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(REVIEW ARTICLE)

A review on emerging applications of emulgel as topical drug delivery system

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Abstract

Topical drug delivery is a convenient mode of drug delivery to treat localized infections. Topical medications are available in many dosage forms, such as creams, ointments, gels, pastes, and lotions. Both emulsions and gels are known for their benefits as topical preparations with few limitations. The literature on emulgel formulations was searched in June 2021 from various scientific journal articles. From a total of 102 searched articles, 24 duplicated articles and 36 irrelevantly judged on the abstract or full papers were excluded. Finally, 47 articles were selected for review. Emulgel possesses many promising properties for dermatological use such as being greaseless, easily removable, easily spreadable, emollient, non-staining, longer shelf-life, transparent, having an elegant appearance and having less potential to cause serious side-effects. Many formulation scientists have started to develop emulgel using various active pharmaceutical ingredients, especially which are hydrophobic in nature. We conclude that formulated emulgels have shown excellent results in aspects such as appearance, rate of drug penetration to skin, rate of drug release and therapeutic response. This review article is mainly focused on formulation, ingredients, methods, and recent developments in emulgel formulations.

Keywords: Emulgel; Gelling agent; Gel; Emulsion; Emulsifier

1. Introduction

Over the last decade, scientists and industrial researchers have become more interested in pharmaceutical semisolid dosage forms, particularly emulgels. The skin is a key site for systemic and local drug administration. Though the skin is an easily accessible route of drug administration, some drugs do not penetrate the skin [1]. A variety of topical medicinal products are available from simple solutions and ointments to multiphase nanotechnology-based products [2]. In the forthcoming years, topical drug delivery systems will be used considerably to improve patient compliance.

Gel is a convenient and preferred dosage form for delivering active ingredients to their site of action. Due to its cross-linked and three-dimensional nature, gel captures small drug particles and promotes their controlled release. The three-dimensional network is composed of macromolecules and is capable of entrapping a large amount of solvent molecules [3]. Gels lengthen the contact time of drug over the skin due to its muco-adhesive property [4]. Most common pharmaceutical gels are formulated by dispersing hydrophilic polymers within a sufficient aqueous phase. After dissolving within an aqueous phase, hydrophilic polymers become lyophilic colloids. Due to their unique physical properties, they are transformed into a self-association type of colloids [5]. There are two types of self-association

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(reversible and irreversible). Thus, so formed lyophilic gels are classified as either type 1 or type 2 gels. In type 1 gels (also termed hydrogels) the interaction between the polymer chains is covalent at the cross-link [6, 7].

Gels have many favorable properties like spreadability, non-staining, greaseless, and thixotropic but a major drawback in delivering hydrophobic drugs to the skin. Active ingredients with a hydrophobic nature exhibit improper drug release in gels due to lack of solubility in the aqueous phase, hence they are not suitable to be added into the gel base [8, 9]. Therefore, to reduce these drawbacks, emulsion-gel based drug delivery systems are being used.

Emulsions are thermodynamically unstable biphasic dosage forms consisting of two immiscible liquids, one of which is uniformly dispersed as globules (internal phase) throughout the second phase (external phase) [10]. Emulsions allow the incorporation of hydrophobic medicinal agents into the oil phase which facilitates the dispersion of oil globules in the aqueous phase and produces an oil-in-water (O/W) emulsion [11-13]. Furthermore, emulsions are capable of acting as controlled drug delivery systems where the medicinal agent to be delivered is stored inside the oil phase. This internal oil phase of an emulsion will function as a drug reservoir and the drug will be released to the skin in a controlled manner. Though emulsions have many satisfactory properties, a major disadvantage is their reduced contact time on the skin surface. Both gel and emulsion individually possess many advantages but due to inherent drawbacks, another dosage form superior to each preparation was identified and thus the discovery of emulgel was made.

Emulgel is a preparation that comprises both emulsion and gel. The emulsion type used can be oil-in-water (O/W) or water-in-oil (W/O), which is eventually mixed with a gelling agent to formulate an emulgel. This type of novel formulation has been developed in recent years for topical drug delivery and has proven its suitability in carrying hydrophobic drugs. Moreover, it is expected that emulgel will become a key solution for loading hydrophobic medicinal agents in a gel formulation [14]. Hence, emulgel possesses the characteristics of both gel and emulsion; thereby, it operates as a dual-control drug release system [15, 16]. Due to these benefits many pharmaceutical manufacturers have stepped into commercial production of emulgels. Such products are Voltaren® Emulgel® (Diclofenac sodium), Miconaz-H (Miconazole nitrate), Pernox® (Benzoyl peroxide) and CLINAGEL® (Clindamycin phosphate).

1.1. Steps involved in preparation of emulgel

1.1.1. Step 1: Formulation of O/W or W/O emulsions (Figure 1)

The initial step of emulsion formulation involves the dissolution of oil-soluble substances in the oil vehicle (e.g. dissolving span 20 in liquid paraffin) and the dissolution of the water soluble substances in the aqueous vehicle (e.g. dissolving tween 80 in purified water). Both phases were mixed under turbulent mixing conditions to ensure the dispersion of two phases into droplets [17, 18]. In the laboratory, the preparation of emulsions involves the use of a mechanical stirrer, whereas the emulsification of industrial manufacturing is generally performed using mechanical stirrers, ultrasonifers, homogenisers, or colloid mills [19].

1.1.2. Step 2: Formulation of gel base

To begin, the water-soluble substances or excipients are dissolved in the aqueous vehicle using mechanical stirring in a mixing vessel. To avoid aggregation, the hydrophilic polymer is slowly added to the stirred mixture, and stirring is continued until the polymer has dissolved while the pH remains within the desired range [20, 21]. Superfluous stirring of pharmaceutical gels may result in the entrapment of air, so the mixing rate must be at a moderate pace.

1.1.3. Step 3: Addition of emulsion into gel base with steady blending: the gel stage is mixed into the emulsion stage to the extent of 1: 1 to get emulgel

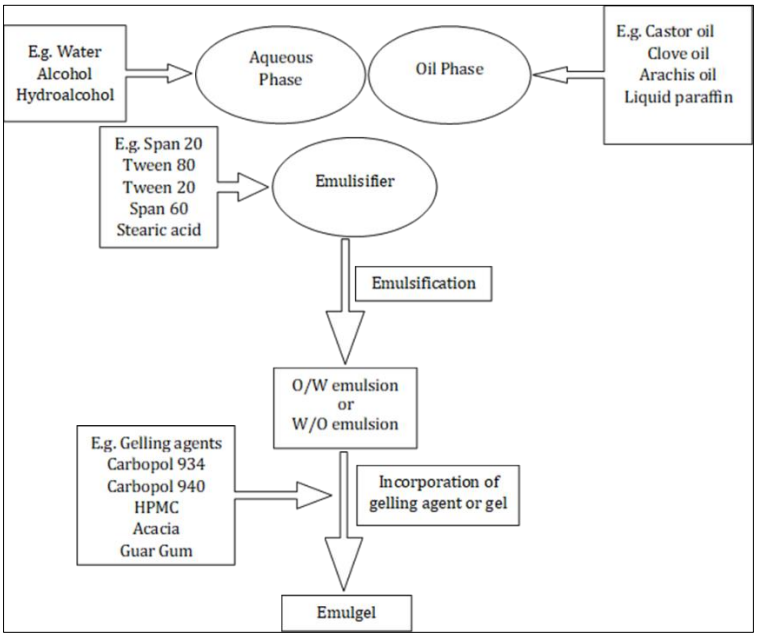

Figure 1 General steps involved in the preparation of emulgels

2. Methods

2.1. Study design

The literature on emulgel formulations was searched in June 2021. Scientific journal articles were used to acquire data for this review. Published articles or papers comprising particulars about the formulation, excipients, and uses of emulgels for review were identified according to Figure 2. A complete search of the literature was conducted in the following databases: PubMed (U.S. National Library of Medicine, USA), Google Scholar and Science Direct (RELX group, Netherlands) for studies published between 1st January 2001 to 30th June 2021, following keywords and headings were used for the search: “emulgel”, “gellified emulsion”, “skin preparation”, and “topical”.

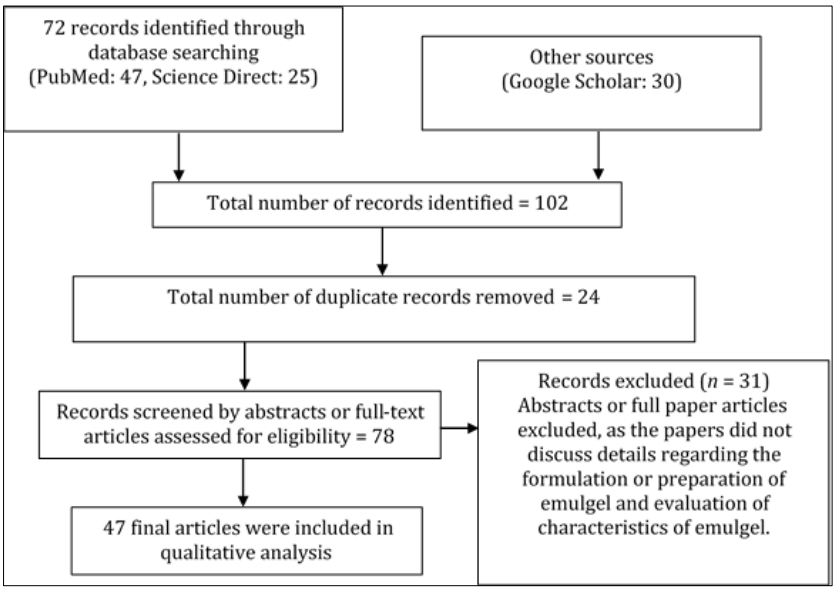

Figure 2 Flow diagram of the literature selection process

This review considered articles regarding preparations or formulations of topical emulgels. Studies only focusing on nano-emulgel development or evaluating the clinical and pharmacological aspects of emulgel preparations were excluded from review. From a total of 102 results, 24 duplicate papers and 36 irrelevant articles judged on the abstract or full papers were excluded. Finally, 47 articles were considered as suitable literature to be included in this review.

3. Results

In recent decades, many formulation scientists have developed emulgels for therapeutic and cosmetic purposes by incorporating various types of active pharmaceutical ingredients and natural extracts obtained from various plant parts. Moreover, these formulations were studied to evaluate their physical properties, stability, and absorption through skin, toxicity and drug release profile. The advantage of using emulgel formulation is not limited to drugs belonging to a limited number of therapeutic classes. Different therapeutic classes of medicinal agents were incorporated into emulgel formulation and used as a topical drug delivery tool in numerous circumstances. The following tables (Table 1-5) briefly summarize the different therapeutic groups of medicinal agents formulated as an emulgel, including excipients used, purpose and outcomes of the study.

Table 1 Emulgel formulations developed using various antibacterial, antifungal and antiviral agents as active pharmaceutical ingredients (APIs)

Antibacterial/ antifungal/ antiviral agents	**Excipients used to formulate the emulgel**	**Purpose of the study**	**Outcomes/ Findings of the study**	**References**
Amphotericin-B and oleic acid	Polaxmer 407, soybean lecithin, ethanol and isopropyl palmitate	Investigation of *in vivo* therapeutic potential of amphotericin B and oleic acid in cutaneous leishmaniasis.	Formulations prepared with amphotericin-B 3% and oleic acid 5% showed better *in vivo* therapeutic response and lesser systemic toxicity. Amphotericin-B emulgel accelerated the wound healing and less adverse-effects were found.	[22]
Chlorphenesin	HPMC, carbopol 934, span 20, tween 20, methyl and propyl parabens and light liquid paraffin	Evaluation of antifungal activity of emulgel with two different gelling agents and determining the influence of gelling agents in drug release and antifungal activity.	Emulgels formulated with HPMC and carbopol 934 showed good physical properties and stability but HPMC-based emulgel with liquid paraffin demonstrated highest drug release and antifungal activity.	[23]
Clotrimazole	HPMC K4M, carbopol 934, tween 80, span 80, propylene glycol, methyl paraben and light paraffin	Formulation of hydrophobic drug Clotrimazole as an emulgel by using HPMC K4M and carbopol 934 as gelling agents.	HPMC K4M based emulgel showed the highest drug release of 58.57 % in eight hours. It also showed a sustained release of Clotrimazole in a controlled manner possessing good stability.	[24]
Metronidazole	Xanthan gum, Capmul908, propylene glycol, methyl and propyl parabens	Development and optimization of metronidazole emulgel.	The emulgel formulation had good stability and showed improved skin permeation compared to conventional gel.	[25]
Ofloxacin	carbopol 940, HPMC, oleic acid, tween 80, span 80, and propylene glycol	Design, development and optimization of ofloxacin gellified emulsion to provide controlled	Emulgel formulated with carbopol 940 showed 76.68±2.52 % *ex-vivo* drug release through goat skin and 88.58±1.82 % *in vitro* diffusion through egg	[26]

		transdermal drug delivery.	membrane with good antimicrobial properties.	
Ciprofloxacin	Gelatin, glycine, mustard oil, tween 80 and propylene glycol	Preparation and characterization of gelatin emulgels using ciprofloxacin as a model drug.	Ciprofloxacin drug release was higher in emulgels whose electrical conductivity was higher. Softer emulgels formulated by increasing the oil fraction of the emulgel.	[27]
Metronidazole and ciprofloxacin	Groundnut oil and sorbitan monopalmitate	Evaluation of groundnut oil-based emulsion gel as a topical drug delivery tool for hydrophobic drugs.	Emulgels loaded with drugs were found to be active against *B. subtilis* and *E. coli*. It was also shown as an effective and multimodal carrier system for both metronidazole and ciprofloxacin drugs.	[28]
Acyclovir and ketoconazole	Xanthan gum, liquid paraffin, glycerin, tween 80, span 60, cetyl alcohol, polyethylene glycol, and methyl and propyl parabens	Formulation and evaluation of the novel Pheroid™ drug delivery system, to determine if it improved the transdermal or dermal delivery of acyclovir and ketoconazole when incorporated into cream and emulgel formulations.	Delivery to the dermal and epidermal and transdermal skin layers were increased by Pheroid™ formulae. The Pheroid™ emulgel and cream increased the topical delivery of ketoconazole and acyclovir, respectively.	[29]
Nimorazole	Carbopol 940, liquid paraffin, tween 20, span 20, and triethanolamine	Preparation and evaluation of radio sensitizing agent nimorazole as a topical emulgel to treat head and neck regions of hypoxic tumours.	The *in vitro* drug release study showed that the drug release was 80-92 % within five to eight hours in rats without any irritation at the site of application. Emulgel formulations were stable for 90 days at cool temperature without any physical changes.	[30]
Terbinafine hydrochloride	Carbopol 934, liquid paraffin, propylene glycol, tween 20, span 20, methyl and propyl parabens	Development of terbinafine hydrochloride emulgel to bypass hepatic first-pass metabolism, reduce dosage regimen and increase residence time.	Emulgel with the liquid paraffin and emulsifying agent in its higher concentration proved to be the formula of choice with 93.23% drug release for 24 hrs. Appearance, homogenicity and spreadability remained unchanged upon three months of storage.	[31]
Clotrimazole	Jojoba oil, HPMC, carbopol 934, propylene glycol, span 60 and triethanolamine	Formulation and evaluation of jojoba oil based emulgel with various concentrations of gelling agents like HPMC, Carbopol 934 and both.	Emulgel formulas containing a combination of the two gelling agents HPMC and carbopol 934 (5: 1 ratio), possessed satisfactory stability and excellent antimycotic activity against *C. albicans*. All formulations showed a little or no thixotropy with non-Newtonian shear thinning behavior.	[32]
Benzoyl peroxide	Carbopol 940, almond oil,	Formulation and evaluation of benzoyl	The emulgel containing sesame oil (6 %w/w) as oil phase,	[33]

	sesame oil, jojoba oil, wheat germ oil, propylene glycol, tween 20, span 60, methyl and propyl parabens	peroxide gellified emulsions using different vegetable oils for anti-acne properties and comparing their properties with marketed products.	exhibited maximum drug release and anti-microbial activity against *S. aureus*, and least skin irritation potential and also found to be greater in anti-microbial than the marketed benzoyl peroxide formulations.	

According to Table 1, the antibacterial, antifungal and antiviral activities of all emulgels which were studied were good, and few studies reported greater activity than the existing marketed products [25, 33]. Emulgels formulated effectively delivered hydrophobic and less water soluble drugs like metronidazole, ciprofloxacin, terbinafine and ketoconazole to the targeted site [25, 27, 28, 29, 31]. Most of the formulations showed a good *in vivo* therapeutic response with reduced systemic toxicity [23-26]. Physical properties like appearance, homogenicity and spreadability remained unchanged for almost all preparations [29-33].

Table 2 Emulgel formulations developed using various nonsteroidal anti-inflammatory agents (NSAIDs) as APIs

NSAIDs	Excipients used to formulate the emulgel	Purpose of the study	Outcomes/ Findings of the study	References
Ketoprofen	HPMC, carbopol, tween 20, span 80, liquid paraffin, propylene glycol, ethanol and methyl paraben	Formulation and evaluation of ketoprofen as an emulgel by using HPMC and carbopol as gelling agents.	Emulgels formulated with carbopol showed better drug release profile compared to HPMC, also 98.46±2.05 % drug released in eight hours with favorable physical appearance and clarity.	[34]
Mefenamic acid	carbopol 940, clove oil, menthe oil, span 20, tween 20, methyl and propyl parabens and liquid paraffin	Formulation and evaluation of mefenamic acid emulgel using carbopol 940 as a gelling agent.	Mefenamic acid emulgel prepared with clove oil as a penetration enhancer showed 56.23% drug release in four hours which was comparable with marketed diclofenac topical gel.	[35]
Indomethacin	carbopol 934, xanthan gum, liquid paraffin, tween 80, span 80, propylene glycol, methyl and propyl parabens	Development and optimization of indomethacin emulgel using carbopol 934 and xanthan gum as gelling agents.	Indomethacin emulgel prepared using xanthan gum with lower liquid paraffin concentration and high tween 80 concentrations was the formula of choice and it showed more promising results in drug release compared to carbopol 934.	[36]
Diclofenac diethylamine	Carbopol 971, liquid paraffin, oleic acid, polysorbate 20, polyethylene glycol, triethanolamine and methyl and propyl parabens	Formulation and evaluation of diclofenac diethylamine gel, emulgel and nanoemulsion-based gel for rheological behavior and *in vitro* diffusion studies.	Formulated gel, emulgel and nanoemulsion-based gel showed a controlled release pattern over 12 hours. The cumulative amount of diclofenac diethylamine permeated was the highest in the emulgel compared to other formulations. Diclofenac emulgel has less systemic side effects than the oral diclofenac products.	[37]
Piroxicam	Sodium alginate, gelurice 39/01 and calcium carbonate	Formulation and evaluation of piroxicam liquid *in situ* emulgels as a sustained release delivery system for analgesic/ anti-	This study showed an improved anti-inflammatory or analgesic response from *in situ* emulgels compared to conventional *in situ* gel formulations. The *in vivo* toxicity studies done in albino rats disclosed no signs of	[38]

		inflammatory properties.	gastric ulceration occurring due to long-term dosing.	
Ibuprofen	Hydroxypropyl cellulose, propylene glycol, glycerol, ethanol, polyethylene glycol 400 and transcutol	Development and investigation of the *in vitro* performance of topical semisolid creams, gels and emulgels with ibuprofen as the model drug.	Permeation rate at the end of 24 hours is higher for clear gel and then emulgel. Formulation parameters like concentration of ibuprofen, physical state of ibuprofen, formulation type, mucoadhesive properties, and viscosity will affect the stability of the emulgel formulation.	[39]
Meloxicam	Carbopol 981 and 974, glycerin, triethanolamine, methyl and propyl parabens	Formulation and characterization of meloxicam loaded emulgel for topical application using carbopol 981 and 974 as gelling agents.	Meloxicam emulgel formulated with 1.5 % carbopol 981 showed an *in vitro* drug release of 89.93 % at the end of eight hours. Also the emulgel helped significantly to optimize the targeting of the drug without any increase in the systemic side-effects.	[40]
Naproxen and nimesulide	*Aloe vera* gel, Carbopol 934 and methyl paraben	Formulation of naproxen and nimesulide liposomal formulation for incorporation in *Aloe vera* trans emulgel and to carry out *in vitro* and *in vivo* evaluation.	*Aloe vera* trans emulgel using naproxen and nimesulide liposomal formulation is stable and *Aloe vera* gel base has a significant anti-inflammatory effect compared to the commercial formulations and for formulation with high drug release.	[41]

As shown in Table 2, many studies have shown an improved anti-inflammatory/ analgesic response from emulgels formulated with NSAIDS as the API compared to conventional gel formulations [35, 36, 41]. Incorporation of penetration enhancers to the formulation has improved the drug release profile and bioavailability [35, 40]. Delivering NSAIDs via the topical route has significantly reduced their systemic side-effects and showed an improved drug release profile [38, 40].

Table 3 Emulgel formulations developed using cardiovascular agents as APIs

Cardiovascular agents	**Excipients used to formulate the emulgel**	**Purpose of the study**	**Outcomes/ Findings of the study**	**References**
Amlodipine besylate	Lecithin, terpenes, azone, carbopol 940, pluronic F127, tween 40, span 80, and propylene glycol	Preparation of emulgel to investigate its percutaneous permeation using rat skin and diffusion cell technique.	The prepared amlodipine besylate emulgels having lecithin as the penetration enhancer have a good potential for transdermal delivery.	[42]
Pravastatin	Cetyl alcohol, isopropyl myristate, polyethylene glycol, ethanol, stearic acid and mineral oil	Formulation and evaluation of 2 % pravastatin emulgels and creams to investigate which formulation delivers	Emulgel formulation of pravastatin showed an increased permeation through skin and rate of drug release compared to the cream.	[43]

		pravastatin best to the target-site.		
Lacidipine	Carbopol 940, soya lecithin, cremophor, ethanol and cholesterol	Development and evaluation of proniosomal gel with corresponding emulgel for antihypertensive drug lacidipine.	Optimized proniosomal gel formulation showed greater skin permeation compared with the emulgel formulation containing equivalent amounts of lacidipine. Emulgel formulation showed a better safety profile and avoided first pass metabolism.	[44]

According to Table 3, the addition of a penetration enhancer like lecithin to amlodipine and lacidipine has improved skin permeation of the APIs from emulgels [42, 44]. Pravastatin and lacidipine extensively get metabolized during their first pass metabolism so delivering these APIs as emulgels helped to avoid first pass metabolism [43, 44]. All studies on emulgel formulations reported that emulgels exhibited an increased drug release and safety profile [42-44].

Table 4 Emulgel formulations developed using immunosuppressants, antioxidants, and vitamin D3 analogue and xanthine oxidase inhibitors as APIs

APIs	**Excipients used to formulate the emulgel**	**Purpose of the study**	**Outcomes/ Findings of the study**	**References**
Cyclosporin-A	Polycarbophil, poloxamer 188, castor oil, glycerol and ethanol	Formulation of ocular delivery emulgel with Cyclosporin-A using polycarbophil as the gelling agent.	Polycarbophil possessed fair drug release and physical properties and remained consistent after storage for three months. Emulgel showed an extended retention time on the ocular surface with improved ocular bioavailability observed.	[45]
Embelin	Olive oil, carbomer, tween 40, span 20, propylene glycol, methanol and ethanol	Formulation of embelin emulgel for topical delivery and evaluating it's *in vitro* antioxidant and anti-inflammatory properties.	Hydrophobic API embelin can be formulated as emulgel and showed potent antioxidant and moderate anti-inflammatory properties. It also had a smooth homogenous texture and glossy appearance.	[46]
Calcipotriol	Carbopol 940, liquid paraffin, propylene glycol, kollicream 3C, kolliphorCS20 and isopropyl alcohol	Formulation and evaluation of calcipotriol topical emulgel as a treatment for psoriasis.	Hydrophobic calcipotriol can be formulated as emulgel for local treatment of psoriasis. The emulgel showed required physicochemical, viscosity, drug release and stability. Addition of penetration enhancers has improved the drug penetration through the epidermis.	[47]
Allopurinol	Carbopol 940, liquid paraffin, propylene glycol, tween 20, span 20, dimethyl sulfoxide, methyl and propyl parabens	Formulation and evaluation of allopurinol emulgels using Carbopol 940 in different ratios as gelling agents.	Emulgel formulations prepared with different carbopol concentrations possessed acceptable physical properties. Formulation containing carbopol 940 and penetration enhancer eugenol 8.0 mL showed excellent drug release across the cellophane membrane.	[48]

As shown in Table 4, cyclosporin-A (immunosuppressant) emulgel prepared for ocular delivery possessed an excellent drug retention time on the ocular surface with satisfactory ocular bioavailability [45]. Calcipotriol (vitamin D3 analogue) and embelin (antioxidant and anti-inflammatory) having hydrophobic natures were formulated as emulgels and showed good therapeutic activity and physical properties [46, 47]. Allopurinol (xanthine oxidase inhibitors) emulgels prepared with a carpool 940 and penetration enhancer eugenol possessed an excellent drug release profile across the cellophane membrane [48].

Table 5 Emulgel formulations developed using plant extracts

Formulations (APIs)	Excipients used to formulate the emulgel	Purpose of the study	Outcomes/ Findings of the study	References
Annona squamoa leaf extract	Carbopol 940, clove oil, liquid paraffin, methyl paraben, tween 20, span 20 and propylene glycol	Preparation and characterization of natural antioxidant emulgels loaded with *Annona squamosa* leaf extract with and without penetration enhancer.	Emulgels developed with 4 % of *Annona squamosa* leaf extract and 8 % clove oil penetration enhancer showed stable properties at tested parameters like pH, conductivity and phase separation. Emulgel formulation showed 90% radical scavenging activity compared to the standard which has 92% activity.	[49]
Cinnamomum tamala extract	Carbopol 940, liquid paraffin, tween 20, span 20, propylene glycol, methyl and propyl parabens	Formulation and characterization of *Cinnamomum tamala* extract loaded emulgel to evaluate antioxidant properties.	Emulgel formulated with *Cinnamomum tamala* extract showed an 81% antioxidant activity and also possessed excellent pharmaceutical stability and physical characteristics in a series of stability test conditions.	[50]
Mimosa pudica seed extract	Carbopol 940, liquid paraffin, propylene glycol, tween 20, span 20, methyl and propyl parabens	Investigation of the polyphenolic contents of *Mimosa pudica* seed extract and its anti-dermatoheliosis potential by developing a stable topical emulgel formulation.	Prepared emulgel was biocompatible and did not show any effect on normal Human keratinocytes viability and structure. Also *Mimosa pudica* seed extract could be a great alternative to deal with dermatoheliosis.	[51]

As shown in Table 5, emulgel formulations prepared with plant extracts showed stable physical properties [49, 50], stability [50] and biocompatibility [51]. Emulgel formulations prepared with *Annona squamosa and Cinnamomum tamala* demonstrated promising antioxidant activity [49, 50]. These evidences show that successful formulations can be developed by incorporating plant extracts into emulgel formulations.

4. Discussion

In this literature review, an attempt was made to find out the formulations prepared as emulgels. Several literature used in this review have proved the fact that emulgel has been formulated and used as a novel topical drug delivery system to deliver medications [21-48]. Furthermore, emulgels are used in both pharmaceutical and cosmetic applications as well as in herbal preparations to deliver plant extracts [49-51]. Combining an emulsion with gel makes it a dual control release system and will solve the problems such as phase separation, creaming, cracking, coalescence associated with emulsion formulations, and improve the stability of the formulation [15-16]. The common problem encountered during the development of new formulations is the hydrophobic nature of the drugs, which leads to solubility and bioavailability problems [9] .Therefore, hydrophobic drugs, can be added into the oil phase of the emulsion and delivered to the skin as an emulgel formulation where gels are not suitable dosage forms in delivering hydrophobic drugs. These characteristics of emulgel make them a more effective dosage form [25-36].

Most of the developed formulations discussed in this paper extensively used carbopol 934, carbopol 940 and HPMC as gelling agents to make the gel part of the emulgel. Likewise, tween 20, 40, 80 and span 20, 60, 80 are the commonly used emulsifiers used to make the emulsion [26-37]. Penetration enhancers are used as an aid in improving the transdermal drug delivery [35, 42, 48]. They will penetrate into the skin and reversibly decrease the barrier resistance therefore, increase the rate of drug absorption. The addition of penetration enhancers like propylene glycol, polyethylene glycol, isopropyl alcohol, ethanol, azones and sulfoxides into emulgel formulations has enhanced the penetration through the skin [52].

Evaluation of emulgels has mainly focused on analyzing their drug release profile, physical properties, stability, penetration through skin and local or systemic toxicity. Physical properties like consistency, homogenicity, appearance, swelling index, extrudability, clarity, spreadability, viscosity, pH value and rheological properties have been tested in most of the studies [25-33, 44-48]. Fewer studies have proved that prepared emulgels are found to have less systemic toxicity and adverse effects compared to parenteral and oral dosage forms of the same active ingredient [29, 37]. Emulgels have superior stability compared to the emulsions. Physical and chemical incompatibilities which frequently occur in emulsions are reduced in emulgel [37, 39]. Nano emulgel is an emerging attractive topic which can take transdermal drug delivery to the next level in the future. Nano sized particles will increase the rate of absorption and bioavailability of the drug therefore, making it more beneficial [37].

5. Conclusion

Many researchers have used emulgel as a novel drug delivery system to deliver medication to local and systemic sites of action. These formulations possessed many advantages, with very few undesired side effects. We conclude that formulated emulgels have shown excellent results in aspects such as appearance, homogenicity, viscosity, rate of drug penetration into skin, drug release profile, and therapeutic outcome. All such points of interest in emulgel over other topical drug delivery systems make them more effective and commercial. In the future, these physical and physico-chemical properties will be utilized to deliver a greater number of topical medications, such as emulgel.

Compliance with ethical standards

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Disclosure of conflict of interest

No conflicts of interest to be declared.

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