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Hydrogels of Interpenetrating Polymer Networks of Poly (2-hydroxyethyl methacrylate) and Poly (N,N-dimethylacrylamide) as Dermal Delivery Systems for Dexamethasone

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Introduction

The skin, being the largest organ of the human body, is a critical site for drug delivery, offering direct access to systemic circulation via topical administration. Dermal drug delivery systems are often designed to improve the localized treatment of a variety of skin conditions, such as inflammation, infections and chronic disorders, by ensuring controlled and sustained release of therapeutics. One such potent therapeutic agent is dexamethasone, a synthetic corticosteroid known for its anti-inflammatory and immunosuppressive properties. Dexamethasone is commonly used to treat inflammatory skin conditions, including eczema, psoriasis and dermatitis, as well as in the management of localized pain and edema. However, the skin's barrier properties pose significant challenges to the effective delivery of dexamethasone and other similar drugs. The stratum corneum, the outermost layer of the skin, restricts the permeation of many drugs, particularly those with poor water solubility or molecular properties unsuitable for transdermal absorption. To address this, researchers have focused on the development of advanced dermal delivery systems, such as hydrogels, which can enhance drug penetration while offering a controlled release of the active agent over time. Among these advanced systems, hydrogels of interpenetrating polymer networks (IPNs) have gained attention due to their unique structural properties and superior performance in terms of drug release control, biocompatibility and mechanical strength.

Description

This paper discusses the development of hydrogels consisting of Interpenetrating Polymer Networks (IPNs) of poly(2-hydroxyethyl methacrylate) and poly(N,N-dimethylacrylamide) as potential dermal delivery systems for dexamethasone. These materials, owing to their hydrogel nature, provide excellent water retention, swelling behavior and tunable mechanical properties that enhance drug loading capacity, diffusion and release profile. This paper explores the synthesis, characterization, advantages and potential challenges associated with using PHEMA/PDMA IPN hydrogels as dermal delivery vehicles for dexamethasone. Hydrogels are three-dimensional, hydrophilic polymer networks that can absorb and retain large amounts of water or biological fluids. These materials can undergo significant volume changes in response to environmental factors such as pH, temperature and ionic strength, making them highly versatile for drug delivery applications. Hydrogels offer several advantages, including their ability to encapsulate both hydrophilic and hydrophobic drugs, provide controlled drug release and ensure minimal irritation or toxicity due to their biocompatibility. For topical and dermal applications, hydrogels provide several benefits, including easy application to the skin, moisturizing effects and the ability to form a barrier that can prevent infection or dehydration of the underlying tissues [1,2].

Conclusion

Hydrogels of interpenetrating polymer networks of PHEMA and PDMA offer a promising approach for the dermal delivery of dexamethasone. These hydrogels combine the advantageous properties of both polymers, including excellent swelling behavior, controlled drug release and biocompatibility, making them suitable for treating inflammatory skin conditions. Despite some challenges in synthesis and optimization, the use of PHEMA/PDMA IPN hydrogels for dexamethasone delivery represents an exciting advancement in dermal drug delivery technology, offering the potential for improved patient outcomes in the management of chronic skin diseases. Further research is needed to optimize these hydrogels for clinical use, focusing on improving their drug-loading capacity, release profiles and long-term stability.

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