

Green Synthesis, Characterization, and Cosmetic Application of Zinc and Titanium Nanowires

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ABSTRACT

Background: *Cassia fistula* (Golden Shower) is known for its antioxidant phytochemicals. However, its use for synthesizing zinc and titanium nanowires remains unexplored.

Objective: This study aimed to develop a green synthesis protocol for Zn and Ti nanowires using leaf extract of *C. fistula*.

Methodology: The Zn and Ti nanowires were characterized using UV-Vis and Fourier transform infrared (FTIR) spectroscopies. The resulting nanowires were formulated into an oil-in-water cream for potential cosmetic and sunscreen use.

Result: UV-Vis spectra of Zn nanowires exhibited two peaks between 200–300 nm and one peak at 550–650 nm, while Ti nanowires showed a single peak at 450–650 nm. The resulting cream was uniform, white, and possessed a soft texture with a rose fragrance.

Conclusion: Preliminary observations suggest good dispersion of nanowires and promising UV-blocking potential without opacity.

Keywords

Nanoparticles, Zinc, Titanium, Cream.

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INTRODUCTION

Nanotechnology focuses on the design and application of structures and materials at the 1–100 nm scale. The unique physicochemical properties of these nanomaterials include high surface area, tunable solubility, and multifunctionality^{1,2}. In cosmetics (nanocosmetics), these properties enhance color, transparency, and ingredient delivery. Nanosomes, liposomes, fullerenes, and solid lipid nanoparticles are currently used in cosmetics^{3,4}. However, safety concerns have prompted regulatory bodies to require thorough testing of any nano-enabled cosmetic^{5,6}.

In sunscreens, inorganic filters like titanium dioxide (TiO₂) and zinc oxide (ZnO) provide broad-spectrum protection against UVB (290–320 nm) and UVA (320–400 nm). Replacing micronized TiO₂ and ZnO with nanoparticles (~100 nm) reduces opacity. Additionally, they alter UVA/UVB balance and raise (photo)cytotoxicity and

genotoxicity risks, especially after prolonged exposure⁷⁻¹¹. Strategies such as combining micro- and nano-ZnO with nano-TiO₂ and applying inert coatings (e.g., silica) can mitigate these effects. However, ongoing research into nanoparticle stability, free-radical generation, and long-term safety remains essential before permitting their widespread use in cosmetics.

Green synthesis using plant extracts offers a scalable, ecofriendly route to metal nanoparticles. Plant metabolites simultaneously reduce metal ions and cap resulting nanoparticles. The resulting nanoparticles are more stable and synthesized more rapidly than those from microbial methods¹². Topical creams are ideal vehicles for such nanomaterials: they are easy to apply, removable, and can deliver agents that cleanse, moisturize, protect, or repair damaged skin^{13,14}.

Cassia fistula (Golden Shower) has recognized antioxidant and therapeutic properties. Given *C. fistula*'s ornamental and medicinal popularity, exploring its potential for nanowire production could yield new, sustainable ingredients for skin-care applications¹⁵⁻¹⁸. However, its potential to synthesize to produce zinc or titanium nanowires has not yet been explored in detail. Here, we report a novel green synthesis of Zn and Ti nanowires using *C. fistula* leaf extract. The resulting zinc or titanium nanowires were subjected to physicochemical characterization followed by their formulation into a cosmetic cream.

MATERIALS AND METHODS

Materials

Zinc nitrate (ZnNO_3), titanium dioxide (TiO_2), stearic acid, cetyl alcohol, white soft paraffin, liquid paraffin rose oil (fragrance), methylparaben, propylparaben, triethanolamine (buffering agent), and distilled water were used in this study.

Green Synthesis of Zinc and Titanium Nanowires

Preparation of Plant Extract

The collected *Cassia fistula* was dried at room temperature and converted into fine powder. The powder was mixed with distilled water and then filtered.

Preparation of Salt Solution

0.075 g of ZnNO_3 was added to 200 mL of distilled water to make a 0.002 molar solution and mechanically mixed for 5 to 10 min. Similarly, 0.031 g of TiO_2 was added to 200 mL of distilled water to make a 0.002 molar solution for the preparation of titanium nanowires.

Dark Reaction

Both plant extract and salt solution (1:1 % v/v) were mixed in the dark using a shaking incubator at 150 rpm for 48 h at 30°C. Then the solution was centrifuged to separate nanoparticles. The nanoparticles were washed with ethanol and dried in an oven. The obtained product after drying was annealed in a furnace to acquire the final and purified form of nanowires at 350°C for 1 h.

Characterization Studies

Both zinc and titanium nanowires were characterized by UV-Vis spectrophotometry and FTIR analysis.

Formulation of Cream

The formulation of the cream is based on oil-in-water emulsion. First, an oil phase was prepared using stearic acid (2 g), cetyl alcohol (5 g), white soft paraffin (8 g), and liquid paraffin (2.5 g). All these chemicals were mixed in a beaker and heated to 75°C. An aqueous phase was prepared by heating zinc and titanium nanowires, rose oil (fragrance), methylparaben (0.005 g), propylparaben (0.007 g), and triethanolamine (buffering agent) in distilled water.

RESULT

Characterization of Zinc and Titanium Nanowires

UV-Vis Spectrophotometry

The UV-Vis spectrum of the zinc nanowires showed three absorbance peaks: two between 200 and 300 nm and one between 550 and 650 nm (Figure 1). Titanium nanowires displayed a single absorbance peak from 450 to 650 nm (Figure 1).

Fourier Transform Infrared (FTIR) Spectroscopy

FTIR spectroscopy is used to check the stabilization of nanowires prepared by the *Cassia fistula* extract and the identification of biomolecule capping. FTIR spectra of zinc nanowires and titanium nanowires were recorded (Figure 2). FTIR analyses reinforced plant metabolites' role as a reducing agent (Table 1-2). FTIR analysis confirmed metal-oxygen bonding (Zn-O, Ti-O-Ti) alongside phytochemical functional groups, indicating successful reduction and capping by *C. fistula* metabolites.

Cream Formulation

The final cream product was prepared by mixing the aqueous and oil phases and was stirred for up to 10 min at room temperature. The cream was then stored in an airtight container for biological applications. The cream was white with a soft texture. It had a rose fragrance. This kind of product can help with better cosmetic applications, and with more study on its properties, it can help to reduce problems related to cosmetics.

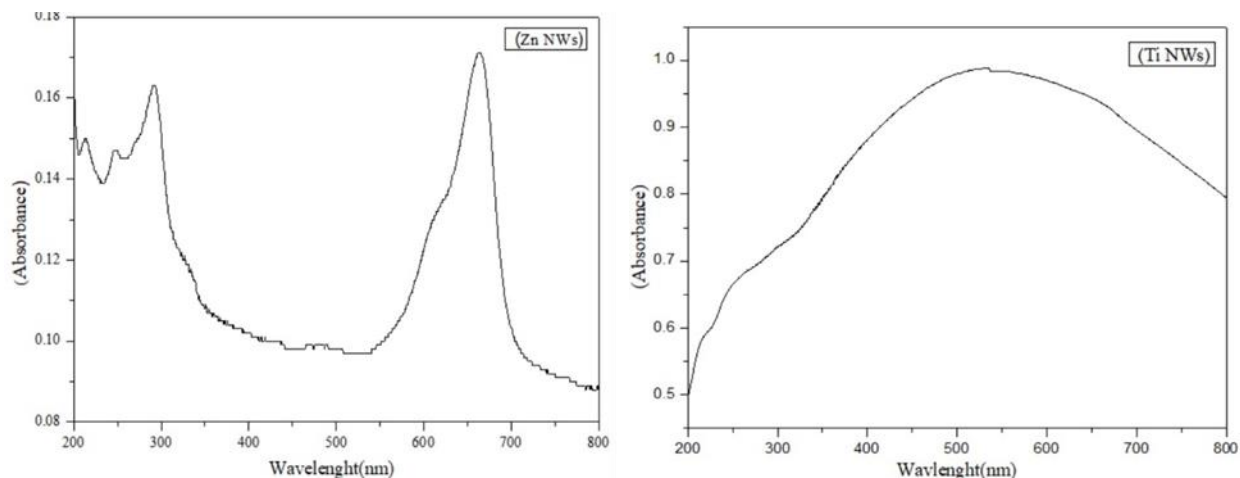


Figure 1. UV-Vis analyses of zinc (right) and titanium (left) nanowires.

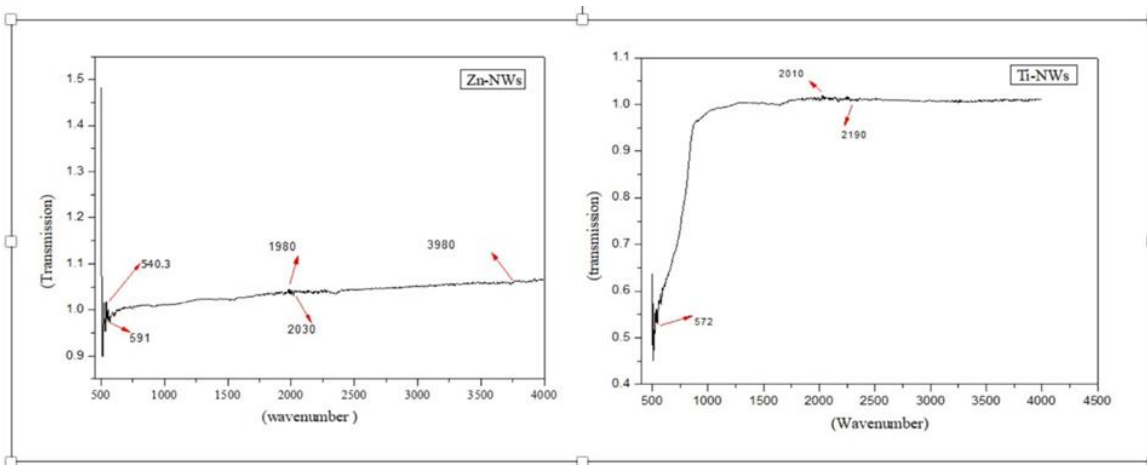


Figure 2. FTIR analysis of zinc (left) and titanium (right) nanowires.

Table 1. Summary of FTIR Absorption Bands Confirming Bonds of Zinc Nanowires.

Peaks (cm ⁻¹)	Inference	References
540–591	Zn-O bending	[19]
1980-2030	C-H stretching	[20]
3980	O-H stretching	[21]

Table 2. Summary of FTIR Absorption Bands Confirming Bonds of Titanium Nanowires.

Peaks (cm ⁻¹)	Inference	References
572	Ti–O–Ti stretching	[22]
2010	C = C stretching	[23]
2190	C=N stretching	[24]
3910	O–H stretching	[25]

DISCUSSION

Premature aging of the skin and symptoms of sun damage such as wrinkles, fragile skin, liver spots, actinic keratosis, and solar elastosis can all be caused by UV exposure. In the United States and Australia, skin cancer is by far the most frequent type of cancer, and it appears to be the outcome of an 'unusual relocation' of people having sun-sensitive skin to subtropical countries²⁶. ZnO nanoparticles in sunscreens seem transparent on the skin and provide good protection against UV-induced sunburn. While nanoparticles are expected to remain on the surface of the skin of healthy adult people and hence are regarded as acceptable for use in sunscreens. No complete assessment of the impact on human health from exposure to metal oxide nanoparticles intended for use in sunscreens has been conducted²⁷. Because of titanium's UV barrier qualities, TiO₂ are used in several sun-blocking pharmaceutical treatments. Different nanomaterials of titanium were synthesized, and their influence on healthy keratinocytes before and after UVB irradiation under in vitro exposure was studied. All the findings point to the beneficial features of nanomaterials. Which can increase the quality and efficacy of nano-based products only if the safe-by-design principle is used during the development process^{28,29}.

Nanowires synthesized were subjected to UV-Vis spectroscopy, and absorption peaks were recorded at 200 to 300 nm and 550 to 650 nm for zinc nanowires. It corresponds positively with other studies³⁰. UV-Vis absorption peaks for titanium nanowires were recorded at 450 to 650 nm and correlated with other studies³¹. Characterization of zinc and titanium nanowires showed the quality of nanowires by using different techniques like UV and FTIR, showing the size, absorbance, and molecular bonding of nanowires produced by green synthesis.

CONCLUSION

Zinc and titanium nanowires were synthesized using *Cassia fistula* leaf extract and incorporated into a cream formulation that effectively treated acne. Future work will focus on comprehensive toxicity testing to confirm its safety for topical use.

CONFLICT OF INTEREST

None.

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