The Impact of Nanoscale TiO_2 and ZnO Used in Sunscreens on Skin Bacteria

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Abstract

Background: Nanoscale titanium dioxide (TiO_2) and zinc oxide (ZnO) are two major physical ultraviolet (UV) blockers used in sunscreens. These particles at size of nanoscale can protect human skin from harmful UV light. Several hundred species of skin bacteria form a complex and diverse community commonly termed skin microbiota. The balance of bacteria population in the microbiota is important to keep skin health. Published studies showed that nanoscale metallic particles can inhibit bacterial growth. So, it is important to find out whether these particles in topical sunscreen can affect skin health by changing the balance of skin bacteria population.

Purpose: This study was aimed to evaluate whether nanoscale TiO_2 and ZnO change the viability of skin bacteria and assess the effects of UV lights on the antimicrobial activities of nanoparticles.

Methodology: Common skin bacterial strains were grown under anaerobic or aerobic conditions. Serial dilutions of bacterial cultures were plated on top of nanoparticle-agar plates with or without further exposure to UVA light (320-400 nm) or UVB light (311 nm). Antimicrobial activities of ten nanoparticles were evaluated by comparing the bacteria colony numbers grown under various condition. Three of these particles are coated nanoparticles, which surfaces are covered with other materials.

Results: Without UV exposure, coated TiO_2 didn't significantly affect the growth of skin bacteria. Uncoated ZnO particles showed dose-dependent antimicrobial activities. One hour-exposure to UVA enhanced bactericidal activities of uncoated ZnO (3.1 mg/mL) against *Cutibacterium acnes*, *Staphylococcus haemolyticus*, *S. warneri*, and *S. epidermidis* by 10^2 - 10^5 folds. Ten minutes-exposure to UVB enhanced about 100 folds bactericidal activities of uncoated ZnO (3.1 mg/mL) against *C. acnes*. Coated nanoparticles compromised the UVB bactericidal effects by increasing 10-100 folds of bacteria cell numbers.

Conclusion: Nanoparticles in sunscreen products combining the influences of UV radiation may impact skin microbiota in a complex manner. The information from this study could advance the knowledge about the safety of nanoparticles in sunscreens on skin health. The *in vitro* approach established from this study can help to evaluate the safety of cosmetics or ingredients on skin health.

Introduction

UV radiation:

UVA (320-400 nm) penetrates the second layer of skin and causes aging, wrinkling, and skin cancer (1).

UVB (290-320 nm) affects skin's top layer and causes sunburn and skin cancer (1).

Inorganic UV blockers: reflection, scattering, absorption.

TiO_2 is more effective in blocking UVB (1).

ZnO is more effective in blocking UVA (1).

Nanoscale or micronized particles: improve cosmesis and ease of application (1); exhibit antibacterial activity (2).

Skin microbiota: a dynamic population influenced by its host and environment (3); prevents many pathogens from establishing in the skin; has implications for infection, metabolism, toxicity, and cancer (4).

Results

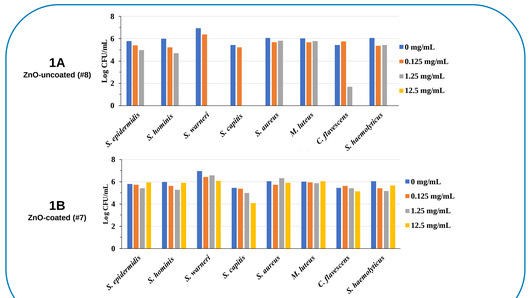

Figure 1. Antibacterial activity of ZnO (UV -)

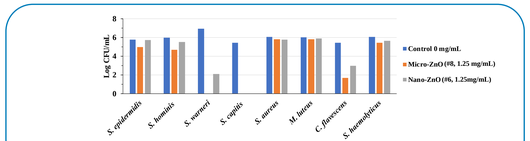

Figure 2. Particle size & Antibacterial activity of ZnO (UV -)

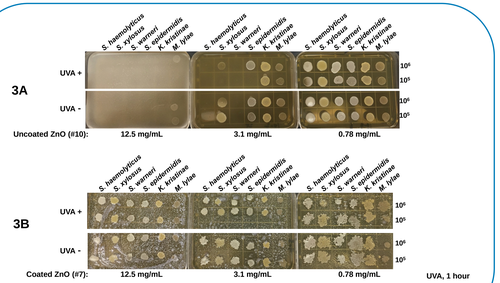

Figure 3. The impact of UVA on antimicrobial activity of ZnO

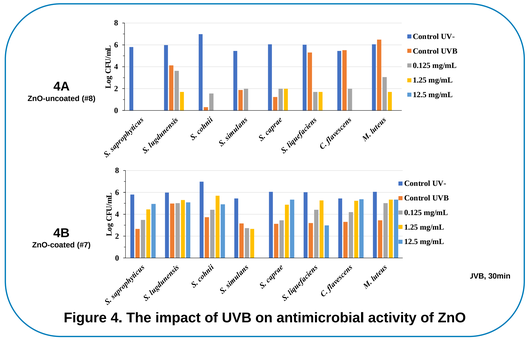

Figure 4. The impact of UVB on antimicrobial activity of ZnO

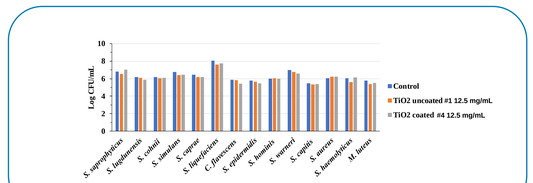

Figure 5. Antibacterial activity of TiO_2 (UV -)

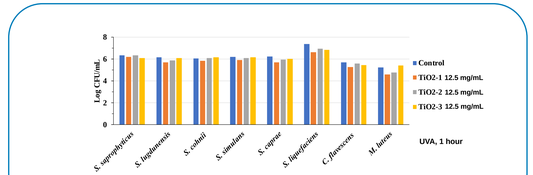

Figure 6. The impact of UVA on antimicrobial activity of TiO_2

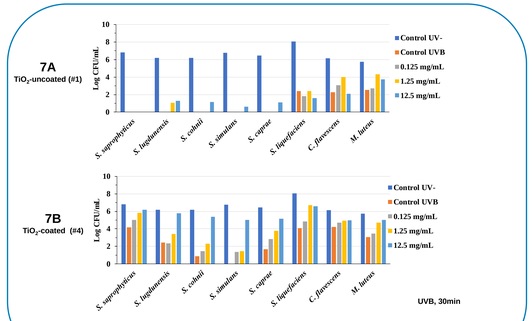

Figure 7. The impact of UVB on antimicrobial activity of TiO_2

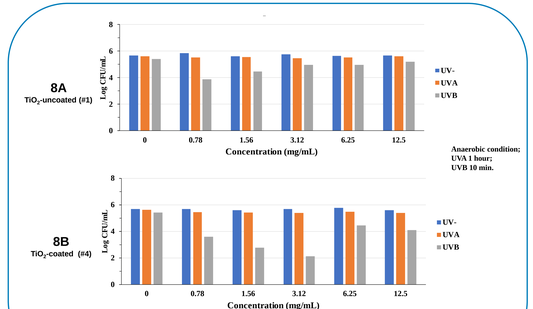

Figure 8. The impact of UV on antimicrobial activity of TiO_2 against *C. acnes*

Results

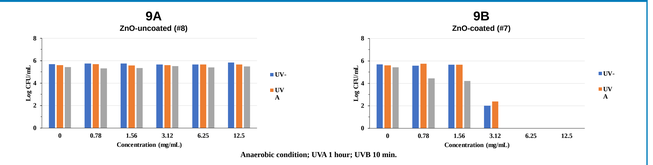

Figure 9. The impact of UV on antimicrobial activity of ZnO against *C. acnes*

Materials

Table 1. Bacterial stains used in this study

Strain name	Strain name
Cutibacterium acnes, ATCC 6919	*Staphylococcus cohnii*, ATCC 29974
Corynebacterium flavescens, ATCC 10340	*Staphylococcus epidermidis*, ATCC 12228
Kocuria kistinae ATCC 27570	*Staphylococcus haemolyticus*, ATCC 29970
Micrococcus lylae, ATCC 27566	*Staphylococcus hominis*, ATCC 27844
Micrococcus luteus, ATCC 4698	*Staphylococcus lugdunensis*, ATCC 43809
Serratia liquefaciens, ATCC 27592	*Staphylococcus saprophyticus*, ATCC 15305
Staphylococcus aureus, ATCC 25923	*Staphylococcus simulans*, ATCC 27848
Staphylococcus capitis, ATCC 27840	*Staphylococcus warneri*, ATCC 27836
Staphylococcus caprae, ATCC 35538	*Staphylococcus xylosus*, ATCC 29971

Table 2. Nanoparticles used int this study

	Name	Coating	Primary Size	Prepared with
1	TiO_2	Uncoated	21nm	ddH_2O
2	TiO_2	Uncoated	21nm	ddH_2O
3	TiO_2, CR50	Coated with alumina	250nm	ddH_2O
4	TiO_2, TTO-SIM14	Coated with alumina, hydrogen dimethicone, and triethoxycaprylylsilane	15nm	Vegetable oil
5	TiO_2, JTTO-MS7	Coated with alumina and hydrogen dimethicone	15nm	Vegetable oil
6	ZnO	Uncoated	50nm	ddH_2O
7	ZnO, HP1-ZCOTE	Coated with triethoxycaprylylsilane	<200nm	Vegetable oil
8	ZnO, ZCOTE	Uncoated	<200nm	ddH_2O
9	ZnO	Uncoated	40-100nm	ddH_2O
10	ZnO	Uncoated	20-30nm	ddH_2O

Conclusion

- Without UV exposure, coated TiO_2 didn't significantly affect the growth of skin bacteria.
- Uncoated ZnO had dose-dependent antimicrobial effects with strain variations.
- UVA exposure enhanced antibacterial effect of uncoated ZnO on some bacteria strains.
- Coated nanoparticles affected the UVB bactericidal effects.

References

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