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RESEARCH ARTICLE

PREPARATION AND EVALUATION OF ANTI-DANDRUFF HAIR GELS

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ABSTRACT

Dandruff is a shedding of dead skin cells from the scalp and is suffered by almost 50% of the population and causes significant discomfort. The severity can range from mild scaling to dry skin to severe scaling. Malassezia furfur is considered to be the cause of dandruff. Dandruff may also be caused by changes in humidity, trauma, seasonal changes or emotional stress. Dandruff is commonly treated using shampoos or lotions containing imidazoles, selenium sulphide, and coal tar, ketoconazole, salicylic acid and zinc pyrithiol. Shampoos or lotions do not last for the long duration on the scalp and these cannot prevent re-occurrence. The anti-malassezial activity of Clotrimazole gel as an attempt was made for formulating gels containing Clotrimazole. Hair gels last long on the scalp. Gel formulations were prepared using carbopol, Methyl cellulose & NaCMC and their activity was tested against Malassezia furfur.

INTRODUCTION

Dandruff

Dandruff (Hay *et al.,* 1997) is a common scalp disorder affecting almost half of the population at the pre pubertal age and of any sex and ethnicity. Pityriasis simplex capillittii(commonly known as dandruff) is the shedding of dead skin cells from the scalp. The word dandruff is of Anglo Saxon origin, a combination of 'tan' meaning 'tetter' and 'drof' meaning dirty. Dandruff can be considered aesthetically displeasing and often causes itching. Dandruff is the result of a combination of factors. Some of these factors are well studied, whereas others have not been thoroughly investigated.

Seborrhoeic Dermatitis

Flaking (Janniger *et al.,* 1995) is a symptom of seborrhoeic dermatitis. Joseph bark notes that "redness and itching is actually seborrheic dermatitis and it frequently occurs around the folds of nose and the eyebrow areas, not just the scalp" (Zouboulis *et al.,* 1998). Dry, thick, well defined lesions consisting of large, silvery scales may be traced to the less common psoriasis of the scalp (Schuab *et al.,* 1999; Schechtman *et al.,* 1995; Basset seguin *et al.,* 1998).

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Dandruff Composition

Dandruff scale is a cluster of corneocytes, which have retained a large degree of cohesion with one another and detach as such from the surface of the stratum corneum. (Hay *et al.,* 1997) The size and abundance of scales are heterogeneous from one site to another and over time. Parakeratotic cells often make up part of dandruff. Their numbers are related to the severity of the clinical manifestations, which may also be influenced by seborrhea.

Causes

The most common cause of dandruff (Hay *et al.,* 1997) is probably the fungus Malassezia furfur (previously known as Pityrosporum ovale) this fungus is a lipid dependent, dimorphic yeast like fungus occurring in human skin as an opportunistic pathogen and is responsible for many cutaneous diseases like dandruff, pityriasis versicolor, seborrheic dermatitis, tinea circinata etc. During dandruff, the levels of Malassezia furfur increase by 1.5 to 2 times its normal level (Cowley *et al.,* 1990). Dandruff is sometimes caused by frequent exposure to extreme heat and cold. The severity of dandruff may fluctuate with season as it often worsens in winter. Other causative factors include family history, food allergies, excessive perspiration, use of alkaline soaps and stress. Even the season of the year can contribute to the problem, cold, dry winters are notorious for bringing on

dandruff. Dan druff can also be aggravated by exposure to dust, UV light/harsh shampoos and hair dyes.

Common sites of dandruff distribution

The distribution (Thomas P, *et al.,* 1996) is classically symmetric and common sites of involvement are as follows:

- Hairy areas of head.
- Eyebrows and eyelashes.
- Beard.
- Fore head.
- The external ear canals.
- Post auricular creases.

Gels

A gel (from the Latin Gelu-freezing ,cold, ice or gelatus-frozen, immobile)is a solid, jelly like material that can have properties ranging from soft and weak to hard and tough. Gels are defined as a substantially dilute cross-linked system, which exhibits no flow when in the steady-state. By weight, gels are mostly liquid, yet they behave like solids due to three dimensional cross linked network within the liquid. It is the cross links within the fluid that give a gel its structure and contribute to stickiness. In this way gels are a dispersion of molecules or particles within the liquid in which the solid is the discontinuous phase and the liquid is the continuous phase (Isobel Adams, *et al.,* 1973; James *et al.,* 1977; Barry *et al.,* 1979).

Composition

Gels consist of a solid three dimensional network that spans the volume of a liquid medium and ensnares it through surface tension effects. This internal network structure may result from physical bonds (physical gels), as well as crystallites or other junctions that remain intact within the extending fluid. Virtually any fluid can be used as an extender including water (hydro gels), oil, and air (aero gel).both by weight and volume, gels are mostly fluid in composition and thus exhibit densities similar to those of their constituent liquids. Edible jelly is a common example of a hydro gel and has approximately the density of water.

Types of gels

Hydrogels: Hydrogel (also known as aqua gel) is a network of polymer chains that are hydrophilic, sometimes found as a colloidal gel in which water is the dispersion medium .Hydrogels are highly absorbent (they can contain over 99% water)natural or synthetic polymers. Hydrogels also possess a degree of flexibility very similar to natural tissue, due to their significant water content.

Organogels: An organogel is a non-crystalline, non glassy thermo reversible (thermoplastic) solid material composed of a liquid organic phase entrapped in a three dimensionally cross-linked network. The liquid can be, for example, an organic solvent, mineral oil, or vegetable oil. The solubility and particle dimensions of the structurant are important characteristics for the elastic properties and firmness of the organogel .Often, these systems are based on self-assembly of the structurant molecules. Organogels have potential for use in a number of applications, such as in pharmaceuticals, cosmetics, art conservation, and food. An example of formation of an undesired thermo reversible network is the occurrence of wax crystallization in petroleum.

Xero Gels: A xerogel is a solid formed from a gel by drying with unhindered shrinkage. Xerogels usually retain high porosity (25%) and enormous surface area (150-900sq.m/g), along with very small pore size (1-10nm). When solvent removal occurs under hyper critical (super critical) conditions, the network does not shrink and a highly porous, low density material known as an aero gel is produced. Heat treatment of a xerogel at elevated temperature produces viscous sintering and effectively transforms the porous gel into a dense glass.

Properties

Many gels display thixotropy, they become fluid when agitated, but resolidify when resting. In general, gels are apparently solid, jelly like materials. By replacing the liquid with gas it is possible to prepare aerogels, with exceptional properties including very low density, high specific surface areas, and excellent thermal insulation properties.

Gel forming compounds

A number of polymers are used to provide the structural network that is the essence of a gel system. These include,

1. ***Natural gums:*** Alginates, carragenan, tragacanth, pectin, xanthan, gum, etc.
2. ***Carbomers:*** Carbopol 934, carbopol 940 and carbopol 941.
3. ***Cellulose derivatives:*** Methyl cellulose, sodium carboxy methyl cellulose, hydroxy ethyl cellulose, hydroxy propyl cellulose and hydroxy propyl methyl cellulose.
4. ***Polyethylenes:*** PEG 200 to PEG 8000.
5. ***Colloidally dispersed solids****:* Microcrystalline silica, montmorrillonite clays, colloidal cellulose.
6. ***Surfactants:*** Non-ionic surfactants.
7. ***Other gellants:*** Bees wax, carnauba wax, cetyl esters wax, PEGs, etc.

In the present study, carbomer, cellulose derivatives (HPMC) and PEGs were selected as gel bases.

MATERIALS AND METHODS

Materials

The following chemicals were used:

Carbopol 940	SD fine Chemicals, Mumbai.
Carbopol 934	SD fine Chemicals, Mumbai.
Methyl cellulose	SD fine Chemicals, Mumbai.
Sodium CMC	SD fine Chemicals, Mumbai
NaOH	SD fine Chemicals, Mumbai.
Clotrimazole	Halcyon Labs, Pvt. Ltd. Mumbai.
Propyl paraben	SD fine Chemicals, Mumbai.
Methyl paraben	SD fine Chemicals, Mumbai.

Methods

Preparation of anti dandruff gels using carbopol

0.5%,0.75%, and 1% carbopol gels were formulated .0.5gm of carbopol was dissolved in 100ml of distilled water, after the complete dissolution of polymer, Clotrimazole was added and stirred gently with a glass rod.2-3 drops of triethanolamine was added at last to get a consistent gel. Concentration of drug in gel is 300micro gm/ml, which is the effective concentration of Clotrimazole as an anti-fungal agent (Barry *et al.,* 1979). In the similar way 75gm and 1gm of carbopol was dissolved in water and drug was added and at last triethanolamine was added and stirred gently until a consistent gel was obtained.

Preparation of anti dandruff gels using methyl cellulose

5%, 6%, 7% methyl cellulose solutions' were prepared.10%NaoH solution was added to it until a gel was obtained. To it drug solution was added, and triethanolamine was added until a consistent gel is obtained. Concentration of drug in the formulated gel was 300micro gm/ml (Barry *et al.,* 1979).

Preparation of anti dandruff gels using sodium carboxy methyl cellulose

4%,5%,6% Sodium carboxy methyl cellulose solutions were prepared.10%NaoH solution was added to it, then gently add Clotrimazole and triethanolamine, stirred gently until a consistent gel was obtained. Concentration of drug was 300micro gm/ml (Barry *et al.,* 1979).

Table 1.

Ingredients	G1	G2	G3	G4	G5	G6	G7	G8	G9
Clotrimazole	30mg	30mg	30mg	30mg	30mg	30mg	3omg	30mg	30mg
Carbopol940(w/v)	0.5%	0.75%	1%	-	-	-	-	-	-
Methyl cellulose(w/v)	-	-	-	5%	6%	7%	-	-	-
Sodium cmc(w/v)	-	-	-	-	-	-	4%	5%	6%
10%NaoH	5ml	5ml	5ml	5ml	5ml	5ml	5ml	5ml	5ml
Triethanolamine	0.6ml	0.6ml	0.6ml	0.6ml	0.6ml	0.6ml	0.6ml	0.6ml	0.6ml
Water	100ml	100ml	100ml	100ml	100ml	100ml	100ml	100ml	100ml
Methyl paraben(grm)	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.075

Evaluation methods of gels

Prepared gels of Clotrimazole were evaluated for the following parameters (Ravichandran *et al.,* 2005; Al-Khamis *et al.,* 1987; Udupa *et al.,* 1993).

a) Physical appearance and homogeneity

Gel formulation containing Clotrimazole were visually inspected for clarity, color, homogeneity, presence of particles and fibers.

b) Determination of pH

The pH of gels was checked by using a digital Elico pH meter at room temperature. Initially, the pH meter was calibrated using standard buffers of pH 4 and 9.2.accurately 2.5gm of gel was weighed and dispersed in 25ml of purified water and then pH meter was dipped in the dispersion and the pH was noted.

c) Viscosity

The viscosity of gels was determined by using Brookfield viscometer. The gel was placed in the sample holder and the suitable selected spindle was lowered perpendicularly in to the sample. The spindle was attached to viscometer and then it was allowed to rotate at a constant optimum speed at room temperature. The readings of viscosity of the formulation were measured after 2minutes.

d) Spreadability

Two glass slides of standard dimensions were selected. The hair gel formulation whose spreadability had to be determined was placed over one of the slides. The second slide was placed over the slide in such a way that the formulation was sandwiched between them across a length of 6cm along the slide. 100 grams of weight was placed up on the upper slide so that the hair gel formulation between the two slides was traced uniformly to form a thin layer. The weight was removed and the excess of the hair gel formulation adhering to the slides was scrapped off. The lower slide was fixed on the board of the apparatus and one end of the upper slide was tied to a string to which 2 gram load could be applied with the help of a simple pulley. The time taken for the upper slide to travel the distance of 6cm and separate away from lower slide under the direction of the weight was noted.

$$\text{Spread ability} = \frac{m \times l}{t}$$

Where,
m = weight tied to the upper slide (2 grm)
l = length of glass slide (5cm).
t = time taken is seconds.

e) Diffusion

Diffusion studies of formulated gels were performed using pre coated cellophane dialysis membrane. In this dialysis method 200ml of media is taken in a beaker which is 7.4 pH phosphate buffer. The gel to be evaluated is placed upon the dialysis membrane and is pasted on to the funnel. This set up is immersed in the media and the diffusion is carried up to 2hr 5ml sample is withdrawn for every 10mins using a cannula and fresh media is introduced again from top of the funnel. the same procedure is repeated for all the gels G1, G2, G3, G4, G5, G6, G7, G8, G9 and the samples were analyzed in UV-Visible Spectrophotometer at the wavelength 209nm Absorbance values were tabulated and a graph was plotted by taking time on x-axis and percent drug release respectively.

RESULTS

Table 2.

S.no	Product	Appearance	Ph	Spreadability (gm .cm/sec)	Viscosity (cps)	Extrudability
1	G1	Translucent,white ,smooth on application	6.4	0.55	90,00,007	Good
2	G2	Translucent, white, smooth on application	6.3	0.52	90,00,015	Good
3	G3	Translucent,white, smooth on application	6.4	0.55	90,00,013	Good
4	G4	Yellow colored ,translucent, smooth on application	7.2	1	89,00,115	Good
5	G5	Translucent ,buffy ,smooth on application	7.3	1.08	89,00,001	Good
6	G6	Translucent ,buffy, smooth on application	7.6	1.1	89,00,122	Excellent
7	G7	Clear, reddish brown colored ,smooth on application	7.5	1.01	91,00,056	Excellent
8	G8	Clear, reddish brown colored, smooth on application	7.3	0.99	91,01,111	Excellent
9	G9	Clear, reddish brown colored, smooth on application	7.9	0.97	90,89,567	Excellent

Table 3. Dissolution Profiles of Anti-Dandruff Gel Formulations

	%DRUG RELEASE								
Time (min)	G1	G2	G3	G4	G5	G6	G7	G8	G9
0	0.000 ± 0	0.000 ±0	0.000 ±0	0.000 ± 0	0.000 ± 0	0.000± 0	0.000 ± 0	0.000 ± 0	0.000 ± 0
10	19.764 ± 0.49	16.853 ±0.97	15.882 ±0.97	28.497 ± 0.49	20.572 ± 0.74	17.014 ± 0.74	19.278 ± 0.49	10.060 ± 0.49	8.605 ± 0.49
20	27.251 ± 0.48	26.290 ±0.48	22.928 ±1.00	39.259 ± 0.28	36.697 ± 0.73	26.290 ± 0.96	27.731 ± 0.48	17.645 ± 0.48	11.881 ± 0.48
30	35.534 ± 0.48	36.010 ±0.48	34.108 ±0.48	49.323 ± 0.48	44.093 ± 0.48	32.681 ± 0.48	34.108 ± 0.73	27.927 ± 0.48	16.040 ± 0.48
40	45.525 ± 0.47	40.819 ±0.47	40.348 ±0.47	59.173 ± 0.47	46.780 ± 0.98	40.819 ± 0.94	44.113 ± 0.47	35.642 ± 0.47	19.641 ± 0.72
50	52.508 ± 0.47	47.850 ±0.47	48.316 ±0.47	66.481 ± 0.47	56.545 ± 0.41	47.695 ± 0.48	52.042 ± 0.54	43.193 ± 0.47	25.028 ± 0.47
60	57.492 ± 0.46	54.727 ±0.46	56.109 ±0.46	72.241± 0.46	64.252 ± 0.70	53.344 ± 0.92	57.953 ± 0.46	47.352 ± 0.46	29.837 ± 0.46
70	66.008 ± 0.46	63.728 ±0.46	60.991 ±0.46	79.690 ± 0.46	73.305 ± 0.91	64.032 ± 0.95	66.008 ± 0.70	52.782 ± 0.46	38.188 ± 0.16
80	77.940 ± 0.45	72.976 ±0.45	70.720 ±0.45	86.964 ± 0.45	78.240 ± 0.26	72.826 ± 0.69	72.074 ± 0.52	62.599 ± 0.45	42.745 ± 0.45
90	86.029 ± 0.45	82.012 ±0.93	77.994 ±0.45	95.402 ± 0.45	85.136 ± 0.45	81.863 ± 0.68	79.333 ± 0.45	73.084 ± 0.45	53.445 ± 0.45
100	94.365 ± 0.44	86.418 ±0.88	85.535 ±0.44	99.663 ± 0.44	92.158 ± 0.44	86.713 ± 0.92	88.184 ± 0.67	76.264 ± 0.44	60.811 ± 0.44
110	99.005 ± 0.44	93.328 ±0.44	91.582 ±0.44	-	99.150 ± 0.67	93.328 ± 0.87	94.202 ± 0.67	80.665 ± 0.44	74.116 ± 0.44
120	99.632 ± 0.43	97.905 ±0.25	96.178 ±0.43	-	-	98.481 ± 0.25	97.041 ± 0.43	87.542 ± 0.43	84.519 ± 0.66

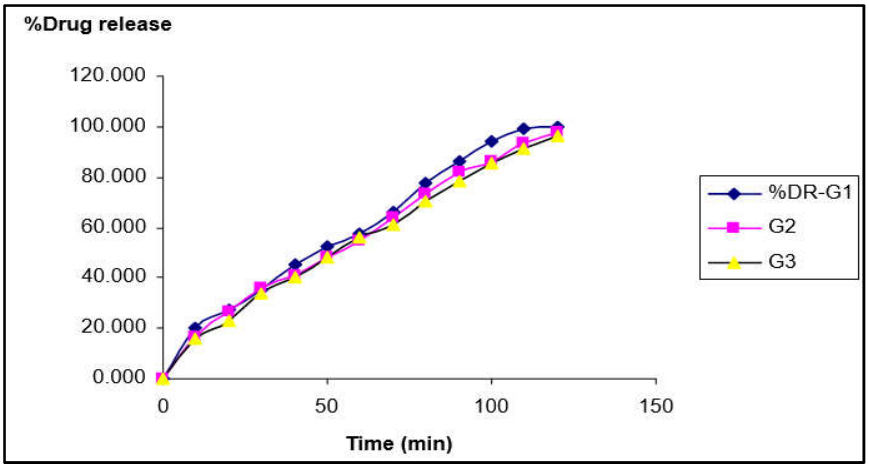

Fig. 1. Dissolution profile of clotrimazole using different concentrations of carbopol

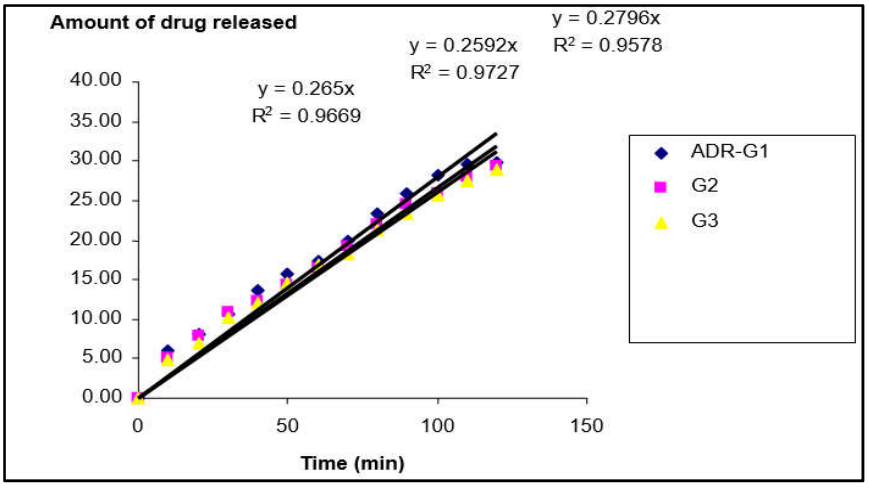

Fig. 2. Zero-order profile of clotrimazole using different concentrations of carbopol

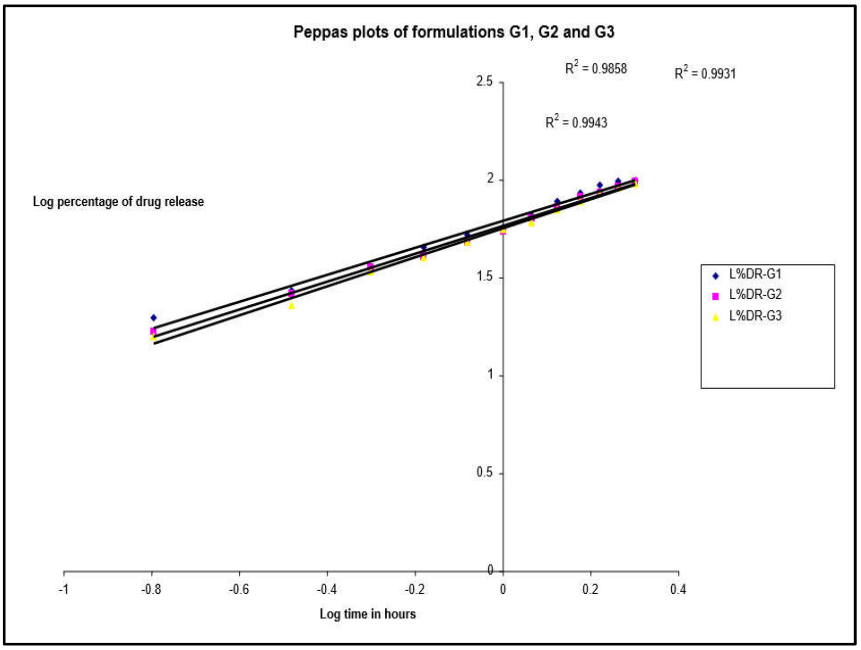

Fig. 3. Peppas plots of formulations clotrimazole using different concentrations of carbopol

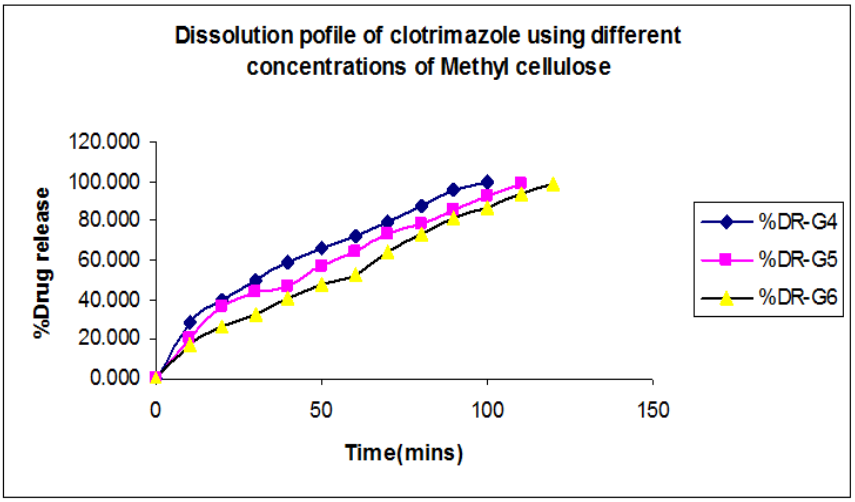

Fig. 4. Dissolution profile of clotrimazole using different concentrations of methyl cellulose

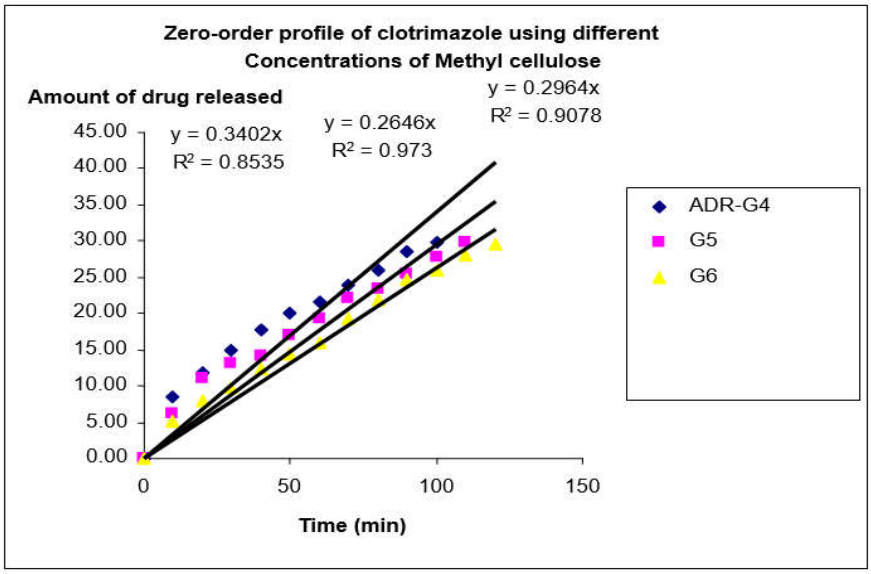

Fig. 5. Zero-order profile of clotrimazole using different concentrations of methyl cellulose

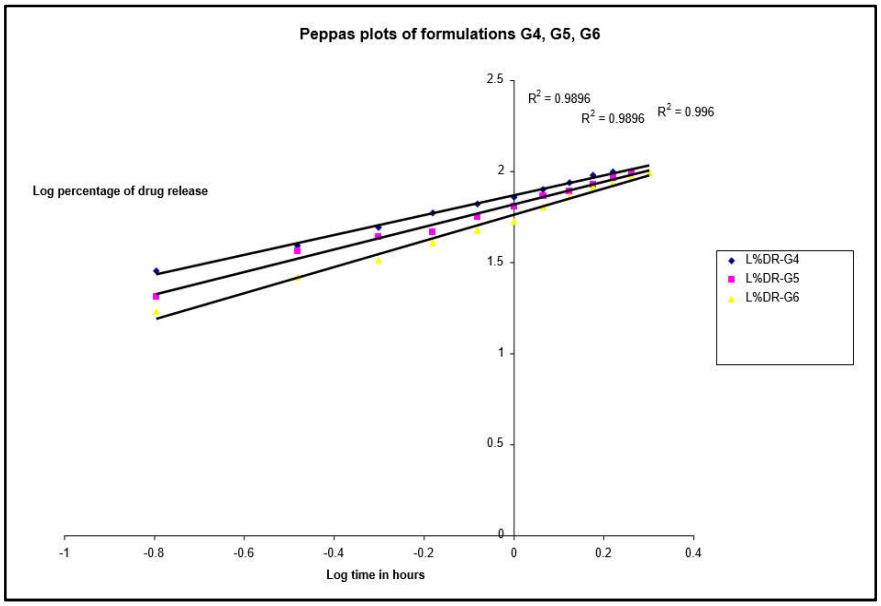

Fig. 6. Peppas plots of clotrimazole using different concentrations of methyl cellulose

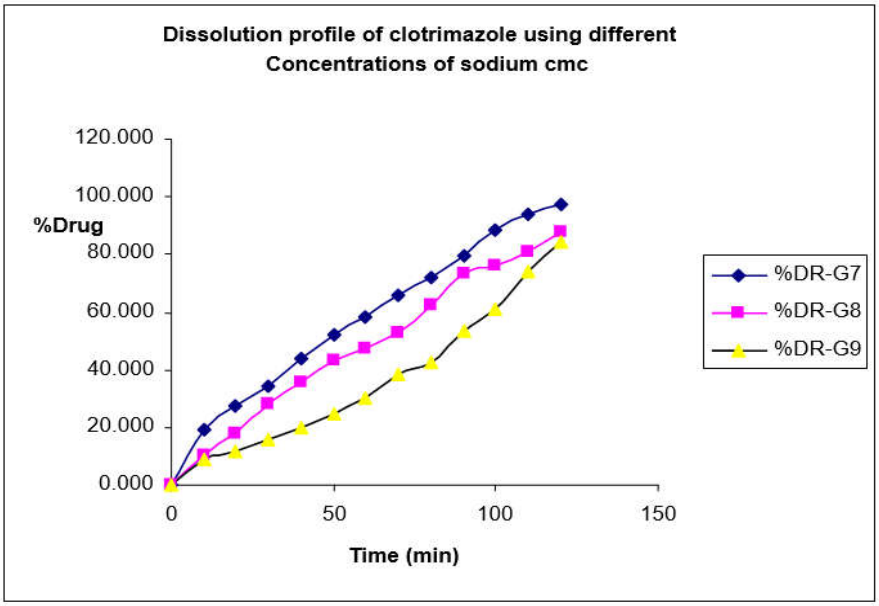

Fig. 7. Dissolution profile of clotrimazole using different concentrations of sodium cmc

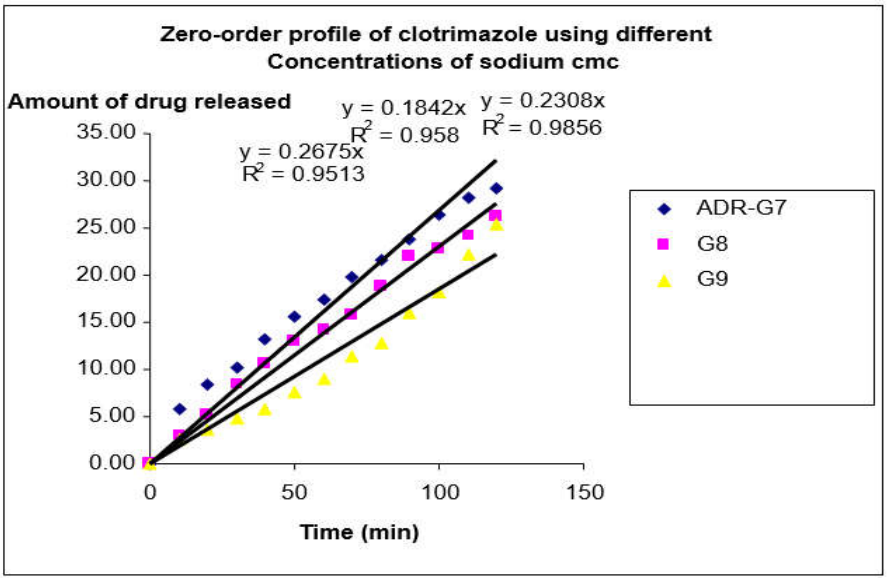

Fig. 8. Zero-order profile of clotrimazole using different concentrations of sodium cmc

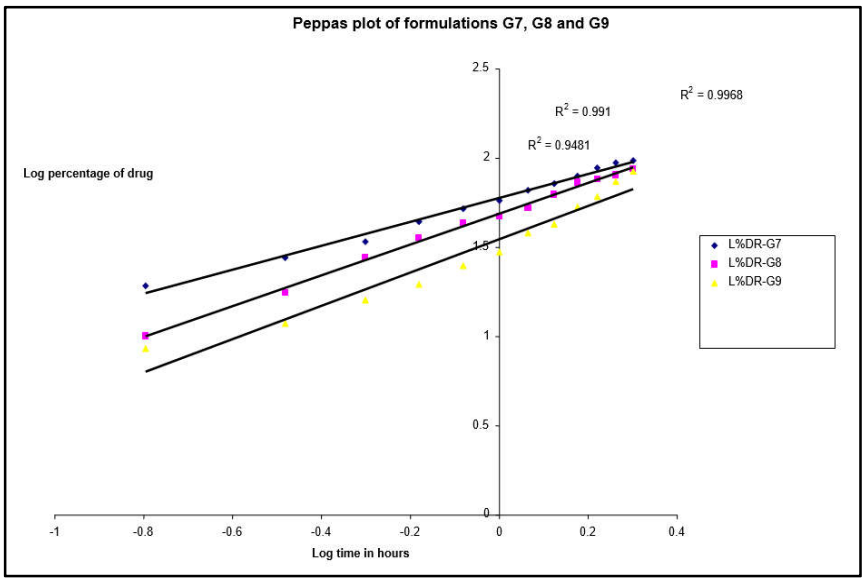

Fig-9: Peppas plots of Clotrimazole using different concentrations of sodium cmc

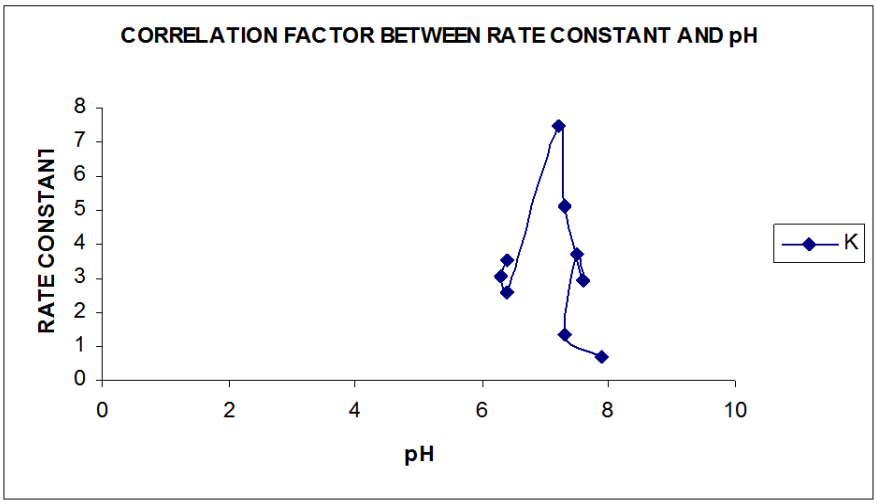

Fig-10:Correlation factor between Rate constant and P"

Table 4. Release Kinetics of Clotrimazole Anti-Dandruff Gels

BATCH	Release model			Higuchi matrix rH	Koresmeyer-Peppas			T50 (min)	T90 (min)
	Zero order		First order						
	Ko	ro			N	Kk	rk		
G1	0.9321	0.9787	0.8592	0.9689	0.6987	3.5385	0.9938	0.743	0.111
G2	0.8834	0.9833	0.9008	0.9673	0.7219	3.0320	0.9969	0.784	0.117
G3	0.8639	0.9863	0.9247	0.9659	0.7508	2.6157	0.9976	0.802	0.119
G4	1.0604	0.9260	0.9445	0.9949	0.5612	7.4843	0.9985	0.653	0.097
G5	0.9512	0.9435	0.8525	0.9864	0.6236	5.1081	0.9925	0.728	0.108
G6	0.8819	0.9863	0.8811	0.9633	0.7289	2.9288	0.9951	0.785	0.117
G7	0.9546	0.9164	0.9172	0.9970	0.5824	6.1914	0.9970	0.725	0.108
G8	0.9244	0.9273	0.8814	0.9917	0.5670	6.3779	0.9933	0.749	0.112
G9	0.8809	0.9858	0.8969	0.9637	0.7282	2.9368	0.9952	0.786	0.117

Table 5. Correlation factor between Rate constant and P^H

Formulation	P^H	K
G1	6.4	3.5285
G2	6.3	3.032
G3	6.4	2.6157
G4	7.2	7.4843
G5	7.3	5.1081
G6	7.6	2.9288
G7	7.5	3.6937
G8	7.3	1.3538
G9	7.9	0.7266

Table 6. Zone of inhibition of gel formulations

FORMULATION	SET-1	SET-2	SET-3
G1	+	+	+
G2	+	+	++
G3	+	+	++
G4	-	-	-
G5	++	++	++
G6	+	+	+
G7	-	-	-
G8	+	+	+
G9	+	++	++
PURE	++	++	++

++: Excellent; +: Good

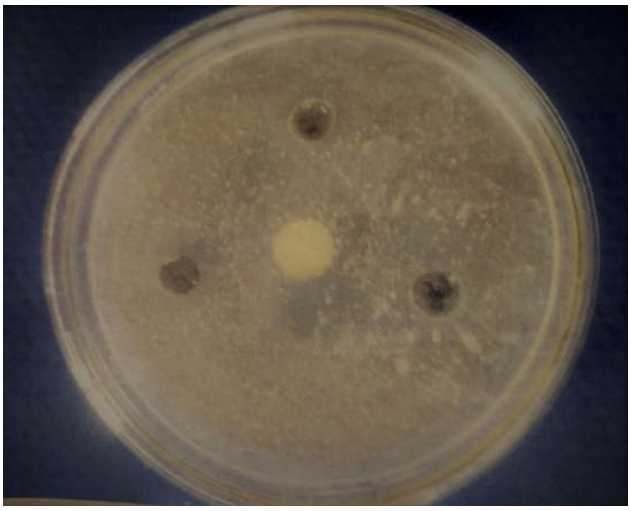

Fig 11. Zone of inhibition of gel formulation

Invitro evaluation of gels

a) **Preparation of innoculum:** For evaluation of anti-fungal activity 24hr fresh culture was used.
b) **Determination of zone of inhibition:** Anti-fungal activity was checked by agar well diffusion method. Previously liquefied media was poured into sterile petri dish. Care was taken for uniform thickness of the layer of medium. After complete solidification, a small inoculums of *M.furfur* was spread over the sabaurods dextrose agar coated with a drop of olive oil. wells were made aseptically with cork borer round the margin of the plates equidistantly (3cm part). In to each of these wells gel solution was placed carefully plates were left for diffusion for 30mins.after, the plates were incubated at 30+2 or 30-2degrees centigrade for 48hrs.after incubation was over, zone of inhibition was measured (Al-Khamis *et al.,* 1987; Udupa *et al.,* 1993; Mamatha Pingili, *et al.,* 2016).

DISCUSSION

Studies on the clotrimazole gels prepared with different concentrations of carbopol

Clotrimazole gels were prepared by using different concentrations of polymers and fixed concentration of active ingredient. The evaluation studies have been performed for pH, spreadability, physical appearance, viscosity, extrudability and anti-fungal activity. As carbopol below 0.5% has no semi solid property and above 1% it has jelly nature so formulations were done using these concentrations only. The results of the physical parameters of the gels were tabulated in table-2. The physical appearance of the gel G1 was translucent, white and smooth on application and G2 was white, translucent, and smooth on application and that of gel G3 was also white and translucent and smooth on application. The prepared gels pH was in the range of 6.3-6.4. The drug content in the formulated gels was in the range of acceptable limits. Which shows that our prepared gel formulations are according to the limits. Viscosity of the formulated gel preparations was determined and the results were found to be 90,00,007cps, 90,00,015cps, 90,00,013cps for gels G1,G2 and G3 respectively. In vitro diffusion studies were carried out and the release profiles of the gels are tabulated in table-3 and fig-1. The release of drug from the formulations follows zero-order kinetics and peppas mechanisms which were shown n fig-2 & 3 respectively. Anti-fungal activity was also carried out and the diameter of zones of inhibition were recorded and tabulated in table-6. Among the three different concentrations of carbopol, gel formulated using 0.5% carbopol i.e., gel G1 has shown best release properties when compared to the other two formulations.

Studies on the clotrimazole gels prepared with different concentrations of methyl cellulose

Clotrimazole gels were prepared by using different concentrations of polymers and fixed concentration of active ingredient. The evaluation studies have been performed for pH, spreadability, physical appearance, viscosity, and extrudability and anti-fungal activity as methyl cellulose could not form gels below the concentration of 5% and above 7% concentration. It has solid state properties so formulations were done using above mentioned concentrations. The results of the physical parameters of the gels were tabulated in table-2. The physical appearance of the gel G4 was translucent, Buffy and yellow colored and G5 was Buffy, translucent and that of gel G6 was also Buffy and translucent. The prepared gels pH was in the range of 7.2-7.6, the drug content in the formulated gels was in the range of acceptable limits .which shows that our prepared gel formulations are according to the limits. Viscosity of the formulated gel preparations was determined and the results were found to be 89, 00,115cps, 89, 00,001cps, 89, 00,122cps for gels G4, G5 and G6 respectively. In vitro diffusion studies were carried out and the release profiles of the gels are tabulated in table-3 and fig-4 the release of drug from the formulations follows zero-order kinetics and peppas mechanisms which were shown in fig-5 & 6 respectively. Anti-fungal activity was also carried out and the diameter of zones of inhibition were recorded and tabulated in table-6 among the three different concentrations of methyl cellulose, gel formulated using 6% methyl cellulose i.e., gel G5 has shown best release properties when compared to the other two formulations.

Studies on the clotrimazole gels prepared with different concentrations of sodium CMC

Clotrimazole gels were prepared by using different concentrations of polymers and fixed concentration of active ingredient. The evaluation studies have been performed for pH, spreadability, physical appearance, viscosity, and extrudability and anti-fungal activity as sodium cmc has no jelling property below the concentration of 4% formulations were done starting from 4% and three different concentrations were chosen as per our convenience. the results of the physical parameters of the gels were tabulated in table:5.4.the physical appearance of the gel G7 was clear, reddish brown and smooth on application and G8 was clear, reddish brown, smooth on application and that of gel G9 was also clear ,reddish brown and translucent and smooth on application. The prepared gels pH was in the range of 7.5-7.9the drug content in the formulated gels was in the range of acceptable limits .which shows that our prepared gel formulations are according to the limits. Viscosity of the formulated gel preparations was determined and the results were found to be 91, 00,0056cps, 91, 01,111cps, 90, 89,567cps for gels G7, G8 and G9 respectively. In vitro diffusion studies were carried out and the

release profiles of the gels are tabulated in table-2 and fig-7 the release of drug from the formulations follows zero-order kinetics and peppas mechanisms which were shown n fig-8 & 9 respectively. Anti-fungal activity was also carried out and the diameter of zones of inhibition were recorded and tabulated in table-6. Among the three different concentrations of sodium cmc gel formulated using 4% sodium cmc i.e., gel G7 has shown best release properties when compared to the other two formulations.

Conclusion

A study involving preparation and evaluation of anti-dandruff hair gels was made. Physiochemical parameters of hair gels were established. *In-vitro* drug release profiles of hair gel were performed. Based on *In-Vitro* drug release profile it was found that release of medicament from prepared hair gels were followed first order kinetics. The formulations G5 of Clotrimazole exhibited good release profile as compared with other formulations, it exhibited same zone of inhibition as that of the pure drug. Hence, G5 was considered to be suitable formulation in treatment of dandruff. In conclusion, the hair gels could be formulated using commonly used gelling agents with improved contact time in number of hours in effected area. However, long term stability studies are needed to establish stable gel products. Further clinical trials are needed to establish its efficiency in the treatment of dandruff.

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