Control of the Nanotoxicity of Polymer-Coated Titania Nanoparticles

*Vesselin N. Paunov, Gillian M. Greenway, Mohammed Al-Awady

Department of Chemistry, University of Hull, Hull, HU67RX, UK

*V.N.Paunov@hull.ac.uk

This study gives important insights of the various factors controlling the nanotoxicity of titania nanoparticles (TiO$_2$NPs). We studied the nanotoxicity of TiO$_2$NPs of various hydrodynamic diameters and crystallite sizes on C. Reinhardtii (microalgae) and S. cerevisiae (yeast) upon illumination with UV/visible light [1]. The cell viability was assessed for a range of nanoparticle concentrations and incubation times. Bare TiO$_2$NPs affect the microalgae viability at much lower particle concentrations than for yeast. We also found an increased nanotoxicity upon illumination with visible light which indicates that they may also interfere with the microalgae photosynthetic system leading to decreased chlorophyll content upon exposure to TiO$_2$NPs. The results indicate that the larger the hydrodynamic diameter of the TiO$_2$NPs the lower is their nanotoxicity, with anatase TiO$_2$NPs generally being more cytotoxic than rutile TiO$_2$NPs. We also prepared a range of polyelectrolyte-coated TiO$_2$NPs using the layer by-layer method and studied their nanotoxicity on yeast and microalgae. The toxicity of the coated TiO$_2$NPs alternates with their surface charge. TiO$_2$NPs coated with cationic polyelectrolyte as an outer layer exhibit much higher nanotoxicity than the ones with an outer layer of anionic polyelectrolyte. TEM images of sectioned microalgae and yeast cells exposed to different polyelectrolyte-coated TiO$_2$NPs confirmed the formation of a significant build-up of nanoparticles on the cell surface for bare- and cationic polyelectrolyte-coated TiO$_2$NPs. The effect is coming from the increased adhesion of cationic nanoparticles to the cell walls. Significantly, coating the TiO$_2$NPs with an anionic polyelectrolyte as an outer layer led to a reduced adhesion and much lower nanotoxicity due to electrostatic repulsion with the cell walls. This suggest a new way of making the TiO$_2$NPs potentially safer for use in different formulations by pre-coating them with anionic polyelectrolytes.