Does the shape of titanium dioxide nanoparticles modulate their biological effects in human keratinocytes?

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Introduction

Skin protection is important element in reducing the level of sunburns (erythema), and cancer risk from the ultraviolet radiation exposure. Titanium dioxide nanoparticles (TiO_2NPs) are commonly used in sunlight protective products in spite of knowledge gaps on the safety issues concerning their use in medicine and cosmetics.

This study aimed to examine the effects of differently shaped TiO_2NPs (wire-, plate- and tube-shaped) on immortalized human keratinocytes (HaCaT cell line) before and after UVB exposure. Stability and morphology of TiO_2NPs, as well as their biological effects on HaCaT cells, were determined.

Materials & Methods

Dynamic (DLS) and electrophoretic light scattering (ELS) measurements were employed to determine the particle sizes (d_h) and zeta potentials (ζ) in TiO_2 nanomaterial suspensions in Dulbecco's Modified Eagle Medium, and electron microscopy was used to determine TiO_2NP morphology.

HaCaT cells were treated with TiO_2NPs and subsequently irradiated with 2 kJ/m^2 of UVB radiation. Neutral Red uptake and fluorescent dyes staining was used to assess cell vability, intracellular glutathione levels, reactive oxygen species generation, and mitochondrial membrane integrity and potential.

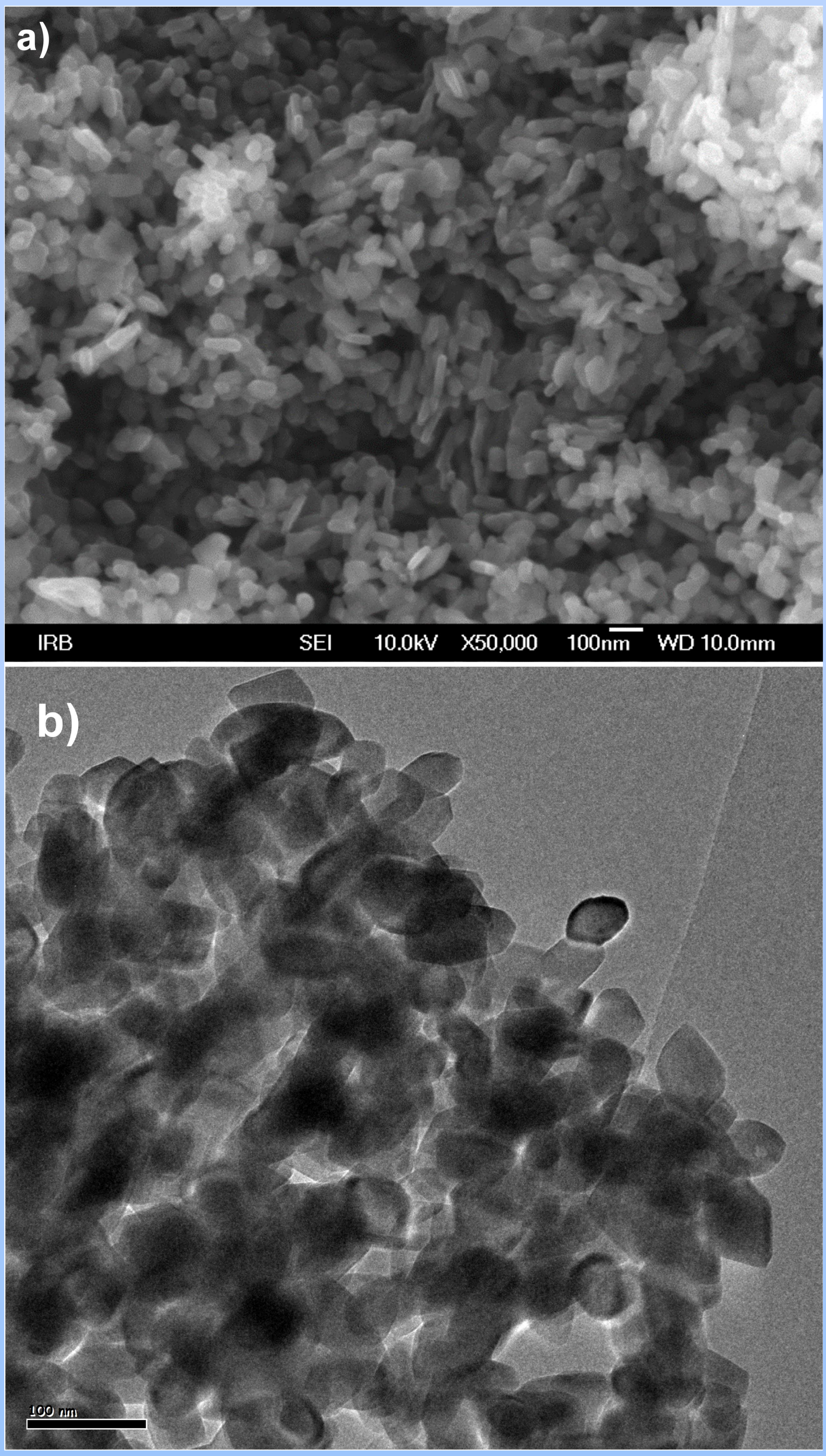

Figure 1. **a)** SEM micrograph and **b)** TEM of TiO_2 TNPs.

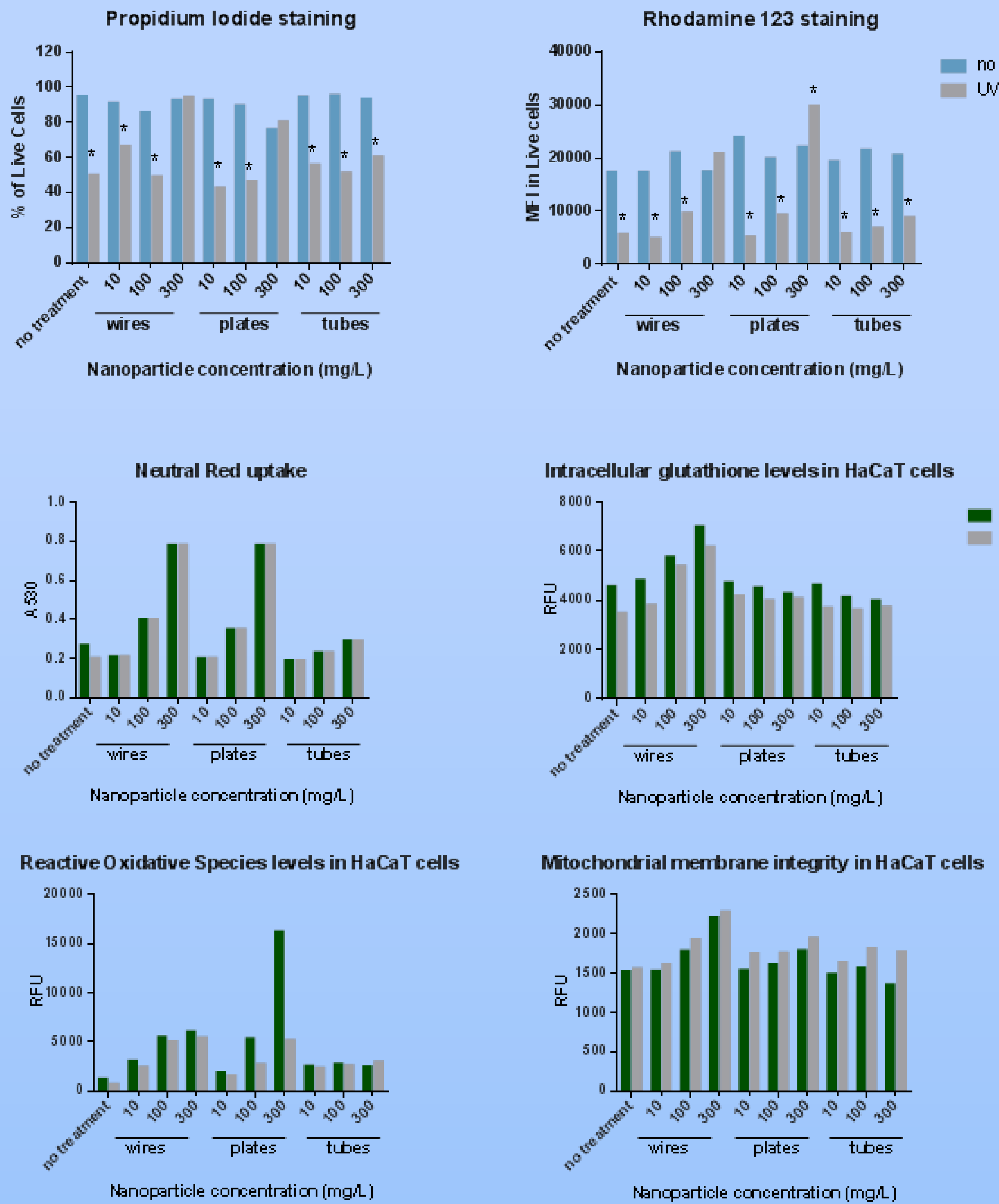

Figure 2. Cell viability and mitochondrial metabolism of HaCaT cells treated with TiO_2NMs with and without subsequent UVB radiation.

Table 1. Particle sizes (d_h) and zeta potentials (ζ) of tested TiO_2 nanomaterials (NMs)

TiO_2 NMs	d_{h1} / nm	% mean volume	d_{h2} / nm	% mean volume	d_{h3} / nm	% mean volume	ζ / mV
TNWs	341.0 ± 29.6	100 ± 0.0	-	-	-	-	-35.2 ± 1.3
TNTs	75.7 ± 18.1	29.0 ± 3.4	211.0 ± 38.9	78.5 ± 19.1	5231.4 ± 162.8	10.5 ± 2.8	-39.6 ± 2.3
TNPs	222.2 ± 31.5	31.7 ± 9.6	771.3 ± 175	66.1 ± 16.9	5053.4 ± 211.7	11.2 ± 4.0	-12.7 ± 3.3

Conclusions

Propidium iodide and Rhodamine 123 staining of dead cells revealed that wires and plates conferred UVB protection to HaCaT cells and maintained their mitochondrial membrane integrity in a dose-dependent matter, whereas tubes did not reduce UVB-induced cellular damage. The dose-dependent signal increase in remaining assays could be attributed to nanoparticle interference with used dyes. These results indicate that TiO_2 nanoparticle shape influences their ability to protect cells from UV radiation.