Keratin Biomembranes

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Difficulties in obtaining human nails that are large enough for examining the penetration of drug formulations led to produce keratin films regenerated from human hair. The structure, surface morphology, chemical characterization and thermal stability of the films were characterized and were compared to those of human nail, hair and bovine hoof samples using SDS-electrophoresis, SEM, XRD, FTIR and TGA. The structure of the obtained films was found to be closer to human nails than to hair or bovine hooves. The keratin films were infected with *Trichophyton rubrum* and were proven to be appropriate for serving as a model for studying onychomycosis.

Keywords: keratin films ; onychomycosis model ; Trichophyton rubrum

1. Introduction

More than 10% of the global population is affected by fungal diseases on nail plates and nailbeds, also known as onychomycosis, which are caused mainly by dermatophytes [1]. No effective medication of onychomycosis has been proposed to date. Current treatment methods include local and oral drug delivery. Local treatment is preferable, since it has fewer negative impacts on internal organs and can be applied in situ. However, it also has some limitations caused by structural and physical properties of the nail plate, which serves as a barrier to the efficient transport of drugs to the infected site [2]. A high rate of drug penetration through the nail plate is a necessary but insufficient condition for successful topical treatment of fungal infections. The total amount of active components needed for effective treatment must also be taken into account [2].

2. Models

A model that can be used to evaluate the effectiveness of various drug formulations could make a significant contribution to preclinical and preliminary assessments of drug penetration. Such models have not been developed to date due to low availability of human nail material. For this reason, it is necessary to produce materials that have similar structural and physiological characteristics to human nail plates and can replace them with maximal similarity to *in vivo* tests.

Several models have been proposed for predicting transungual drug absorption into human nail plates [3][4]. However, these models require individual nail plates, which complicate their widespread use. Other models use membranes based on bovine hooves [5]. These models do not provide a close approximation to human nails, since the density of the keratin fibers matrix in bovine hooves is lower compared to the human nail. The low density of the matrix in bovine hooves is due to fewer disulfide bounds compared to human nail plates [6][7]. As a result, bovine hooves can be less sensitive to factors disrupting disulfide bonds applied to increase the permeability of drugs.

Keratin films made from human hair were proposed for *in vitro* simulations [8][9]. Sufficient size and flat shape of the prepared membranes enable the application of the drugs to the membrane surface in a uniform manner to study their penetration potential.

The structure of the films was compared to that of human nail plates and bovine hooves using X-ray diffraction analysis (XRD), scanning electron microscopy (SEM), thermogravimetric analysis (TGA) and Fourier transform infrared spectroscopy (FTIR) [10]. Properties of the films were found to be much closer to the nail pattern than to hair from which the films were produced or the hoof sample.

The keratin films were infected with the dermatophytic fungus *Trichophyton rubrum* and three days after infection, all films were not only covered superficially by white and cotton-like fungi on the surface, but fungi also penetrated inside and through the films. The keratin films can be used as a substitute for nails in *in vitro* experiments on modelling and treatment of onychomycosis and can replace nail plates in permeation and penetration studies of antifungal drugs [10].

References

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