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A Review Study on Hydrogel Under Eye Patches

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ABSTRACT: Under eye dark circles, puffiness, dryness, and irritation under the eyes are common problem from stress, too much screen time, pollution, and aging skin; these conditions require gentle, non-irritating solutions suited to sensitive skin. The work presented emphasizes the use of safe, biodegradable, and plant-derived ingredients to deliver antioxidant, anti-inflammatory, depigmenting and moisturizing effects through a soft hydrogel matrix that support sustained release.

This research creates and tests natural hydrogel eye patches using safe plant ingredient like *Tabernaemontana divaricata* (a flower plant), *Rubia Cardifolia* (madder root) , *green tea*, *aloe vera*, *honey*, *chamomile*, *licorice*, and *potato* (including potato peel derivative). The selected plants are known to contain phenolic compound, tannins, flavonoids, hydroquinone derivative and other bioactive phytochemicals that together provide reduction of local inflammation and modulation of pigmentation pathways. The hydrogel patches were formulated to be free from synthetic colorants, fragrances, and harsh additives, addressing the common sensitivity of under eye skin and reducing the risk of irritant and allergic reactions.

In conclusion, the presented poly-herbal hydrogel under eye patch offers a plausible, plant based approach for addressing multiple concerns via combined antioxidant, depigmenting, and moisturizing actions delivered from a biodegradable hydrogel matrix

KEYWORDS: Herbal eye patch, Under eye dark circles, Antioxidants, Cosmeceuticals, Herbal extract

I. INTRODUCTION

The skin surrounding the eyes is among the thinnest and most sensitive regions of the body. Because of its delicate nature, it is highly susceptible to dehydration, puffiness, fine lines, and pigmentation changes that manifest as dark circles. These changes are often linked to aging, stress, insufficient sleep, and environmental exposure. Clinically, dark circles are referred to as periorbital hyperpigmentation (POH), describing the discoloration that appears beneath the eyes, on the eyelids, and around the orbital area.

➤ TYPES OF DARK CIRCLES:

- Vascular dark circles:

Caused by visible blood vessels under thin skin. They appear blue, purple, or pink and worsen with lack of sleep or poor circulation.

- Mixed dark circles:

A combination of two or more types (vascular, pigmented, structural). They show multiple colors and are harder to treat.

- Structural dark circles:

Caused by hollows, tear troughs, or eye bags creating shadows. They look darker due to facial anatomy, not pigmentation.

- Brownish tone (pigmented) dark circles:

Due to excess melanin. They appear brown or dark brown, common in Indian skin tones and worsen with sun exposure.

➤ CAUSES OF DARK CIRCLES ON SKIN:

Dark circles under the eyes are defined as bilateral, round, homogenous pigmented macules on the under-eye areas. They are caused by etiological factors such as genetics, dermal melanin, post-inflammatory hyperpigmentation due to atopic or allergic contact dermatitis, periorbital edema, superficial location of vasculature, and shadowing due to skin laxity.

- Genetic predisposition: Family history often plays a role in under-eye pigmentation.
- Dermal melanin deposition: Increased melanin within the dermis enhances light absorption, deepening discoloration.
- Post-inflammatory hyperpigmentation: Allergic reactions or dermatitis can trigger inflammation, leading to residual pigmentation.
- Edema: Fluid accumulation beneath the skin accentuates shadows and discoloration.
- Skin laxity and vascular visibility: Thinning skin and superficial vasculature further exaggerate the appearance of darkness..

**Fig 1: Under Eye Dark Circles****➤ HYDROGEL UNDER EYE PATCH:****• Hydrogel:**

A hydrogel is a biphasic material, a mixture of porous and permeable solids and at least 10% of water or other interstitial fluid.

The solid phase is a water-insoluble three-dimensional network of polymers.

In other words hydrogels are the three-dimensional networks of cross-linked polymers That can absorb water in any form, swell without dissolving or altering the chemical structure.

• Types of Hydrogel:

According to source of polymer:

Natural

Synthetic

Hybrid

According to cross linking:

Covalent

Non-Covalent

Based on degradation

Biodegradable

Non-Biodegradable

II. HYPOTHESIS AND AIMS:

Hydrogels are emerging as promising platforms for cosmetic under-eye treatments, offering potential benefits for dark circles, wrinkles, fine lines, and puffiness that affect many aging individuals worldwide. Their capacity to hold large amounts of water gives them a soft, tissue-like consistency that can better mimic the delicate periorbital skin, while also providing superior biocompatibility and a lower foreign-body response compared with traditional patches. Although hydrogel patches can be prone to tearing, they generally cause fewer adverse reactions than many existing under-eye products. Modern hydrogel eye patches—now affordable and widely available—are designed to re-hydrate the dry skin around the eyes, diminish swelling, and smooth fine lines. These patches consist of a hydrated hydrogel matrix that delivers concentrated serums rich in vitamins, minerals, and other active ingredients. By leveraging the hydrogel's high water content and hydrophilic network, the patches enhance moisture retention, improve delivery of actives, and can regulate skin temperature, thereby supporting skin regeneration and reducing visible signs of aging. The current project aims to fabricate such hydrogels, evaluate their water permeability, total water content, distribution, and swelling behaviour in various solvents, explore how different formulation components influence their performance in under-eye applications.

Hydrogel under-eye patches trace their origin to a South Korean researcher. Early versions resembled Band-Aid-style cloth strips soaked in a sticky emulsion, making them costly and inaccessible to most consumers. Today, these patches are affordable and widely available. In essence, under-eye patches are small dressings intended for the delicate skin beneath the eyes; most are composed of hydrogel, though some utilize cloth, bio-cellulose, or alternative substrates. The hydrogel matrix is saturated with serums or essences rich in vitamins, minerals, moisturizers, and other active compounds. Their primary function is to hydrate the periorbital area, which lacks abundant sebaceous glands and is therefore prone to dryness, fine lines, and other aging signs. Proper moisturization is crucial, and these patches also help diminish puffiness, dark circles, and wrinkles, enhancing overall skin health. Hydrogels are favoured because their high water content and hydrophilic network form a supportive matrix that efficiently delivers actives, regulates skin temperature, and promotes physiological activity. Additionally, they offer good elasticity and ease of application. This project focuses on fabricating hydrogel formulations for under-eye patches, assessing water permeability, the influence of various ingredients, total water content, water distribution, and swelling behaviour in different solvents, and exploring diverse hydrogel-based patch designs.

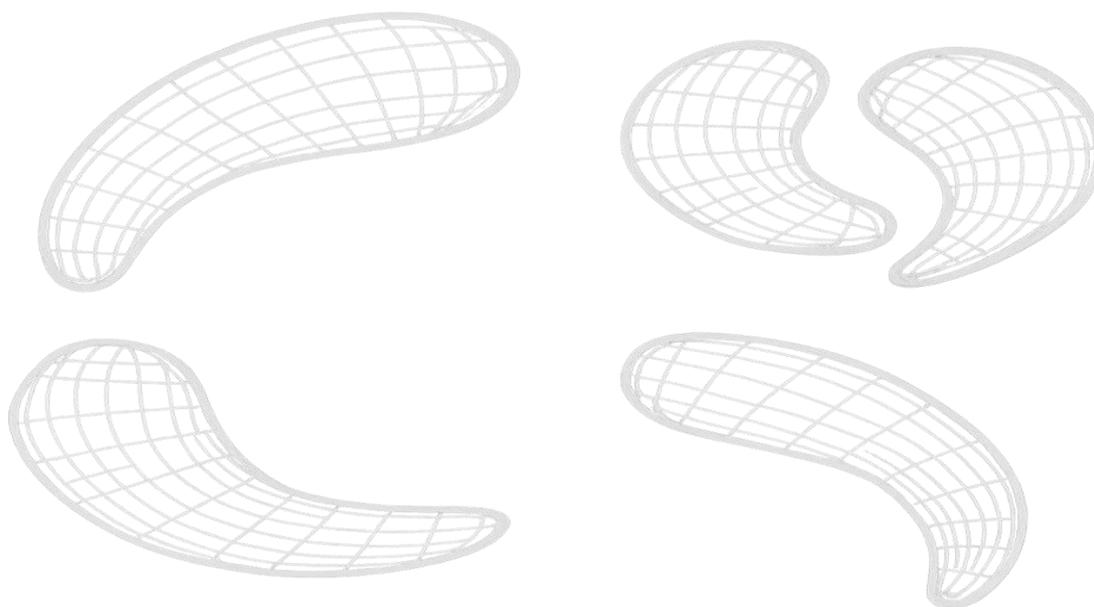


Fig 2: Hydrogel under eye patches from different angle

INGREDIENTS USE FOR UNDER EYE PATCHES THEIR SOURCES AND ROLES:

INGREDIENTS	SOURCE	ROLE
Tabernaemontana divaricata	Plant (flower)	valued for its soothing and anti-inflammatory properties.
Rubia Cardifolia	Plant (root)	traditionally used to lighten pigmentation and minimize dark circles.
Green tea extract (Camellia sinesis)	Leaf extract	rich in antioxidants, helps reduce puffiness and refresh tired eyes.
Aloe vera gel	Leaf gel	hydrates and calms the delicate under-eye skin

Chamomile extract	Flower extract	provides a gentle calming effect and reduces irritation.
Licorice extract	Root extract	brightens skin tone and offers anti-inflammatory activity.
Potato peel extract	Tuber	brightens skin tone and offers anti-inflammatory activity.
Hydrogel polymer (gelatin / agar)	Biopolymer	act as the structural base for the patch.
Purified water	Natural	serves as the solvent and carrier medium.

1) *Tabernaemontana Divaricata*:-

Antioxidant: Protects cells from oxidative stress.

Antiinflammatory: Reduces inflammation, which is beneficial in treating various diseases.

Antimicrobial: Exhibits activity against bacteria and fungi, contributing to its traditional uses in treating infections.

2) *Rubia Cardifolia* (Roots):-

These compounds are known for their potent Antioxidant properties and are associated with various therapeutic effects such as anti-inflammatory, antibacterial and anti-cancer effects.

3) *Camellia Sinesis* (Green Tea) :-

These compound are known for their strong antioxidant properties and soothing effects; the most abundant catechin is Epigallocatechin gallate (EGCG), recognized for the its ability to neutralize free radicals and oxidative stress.

4) Aloe vera (Gel/Extract) & Honey :-

Aloe vera gel and Honey contain anti oxidant activity and hydration which make it a valuable part for cosmetic products to its abundance of bioactive compounds.

5) Licorice:-

Licorice contains properties such as anti-inflammatory and skin brightening phytochemicals.

6) Potato and Potato peels:-

Potato (including potato peel derivatives) as a biodegradable hydrogel base and natural source of humectants and mild reducing agents.

III. APPLICATION OF HYDROGELS

Hydrogels are highly adaptable materials with broad utility across engineering, biology, and pharmaceutical fields. Polyelectrolyte hydrogels are especially valuable because their chains can acquire or generate charges that attract oppositely charged species, enabling the formation of complexes for drug delivery, protein and peptide transport, pesticide and nutrient release, hormone administration, agricultural and horticultural uses, biotechnology, cell-based constructs, and a wide range of biomedical applications.

Biomedical uses :

These gels can mimic the responsive behavior of human tissues, reacting to stimuli such as pH, temperature, enzymes, or electric fields. Consequently, they serve in medical implants, prosthetic muscles or organs, robotic grippers, diagnostic devices, bone-implant stabilization, prevention of intimal thickening, and thrombosis reduction. A notable advanced application is the conversion of electrochemical signals into mechanical motion—reversible contraction and relaxation—making hydrogels suitable for electrically driven artificial muscles that emulate natural muscle function.

Biotechnological uses :

Hydrogels act as immediate matrix membranes in sensors, offering tunable hardness, elasticity, selective diffusion, and refractive index. “Smart” hydrogels can concentrate dilute solutions of macromolecules (proteins, enzymes) without compromising activity, by adjusting temperature or pH to trigger controlled swelling-shrinkage. This reversible behavior is also exploited in purification systems.

Pharmaceutical uses :

- PVA-based hydrogels: Employed for targeted delivery to insulin-responsive sites, liver, gastrointestinal tract, brain, blood, nervous system, and tumors, emphasizing controlled-release strategies.
 - PEG–PCL hydrogels: Diacrylate PEG/PCL networks provide thermosensitive swelling, high elasticity, and biocompatibility for drug delivery and tissue regeneration.
 - PNIPAAm-PEGDA hydrogels: Temperature-responsive composites enable on-demand drug release; both micro- and nanoparticles derived from these systems show excellent loading efficiency.
- These diverse functionalities illustrate why hydrogels are central to modern biomedical, biotechnological, and pharmaceutical innovations.

➤ Clinical / consumer outcomes:

The patch is meant to calm the thin skin under the eyes, which often shows dark circles, puffiness and dryness because of stress, screen time or aging.

It mixes plant extracts that are rich in antioxidants (green-tea catechins), anti-inflammatory agents (aloe-vera, licorice) and pigments-lightening compounds (rubia root).

These ingredients work together to brighten colour, reduce swelling and keep the area well-hydrated, so users notice lighter circles, less puffiness and smoother skin.

The hydrogel base (made from agar-agar) holds a lot of water, feels soft like a jelly, and fits the eye contour without sliding off, giving a cooling feel that further eases swelling.

Because no synthetic dyes, fragrances or harsh additives are added, the patch is unlikely to irritate the sensitive eye area.

➤ Future directions & challenges:

1. Herb consistency: Plants vary by season and location; setting measurable markers (e.g., amount of EGCG or chlorogenic acid) will keep each batch similar.
2. Shelf-life: The water-rich gel can support microbes, so researchers need preservative-free ways to keep it stable (e.g., drying the patches before packaging).
3. Manufacturing: Moving from small lab moulds to large-scale production requires tight control of temperature and drying so every patch stays the same thickness.
4. Regulation: Because the product sits between a cosmetic and a medical device, developers must decide which regulatory route to follow, which affects labeling and safety testing.
5. Clinical proof: Bigger, double-blind studies with objective measurements (melanin index, wrinkle depth) are needed to confirm the benefits for different skin types.

IV. CONCLUSION

This review highlights that poly-herbal hydrogel under-eye patches are a promising, plant-based solution for sensitive skin concerns. The patches combine hydration from the hydrogel with antioxidant, anti-inflammatory, and depigmenting properties from natural extracts, making them effective against dark circles, puffiness, and dryness. Their biodegradable and irritation-free nature make them safer compared to synthetic alternatives. While the study shows encouraging outcomes, further clinical testing and large-scale production studies are needed to confirm long-term safety, stability, and effectiveness across different skin types.

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