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Curcumin and Nanocurcumin in the Treatment of Photodynamic Therapy for Skincare

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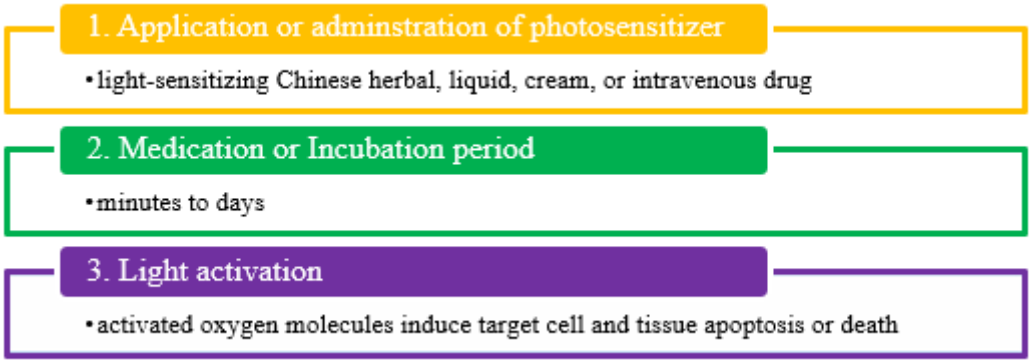
Abstract: Can photodynamic therapy be suitable for skincare? Do curcumin and nano-curcumin as photosensitizer for this photodynamic therapy? What are the differences between them? Is it a possible choice for photorejuvenation? There are still many questions on this topic. Let's discuss the photodynamic therapy in skincare, curcumin, and its research progress for skin, as well as the difference between curcumin and nano-curcumin in the treatment of photodynamic therapy for skincare.

Keywords: curcumin; nanocurcumin; photodynamic therapy; skincare.

1. Introduction

Photodynamic therapy (PDT) in skincare is common nowadays and has been recognized by the food and drug administration (FDA) for a long time [1,2]. This is a unique and non-invasive treatment without any long-term side effects; it is conducted with fewer procedures in a short time to prevent infection or bleeding situations, etc. PDT utilizes a photosensitizer (PS) and is activated with a light source on a target site of the skin problems, such as acne, actinic keratosis, and skin cancers. Generally, it is applied in blue light therapy with wavelengths between about 450 and 495 nanometers (nm) to activate the PS agents, which are relatively selectively concentrated in abnormal or neoplastic cells and induce cell apoptosis or death in the presence of reactive oxygen species (ROS) [3-6]. It has three typical steps for PDT of skin treatment (Flow chart 1).



Flow chart 1. Three typical steps for PDT of skin treatment.

However, PDT has a primary limitation on the skin; it only involves 1/3 of an inch (approximately 1 cm) in a light source for skin depth penetration [7]. The major benefit of using PDT is selective cell and tissue destruction. In 2008, FDA approved drugs such as Levulan® Kerastick™ for skin PDT treatment. Levulan® Kerastick™ was a 20% aminolevulinic acid (ALA) solution (PS) and allowed on the face for 14 to 18 hrs incubation, then utilized with a blue light source for 16 mins and 40 s in full-face PDT (ALA-PDT) for the actinic keratoses (AKs) and photorejuvenation [8-13], also improve lentigines, skin roughness, fine lines, and sallow complexion [14].

2. Curcumin and its Research Progress for Skin

2.1. Background and function of curcumin (PS).

Curcumin is a natural product, also known as turmeric, and used in traditional Chinese medicine. It is extracted from *Curcuma longa* plant roots grown in Asian countries [15], which possess a wide range of biological activities, e.g., (a) antioxidant, (b) anti-inflammatory, (c) antimicrobial, and (d) anticancer properties [16]. It also can act as a PS agent to absorb blue light (420-480 nm), producing ROS in PDT for many skin diseases and skin care [17].

2.2. Antioxidant and anti-inflammatory.

Niu T *et al*. reported low concentrations of curcumin (1.25 to 3.12 μM) with a strong antioxidant and anti-proliferative effect on TNF-α-induced psoriasis-like inflammation in the presence of blue light. It reduced the viability of human skin keratinocytes, decreased cell proliferation, induced apoptosis, inhibited NF-κB activity, and activated caspase-8 and caspase-9 when combined with a red light at 630 or 660 nm, which regulated the proliferation and apoptosis in skin keratinocytes [18].

2.3. Antimicrobial.

Yang MY *et al*. identified a low dosage of curcumin (1.52 μM) with 0,09 J/cm^2 blue light PDT significantly decreased the viability of Propionibacterium acnes (*P. acnes*) which enhanced the antimicrobial activity of curcumin (aPDT). It triggered a series of cytotoxic actions of curcumin on *P. acnes* [19]. Pereira AHC *et al*. indicated the usage of curcumin inPDT to Cutaneous leishmaniasis (CL), which was skin lesions infected with *L. braziliensis* and *L. major*. Serial dilutions of curcumin from 500.0 to 7.8 μg/mL using blue light, with a light dose of 10 J/cm^2 were effective in causing cell destruction in both macrophages and intracellular parasites because of an increase in mitochondrial membrane polarity and a decrease in the number of parasites through the aPDT process [20]. Recently, Paolillo FR *et al*. described the effects of a PDT-treated with 250 μL curcumin in blue light with 80 mW/cm^2 associated with artificial skin to accelerate the wound contraction of rats significantly resistant to *Staphylococcus aureus* [21].

2.4. Anticancer.

Park K *et al*. discovered that the combination of Ultraviolet B (UVB) with curcumin induced the apoptosis of skin cancer cells. The molecular mechanisms underlying apoptosis involved the activation of caspase-8, caspase-3, and caspase-9. [22].

3. Discussion

Currently, nano-curcumin has become more utility than curcumin. Why does this situation appear? Although curcumin can function as a PS agent in PDT, the bioavailability is not good, including poor water solubility and a rather broad absorption peak from 300 to 500 nm, with a maximum absorption band at wavelength 430 nm [23]. An ideal PS absorption band must be nearly 630 nm [24]. How do we improve bioavailability? Nanotechnology is a choice applied in curcumin to develop nano drug-delivery vehicles in a molecular scale system and enhance its bioavailability [25]. Growing evidence has shown that a nanosystem of curcumin is effective in the skincare of PDT, such as (a) Liposome, (b) Nanocarrier, (c) Nanoemulsion, etc., which with better antioxidant, anti-inflammatory, antimicrobial, and anticancer properties.

3.1. Liposome.

Woźniak M *et al*. reported curcumin encapsulated in hydrogenated soy phosphatidylcholine liposomes and increased photoactive properties in PDT. Its liposomal formulation improved the poor solubility of the PS agent (curcumin). The 5 to 10 μM of nano-curcumin mediated PDT treatment after 4 hrs of blue light low irradiation (2.5 J/cm2) increased the ratio of apoptotic and necrotic cells in skin cancer and reduced toxicity in normal keratinocytes [26].

3.2. Nanocarrier.

Abdel Fadeel DA *et al*. designed PEGylated lipid nanocarriers (PLN) loaded with different concentrations of curcumin (Cur) from 20, 10, 5, 2.5, and 1 μg/ml to target skin cancer by PDT. The photo-cytotoxicity study on a human skin cancer cell line (A431) decreased upon irradiation with blue light (410 nm) and could extend the effect to deeper skin layers for treatment [27].

3.3. Nanoemulsion.

Ebrahiminaseri A *et al*. hypothesized that a combination treatment of the dendrosomal nano-curcumin and low-level laser therapy or PDT (450 nm) simultaneously promoted the wound healing process because of increased proliferation and migration of mouse embryonic fibroblasts and being more efficient in significantly upregulating growth factors (TGF-β, VEGF) and decline in inflammatory cytokines (TNF-α, IL-6) in the presence of ROS [28].

4. Conclusion

The above information demonstrates that PDT of curcumin and nano-curcumin suits skincare. Nano-curcumin is much better than curcumin alone since it improves the bioavailability, especially in the water solubility problem, to enhance its PDT function with better antioxidant, anti-inflammatory, antimicrobial, and anticancer properties. Thus, PDT of curcumin and nano-curcumin are possible choices for photorejuvenation. However, more work needs to be done, including a series of human safety assessments of different types of nano-curcumin on the skin.

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Conflicts of Interest

The authors declare no conflict of interest.

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