Comunicación breve

Lipid and Polymeric Nanoparticles for Organic Sunscreen Filters

Nanopartículas lipídicas y poliméricas para filtros solares orgánicos

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ABSTRACT

Introduction: Organic filters are used in sunscreens due to its photoprotective effect on the skin against ultraviolet radiation. However, there is concern regarding their usage, due to its photostability, penetration into skin, skin irritation, and toxicity. Therefore, over the years, researches have been carried out in an attempt to improve these characteristics of organic filters. A large part of this research involves nanotechnology.

Objective: To analyze the usage of solid lipid nanoparticles, nanostructured lipid carriers, and polymeric nanoparticles to overcome drawbacks in the production of organic filters.

Methods: Searches in *PubMed*, *Google Scholar*, and *Science Direct* were carried out, between May and September 2020, using the keywords nanostructured lipid carriers, solid lipid nanoparticles, polymeric nanoparticles, and organic sun filters. The most relevant results of the search were selected for the study.

Conclusions: Nanostructured lipid carriers, solid lipid nanoparticles, and nanocapsules have been used efficiently for the production of organic filters, with better photostability and less skin penetration, maintaining good sun photoprotection.

Keywords: organic filter; sunscreen; lipid nanoparticles; polymeric nanoparticles.

RESUMEN

Introducción: Los filtros orgánicos son utilizados en los protectores solares por su efecto fotoprotector en la piel contra la radiación ultravioleta. Sin embargo, existe una preocupación sobre su uso debido a su fotoestabilidad, penetración en la piel, irritación de

la piel y toxicidad. Por lo tanto, a lo largo de los años, se han realizado investigaciones en un intento de mejorar estas características. Una gran parte de estas investigaciones involucra la nanotecnología.

Objetivo: Analizar el uso de nanopartículas lipídicas sólidas, transportadores lipídicos nanoestructurados y nanopartículas poliméricas para superar los inconvenientes en la producción de filtros solares orgánicos.

Métodos: Se realizaron búsquedas en PubMed, Google Scholar y Science Direct, entre mayo y septiembre de 2020, se utilizaron las siguientes palabras clave: *nanostructured lipid carriers* [transportadores lipídicos nanoestructuados]; *solid lipid nanoparticles* [nanopartículas lipídicas sólidas]; *polymeric nanoparticles* [nanopartículas poliméricas], and *organic sun filters* [filtros solares orgánicos]. Se seleccionaron los resultados más relevantes para el estudio.

Conclusiones: El uso de transportadores lipídicos nanoestructurados, nanopartículas lipídicas sólidas y nanocápsulas como trasportadores de filtros solares orgánicos mejora la fotoestabilidad, reduce la penetración en la piel y mantenienen una adecuada fotoprotección solar.

Palabras clave: filtros orgánicos; protectores solares; nanopartículas lipídicas; nanopartículas poliméricas**.**

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Introduction

Sunscreens are an essential tool for protecting the skin against sun damage, including photocarcinogenesis and photoaging, and management of photodermatoses.[1,2] Sun filters are the components of the formulation that promote these photoprotective effects and are classified into inorganic and organic. Inorganic filters are minerals that reflect, disperse, and absorb UV light. In contrast, organic filters can absorb high energy photons due to the aromatic compounds combined with carbonyl groups in their molecules.[3] These are preferably used in photoprotective formulations, because, unlike physical filters, they do not leave an unpleasant white film and are easier to formulate.[4]

However, the photostability of sunscreens is a critical factor. Photochemical reactions occur in their molecules during solar exposure, generating reactive oxidative species (ROS) and other degradation products. Besides, the UV filtering efficacy of the sunscreen is compromised. For example, Avobenzone loses from 50% to 90% of its particles after 1 hour of UV exposure, generating compounds less effective as sunscreens.[5,6] Besides, there is concern about the use of these compounds, which could be related to toxicity, irritation, and skin sensitization[7,8]. Benzophenone-3, for example, penetrates the skin and is the most common cause of photo-contact allergic and irritant dermatitis.[9] Moreover, some of the chemical and physical actives harm marine ecosystems by causing coral bleaching and oxidative damage to phytoplankton.[10,11] Therefore, an ideal sunscreen should protect efficiently against UVB and UVA rays, forming a stable and protective film throughout exposure to this radiation, besides being cosmetically acceptable[8]. In addition, there is a need for more environmentally safe and healthier broad-spectrum sunscreen actives.[10]

Nowadays, nanotechnology is a great tool to obtain sun filters with better photostability, less photodegradation, and, consequently, greater effectiveness.[7] Metallic nanoparticles (TiO_2 and ZnO NPs) are commonly used in inorganic sunscreens, however, there is concern about the effects on the environment and human health.[11,12]

Several researches with solid lipid nanoparticles (SLN), nanostructured lipid carriers (NLC), and polymeric nanoparticles have been carried out to try to improve some undesirable characteristics of organic sunscreen filters. Therefore, the aim of this article is to discuss the use of SLN, NLC, and polymeric nanoparticles to overcome its drawbacks for the production of organic filters. For that, a compilation of bibliographic references was carried out and based on the search made in PubMed, Google Scholar and Science Direct and from keywords as NLC, SLN, polymeric nanoparticles and organic filters between May and September 2020.

Methods

A research was carried out in PubMed, Google Scholar, and Science Direct using the keywords NLC, SLN, polymeric nanoparticles, and organic filters between May and September 2020, and as the results deemed relevant to this study were compiled as bibliographic reference.

Lipid Nanoparticles

Solid Lipid Nanoparticles (SLN) emerged in the 90s and were developed as an alternative to liposomes, microemulsions, and polymeric nanoparticles, being the first generation of lipid nanoparticles.[4,13] They are made of raw materials that are physiologically well-tolerated, which consist of solid lipids dispersed in an aqueous phase containing emulsifiers.[13,14] Despite its advantages, they have some limitations, such as low drug loading capacity and drug expulsion during storage.[15]

The second generation of these nanoparticles are nanostructured lipid carriers. They are characterized by having a heterogeneous matrix in which solid lipids are mixed with liquid lipids in a proportion that can vary from 70:30 to 99.9: 0.1. They have a higher loading capacity for a number of active compounds, a lower water content in the suspended particles, and are able to prevent or minimize the possible drug expulsion during storage compared to SLNs.[16]

Lipid nanoparticles can be used as a strategy to increase the stability of assets in cosmetics. In addition to exhibiting high stability and protecting the asset, they can act as a physical filter. Therefore, they allow the creation of a product with a higher Sun Protection Factor (SPF) or with the same SPF but using a smaller amount of chemical filters.[17]

Over the years, several organic filters have been encapsulated with SLNs and NLCs with satisfactory results such as butylmethoxydibenzoylmethane;[13] oxybenzone[18] and Octocrylene,[19] Avobenzone[20] (Table). The literature on the topic shows that lipid nanoparticles could improve the photostability, reduce skin irritability and penetration with good UV protection. The synergistic effect of lipid nanoparticles as showed by *Dario et al* allows a reduction of organic filters in sunscreen products.

Table - Researches of organic filter encapsulated with lipid nanoparticles

Reference	Lipid Nanoparticles	Sun Filter	Results
(13)	NLC	butylmethoxydibenzoylmethane	Improved photostability with good UV protection
(18)	NLC	oxybenzone	Reduced skin irritability and increased UV protection
(19)	NLC e SLN	Octocrylen and butyl-methoxydibenzoylmethane	Reduced skin penetration and improved photostability and UV protection
(20)	NLC	avobenzone and octocrylene	Improved the UV protection
(21)	NLC	diethylamino hydroxybenzoyl hexyl benzoate and 2-ethylhexyl salicylate	Improved the UV protection and antioxidant activity

Besides, the association of natural molecules with nanomaterials offers an advance for the production of more stable, sustainable formulations, with a broad-spectrum photoprotection and appropriate antioxidant activity, often allowing a lower concentration of UV filters, as demonstrated by *Lacatusu et al*, who used plant oils derived from Amaranthus cruentus and Cucurbita seeds spp in the production of co-loaded NLCs as common UVA and UVB filters.[21]

Andréo-Filho *et al* developed two types of SLNs: one containing the octile chemical filter methoxycinnamate (OMC) and the other replacing 20% of the OMC with urucum oil. The study showed that the formulations did not induce toxic responses in the skin and the SLNs containing urucum oil and a lower OMC content, there was no reduction of SPF.[17]

Polymeric nanoparticles

Polymeric nanoparticles are colloidal particles ranging in size from 10 nm to 1 µm. They can be classified as nanospheres and nanocapsules. The nanospheres systems are formed by a matrix with low loading capacity. Nanocapsules, on the other hand, are composed of a reservoir system containing an oily or aqueous core with a high loading capacity.[22]

These nanoparticles have great potential in carrying drugs. Its use in sunscreens can decrease the UV filters photodegradation and decrease the penetration of these molecules into the skin or may even increase the sun protection due to the occlusive barrier formation on the skin surface.[22,23].

Gilbert et al carried out a comparative study between polymeric nanocapsules and lipid nanoparticles containing benzophenone-3. All produced formulations showed good stability. Besides, nanostructured polymeric nanocapsules and lipid carriers reduce the penetration of benzophenone-3 into the skin, and, consequently, they presented the highest SPF.[4] *Barbosa et al* also observed a synergistic effect in the SPF using poly(ε-caprolactone) nanocapsules loaded with benzophenone-3 with no cytotoxicity against fibroblasts cells.[24]

The use of antioxidants in conjunction with sunscreens is expected, due to the properties of these molecules to eliminate free radicals generated by exposure to UV radiation. The nanoencapsulation of these antioxidants can be used for the development of innovative sunscreens. Knowing this and following the line of use of bioactive, Oliveira *et al.* produced gelatin nanoparticles containing rutin, a natural antioxidant, and associated them with

organic filters. The study showed that with the encapsulated rutin, there was an increase in the SPF and antioxidant activity 74% greater than the non-encapsulated rutin.[25]

Conclusions

The use of nanotechnology has been used efficiently for the production of organic photoprotectors filters with better photostability, less penetration into the skin, and, often, allows the sunscreens production with lesser amounts of these molecules and with better efficiency or without loss of sun protection. Besides, there is a great interest in the use of natural molecules in NLC, SLN, and nanocapsules, allowing the production of sustainable products with even better photoprotection and with additional properties, such as the antioxidant activity.

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Conflict of Interest

The authors declare that they have no conflict of interest.

Author contributions

Jéssica Sales Barbosa: Writing-review-editing; Methodology.

Tamara Gonçalves Araújo: Supervision; Writing-review-editing.

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