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COMPARATIVE EVALUATION OF FILM FORMING PROPERTIES OF SOME NATURAL POLYMERS

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ABSTRACT

The aim of the present work was to formulate and evaluate transdermal films using natural polymers and to check its effectiveness for control of drug release using Ibuprofen as model drug. Study was undertaken to report the film forming properties of the natural polymers and their physicochemical data. Various drug free films with varying quantities of polymers i.e. Pectin (4, 6, 8 %), Locust bean gum (1, 2, 3 %), Chitosan (0.5, 1, 2 %), Shellac (2.5, 5, 7.5 %) and plasticizer i.e. Poly ethylene glycol-400 (PEG-400) in 10, 20, 30 % were formulated using solvent casting method using mercury as a substrate. Initially, the drug free films were formulated and were evaluated for various parameters like folding endurance, uniformity of thickness, water vapor transmission rate (WVTR), tensile strength, break force, % elongation. The FTIR study revealed that the drug & polymers were compatible with each other. The film composition which showed significant results were selected and drug loaded films with same composition incorporating 200mg of drug and varying quantity of permeation enhancer i.e. Dimethyl Sulfoxide (DMSO) in 5, 10, 15 % were formulated and in-vitro diffusion study using Franz diffusion cell was carried out.

Keywords: Natural polymers, Poly ethylene glycol-400, Dimethyl Sulfoxide, Ibuprofen, Franz diffusion cell

INTRODUCTION

Polymers are the base of a transdermal drug delivery system as they regulate the release of the drug from the device. Biodegradable polymers attracts the attention of its use as they can be degraded to non-toxic monomers and most important, a constant rate of drug release can be achieved from a biodegradable polymer based controlled release device. Since plant derived excipients act in accordance with many requirements expected of pharmaceutical excipients such as non-toxicity, stability, availability and renewability they are extensively investigated for use in the development of various dosage forms. Natural polymers can be used as the means of achieving preset rates of drug delivery and their physico-chemical characteristics with the ease of availability afford a platform to use it as a polymer for transdermal drug delivery systems [1, 2, 3]. A Transdermal Drug Delivery System is a device that is prepared of one or more types of polymers embedded with drug(s) to transport the embedded drug through the skin over a controlled phase of time. In this case, the principal means of action of the product is controlled drug release and hence it becomes exceptionally crucial to understand and choose materials and techniques that would make it possible to control the drug release [1, 2, 4]. A Transdermal Drug Delivery System (TDDS) can be defined as a self contained distinct dosage form which when applied to the intact skin delivers the drug through the skin at a controlled rate to the systemic circulation [5]. Delivery of drugs via the skin has plenty of attractions which include increased patient compliance, non-invasiveness, lesser side effects, sustained drug delivery, avoidance of gastrointestinal disturbances and first pass metabolism and interruption or termination of treatment when required. The principle characteristics such as poor bioavailability (40 to 75%), short biological half-life (1 ½ to 2 hours), extensive first pass metabolism etc requirement for the transdermal delivery of a drug, were seen with ibuprofen as the selected drug. [5, 6].

Ibuprofen is a Non Steroidal Anti-Inflammatory Drug (NSAID) used for relief of symptoms of arthritis, fever, as an analgesic (pain reliever). Molecular weight is 206.28. Ibuprofen is a white to off –white crystalline powder, practically insoluble in water, very soluble in ethanol. It acts by Inhibition of COX-1 & COX-2 enzyme. It has a half life of 2 Hrs and dose of 200-2400 mg daily. The oral bioavailability is 40-55 % [6]. Chitosan is a linear polysaccharide composed of randomly spread β-(1-4)-linked D-glucosamine (de-acetylated unit) and N-acetyl-D-glucosamine (acetylated unit). It has a number of viable and feasible biomedical uses. Chitosan is soluble in dilute acids such as acetic acid, formic acid, etc [7, 10]. Pectin, a naturally occurring polysaccharide is the methylated ester of polygalacturonic acid residues in α-(1–4) chain. Isolated pectin has a molecular weight of typically 60–130,000 g/mol, varying with origin and extraction conditions [7, 11]. Locust bean Gum comprises of the high molecular weight (approximately 50,000-3,000,000) polysaccharides composed of galactose and mannose units. Locust bean gum is insoluble in nearly all organic solvents including ethanol. It is partially soluble in water at ambient temperature and soluble in hot water [7, 12]. Shellac is the purified product of lac, a natural resinous oligomer (MW ≈ 1000 D) secreted by the parasitic insect Kerria lacca. Shellac consists of polyesters of mainly aleuritic acid, shellolic acid, and a small amount of free aliphatic acids. Shellac has excellent film-forming properties, high gloss, and poor permeability to gases and water vapor [7, 13].

MATERIALS & METHODS

Shellac was gifted sample from Abbott India Ltd., Goa, India, Locust bean gum (Research Lab Fine Chem., Mumbai, India), Pectin (Loba Chemie, Mumbai, India), Chitosan (Research Lab Fine Chem., Mumbai, India), PEG 400 (Qualigens Fine Chemicals, Mumbai, India), Dimethyl Sulfoxide (Merck, Mumbai, India), and Ibuprofen. All other chemicals used were of analytical grade.

The composition of transdermal films has an intense influence on the physical, mechanical properties as well as the permeability of drugs. Transdermal films were prepared by solvent casting technique employing mercury as a substrate. The casting solutions were prepared by dissolving appropriate quantity of polymer and PEG-400 as plasticizer in 20 mL of suitable solvent using magnetic stirrer to get uniform dispersion. Plasticizer was added at a concentration of 10, 20 & 30 % w/w of polymers. The solution was then poured onto the surface of mercury, filled in petridish. Solvent evaporation was carried out by air drying. These were left undisturbed at room temperature till complete drying took place. The films were retrieved integral by slowly lifting from the edges from the mercury substrate and kept in the sealed zip pouches until used. The compositions of transdermal films formulated with different polymers are shown in tables below. The formulated films were evaluated for the different physicochemical properties and the results reported are shown in tables below.

Formulation of Drug Free Films: In order to evaluate the film forming properties of various polymers, drug free films were formulated with varying concentration of polymers. PEG 400 was used as plasticizer and trials were carried out with varying quantities of plasticizers. In each polymer trial according to its solubility, suitable solvent was used. The films with varying concentration of Chitosan, Pectin, Locust bean gum, Shellac and plasticizer were formulated.

Chitosan: The films of chitosan were formulated in 0.5, 1 & 2 % concentration with 10, 20 & 30 % PEG-400 as plasticizer using 1% acetic acid solution as solvent, employing mercury substrate method (Table 1).

Pectin: The films of Pectin were formulated in 4, 6 & 8 % concentration with 10, 20 & 30 % PEG-400 as plasticizer using distilled water as solvent, employing mercury substrate method (Table 1).

Locust Bean Gum: The films of Locust Bean Gum were formulated in 1, 2 & 3 % concentration with 10, 20 & 30 % PEG-400 as plasticizer using hot distilled water as solvent, employing mercury substrate method (Table 1).

Shellac: The films of Shellac were formulated in 2.5, 5 & 7.5 % concentration with 10, 20 & 30 % PEG-400 as plasticizer using ethanol as solvent, employing mercury substrate method (Table 1).

Evaluation of Drug Free Films: The prepared films were evaluated for physical appearance, thickness, folding endurance, tensile strength, percentage elongation and water vapour transmission rate [8, 9, 14].

Thickness [3, 5, 14]: Uniformity of thickness exhibits good physical appearance. It shows uniformity in distribution of contents. The thickness of transdermal films was measured at three different

places using a vernier caliper (N-12, Mitutoyo, Japan)and the mean values were calculated [8, 13].

Tensile strength [3, 5, 9]: Tensile strength is the maximum stress applied to a point at which the specimen breaks, and can be computed from the applied load at rupture and the elongation of the patch as described from the following equation. Mechanical properties of the polymeric films were conveniently determined by measuring their tensile strength. The tensile strength of the films was determined by using a manually designed tensile strength measurement instrument. The patch of 25 mm width and 50 mm length were cut and clamped between two clamps, weights were added to the pan on other side until the patch breaks. The weight required for breaking the patch was noted and tensile strength was noted.

Tensile Strength = break force/ a.b (1+ΔL/L)
Where,
a,b and L are width, thickness and length of the strip respectively.
ΔL is the elongation of patch at break point.
Break force = Weight required to break the patch (Kg.)

Percentage Elongation [3, 5, 9]: Percentage elongation was calculated by measuring the increase in length of the film after tensile strength measurement by using the following formula.
Percentage elongation = (LF- LO) X 100 / LO
Where,
LF = final length,
LO = initial length.

Folding Endurance [3, 14, 17, 19]: The folding endurance is defined as the number of folds required to break any polymeric patch . This test was carried out to check the efficiency of the plasticizer and the strength of the patch prepared using different polymers. A strip of film having an area of 2cm2 was cut evenly and repeatedly folded at the same place till it broken/cracked. The number of times the patch could be folded at the same place without breaking/cracking gave the value of folding endurance.

Water Vapor Transmission Rate (WVTR) [3, 5, 16, 18]: For water vapor transmission studies glass vials of approximately equal diameter were used as transmission cells. These transmission cells were washed thoroughly and dried to constant weight in an oven. About 1 g of fused calcium chloride as a desiccant was taken in the vials and the polymeric films were fixed over the brim with the help of an adhesive tape. These pre-weighed vials were kept in a chambers filled with saturated salt solutions to achieve the required humidity conditions for a period of 24 h. Different saturated salt solutions are used to maintain the desired humidity condition like Potassium chloride (90 % RH), Sodium chloride (75 % RH), Potassium carbonate (45 % RH). The weight gain was determined after a period of 24 h and water vapor transmission rate was calculated. Water vapor transmission (Q) usually expressed as number of grams of moisture gain per 24 h per square centimeter, was calculated using the Utsumi's equation [16],

Water Vapor Transmission Rate, Q = WL/S
Where,
W is gm of water transmitted / 24 h
L is patch thickness in cm
S is surface area in cm2

Drug-Polymer Interaction Study [8]: The compatibility study was carried out using FTIR-Spectrophotometer [Model - Spectrum RX-1, Perkin Elmer, U.S.]. The mixture of drug and polymer were kept in glass vials for 1 month at 40±20C/75±5% RH and were analyzed.

Analytical Method: Standard graph of Ibuprofen was plotted using Phosphate buffer pH 7.2 by UV Spectrophotometric method. The standard solutions were scanned between 200-400 nm, the drug showed absorption maxima (λ max) at 221 nm. Hence all further analysis was carried out at 221 nm. Regression factor R2 was found to be 0.9986 and the straight line intercept was found to be Y = 0.0225x.

In-vitro Drug Diffusion/Release Study [3, 5, 16]: Diffusion study is carried out to calculate the drug release through the film. The release studies were performed in Franz diffusion cell (cell capacity 17ml). The cell consists of two chambers i.e. donor and receptor. A film of 2.25 cm2 area was mounted carefully between the donor and receptor compartment. Diffusion study was carried out using cellophane membrane. Donor compartment was empty and open to the atmosphere while the receptor compartment was filled was 17ml of phosphate buffer solution with a pH 7.2. This compartment was maintained at 37±1°C by circulation water in the jacket and the receptor fluid was stirred using a magnetic stirrer (Remi, Mumbai, India). The samples (2 mL) were collected at periodic intervals i.e. 30, 60, 120, 240, 480 & 720 minutes through the sampling port and after each sampling equal volume of drug free phosphate buffer pH 7.2 solution pre-warmed to 37±1°C was added to maintain the constant volume

of the receptor fluid. The drug content was assayed spectrophotometrically at 221 nm using UV-spectrophotometer [Model – Lambda 25, Perkin Elmer, U.S.] after a appropriate dilution of the withdrawn sample and the amount of the drug diffused was determined with the help of the standard calibration curve of Ibuprofen prepared in phosphate buffer, pH 7.2, taking a dilution factor into account in the calculations.

Result of Evaluation of Drug Free Films: The drug free films were evaluated for physico-chemical properties like thickness, folding endurance, percent elongation, tensile strength, water vapor transmission rate studies. The results of the evaluation of chitosan, pectin, locust bean gum, shellac drug free films are shown in Table 2.

Formulation of Drug Loaded Films: From the results of evaluation of drug free films, inference was drawn that formulation C6, P3, L3, S9 exhibit significant results, hence they were selected for further formulation proceedings. The films with above composition were formulated with incorporation of drug i.e. Ibuprofen and varying quantity of permeation enhancer i.e. Dimethyl Sulfoxide (DMSO) was added. The details of the formulation composition of drug loaded films are shown in table 3.

Evaluation Results of Drug Loaded Films

Drug-Polymer Interaction Study: The Drug-Polymer interaction study was carried out using FTIR-Spectrophotometer. The Drug: polymer mixtures at initial and at 1 month were analyzed. The IR spectra of initial and 1 month samples were compared to determine significant changes in the major peaks to determine interaction and results are shown in figure 1-5.

Physical Parameters; The prepared drug loaded films were evaluated for physical appearance, thickness, folding endurance, tensile strength, percentage elongation, water vapor transmission rate and the results are reported in table 4.

Drug Diffusion Study: The drug loaded films were tested for drug diffusion study using Franz Diffusion cell. The results of the diffusion study and comparisons of diffusion profile of various films of different polymers are shown in figure 6-9.

RESULTS AND DISCUSSIONS

Prepared films exhibited significant physic-chemical properties. Solvent casting technique and mercury substrate method used to prepare the films produced good and uniform films. From the physicochemical evaluation data of the films (table 2) it is evident that the results were significant with respect to different properties. The thickness was found to be uniform for almost all the films prepared with varying concentration of polymers in combination with varying amount of PEG 400 as plasticizer (table 2).

In tensile strength measurement, films prepared with chitosan, pectin, locust bean gum exhibited good results, where as films prepared with shellac were having low tensile strength and it was observed that the tensile strength in each polymer film decreased with the increase in concentration (table 2). It may be due to the fact that as the concentration of polymer is increased, the films exhibited brittleness.

Evaluation for percentage elongation revealed that only the films prepared at higher concentration of shellac showed elongation in length, whereas all other formulations showed no elongation.

In case of folding endurance the formulations prepared with lower concentration of chitosan, locust bean gum showed good results, where as films prepared with pectin showed low values of folding endurance, which further decreased with increase in concentration of polymer (table 2). The films prepared with shellac were brittle in lower concentration, whereas the value of folding endurance increased with increase in polymer and plasticizer concentration. [6]

The water vapor transmission rate pattern was found to be variable (table 2). Further investigation revealed that at different humidity conditions generated with different saturated salt solutions i.e. 45% (K2CO3), 75% (NaCl) and 90% (KCl) also, the WVTR seems to be variable.

In case of drug loaded films prepared after selection of best placebo concentration of each polymer, the physicochemical data reveals that the results were good. The thickness of all the drug loaded films were found to be uniform, the result of folding endurance were significant for drug loaded films prepared with chitosan, locust bean gum and shellac and the values were above 250 folds, whereas the films prepared with pectin showed lower values of folding endurance and were found to be brittle (table 4).

The drug loaded films prepared with chitosan and shellac showed good results for percent elongation studies whereas films prepared with pectin and locust bean gum were brittle (table 4). The tensile strength

measurement showed results in the following pattern DC>DL>DP>DS (according to trial code) revealing that the tensile strength decreased from chitosan films with highest value to shellac films being at the lowest (table 4). The water vapor transmission pattern was found to be variable. Further investigation revealed that at different humidity conditions generated with different saturated salt solutions i.e. 45% (K2CO3), 75% (NaCl) and 90% (KCl) also, the WVTR seems to be variable (table 4).

The FTIR study revealed that the drug and polymers were compatible with each other and there was no interaction between them (figure 1-5).

In the diffusion study (figure 6-9) for drug loaded films, the standard beers plot of Ibuprofen was prepared using various standard concentrations. In vitro release study shows that among all the formulations prepared the films prepared with chitosan showed good results with around 80-85 % drug release in 12 hours, in which the same films prepared with varying concentration of permeation enhancer, i.e. DMSO showed a little difference in results showing that the varying concentration does not significantly alter the drug release. The films formulated with pectin showed drug release up to 75-80 % in 12 hours with little difference in drug release with change in permeation enhancer. The drug release in case of films formulated with locust bean gum was 60-65 % in 12 hours whereas in case of films prepared with shellac the drug release was around 20 % in 12 hours, showing that shellac shows poor drug permeability. Based on absorbance shown at 221nm percent drug content was calculated.

CONCLUSION

Natural polymers hold good promise for administration of drug via transdermal route. The various physicochemical parameters that were evaluated help to understand the usefulness and suitability of natural polymers to be useful for formulation as a transdermal film with different concentrations. It is evident from the present study that the films prepared chitosan and pectin showed significant drug release with considerably good physicochemical properties. But there is a need to modify the physicochemical properties to formulate a good formulation exhibiting significant results in all parameters, thus there is an opportunity to modify the film composition and additives ratio to get the optimum release over a prolonged period of time. Considering the study results, it can be concluded that the natural polymer based films containing drug can emerge out as an efficient drug delivery system.

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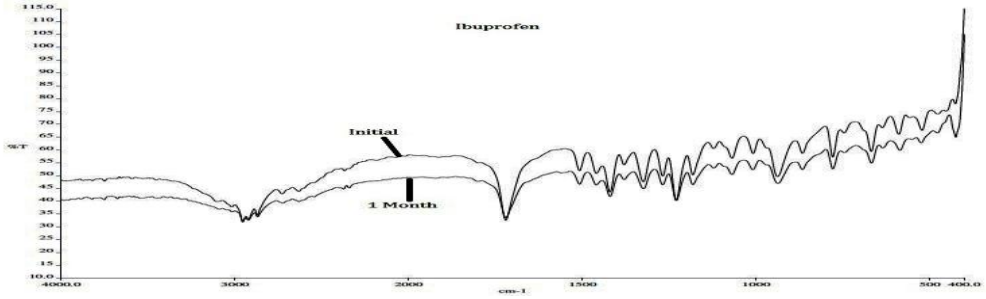

Figure 1: IR Spectrum of Ibuprofen

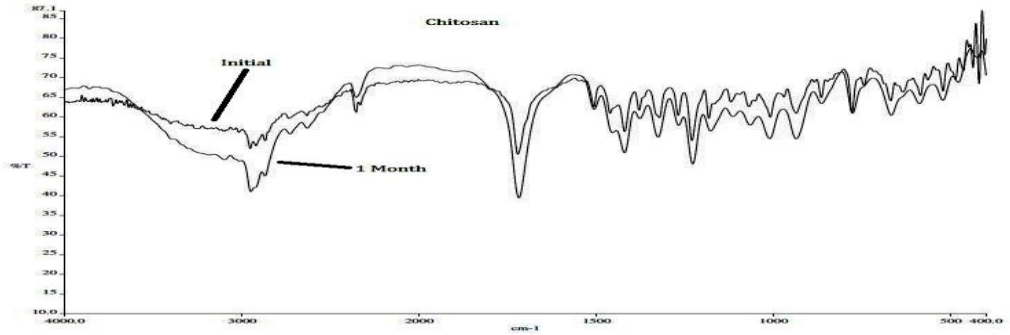

Figure 2: IR Spectrum of Chitosan

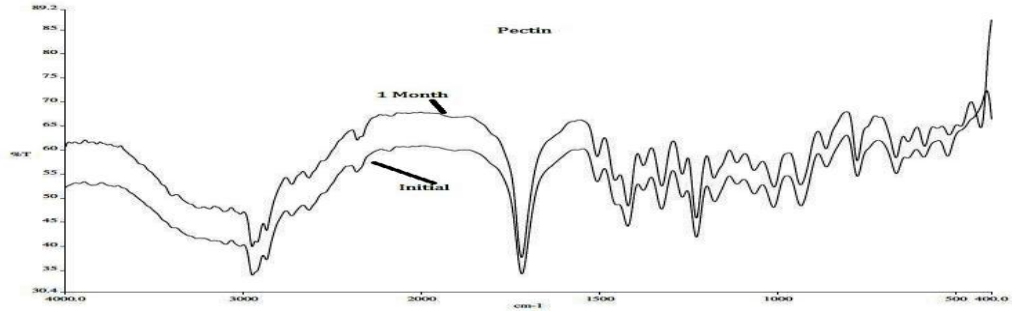

Figure 3: IR Spectrum of Pectin

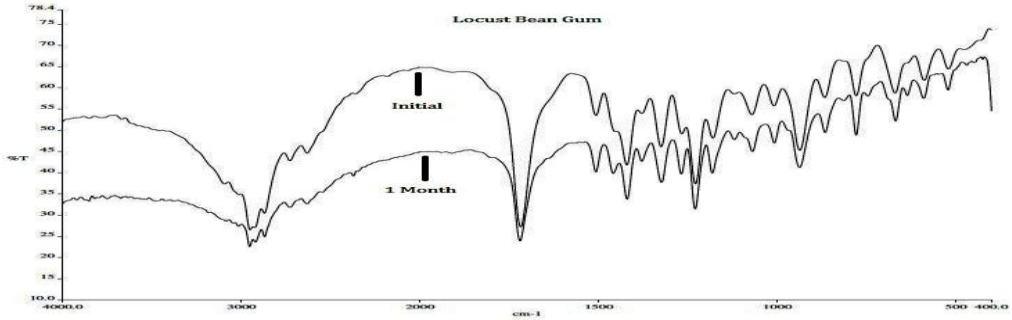

Figure 4: IR Spectrum of Locust Bean Gum

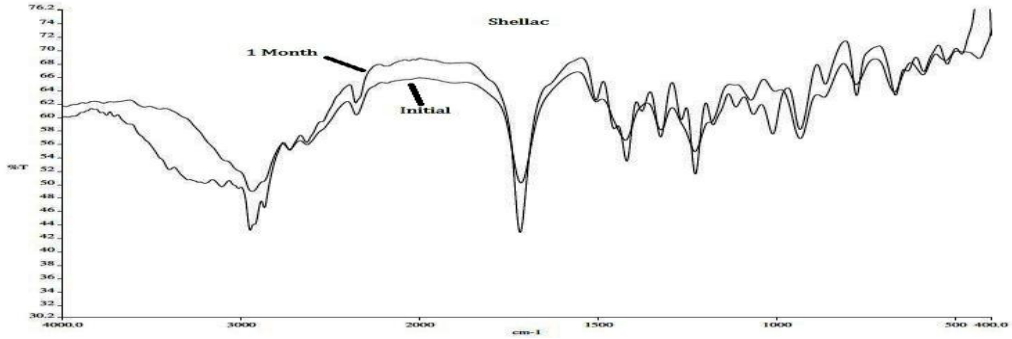

Figure 5: IR Spectrum of Shellac

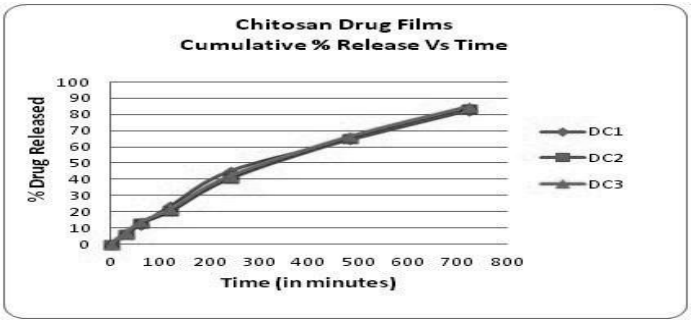

Figure 6: Cumulative % Drug Release of Chitosan Films

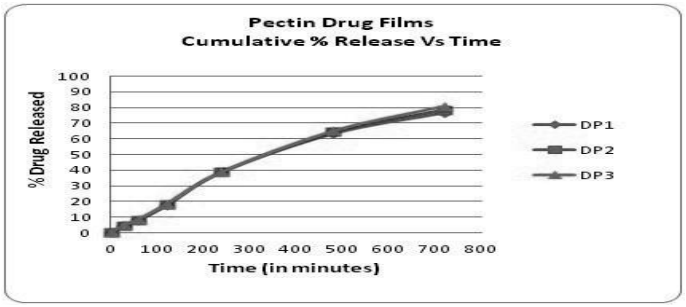

Figure 7: Cumulative % Drug Release of Pectin Films

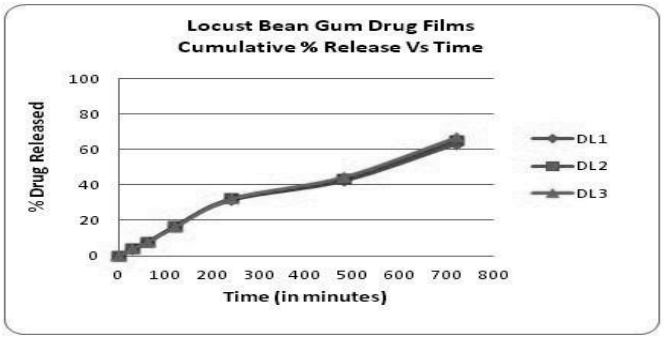

Figure 8: Cumulative % Drug Release of Locust Bean Gum Films

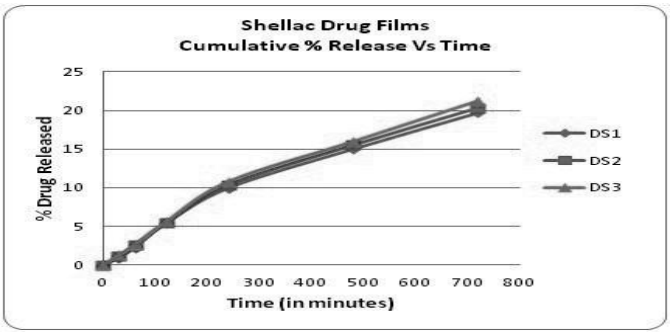

Figure 9: Cumulative % Drug Release of Shellac Films

Table 1: Drug Free Film Trials

S.No	Code	Polymer (%)	Plasticizer (%)	Casting Solvent	S.No	Code	Polymer (%)	Plasticizer (%)	Casting Solvent
1	C1	0.5	10	20	**19**	L1	1.0	10	20
2	C2	0.5	20	20	**20**	L2	1.0	20	20
3	C3	0.5	30	20	**21**	L3	1.0	30	20
4	C4	1.0	10	20	**22**	L4	2.0	10	20
5	C5	1.0	20	20	**23**	L5	2.0	20	20
6	C6	1.0	30	20	**24**	L6	2.0	30	20
7	C7	2.0	10	20	**25**	L7	3.0	10	20
8	C8	2.0	20	20	**26**	L8	3.0	20	20

9	C9	2.0	30	20	**27**	L9	3.0	30	20
10	P1	4.0	10	20	**28**	S1	2.5	10	20
11	P2	4.0	20	20	**29**	S2	2.5	20	20
12	P3	4.0	30	20	**30**	S3	2.5	30	20
13	P4	6.0	10	20	**31**	S4	5.0	10	20
14	P5	6.0	20	20	**32**	S5	5.0	20	20
15	P6	6.0	30	20	**33**	S6	5.0	30	20
16	P7	8.0	10	20	**34**	S7	7.5	10	20
17	P8	8.0	20	20	**35**	S8	7.5	20	20
18	P9	8.0	30	20	**36**	S9	7.5	30	20

Table 2: Chitosan Drug Free Film Results

S.No	Code	Thickness (cm) n = 3	Folding Endurance n = 3	% Elongation (%) n=2	Tensile Strength (Kg/cm^2) n=2	WVTR g/cm^2/24 hrs		
						KCl	NaCl	K_2CO_3
1	C1	0.040 ± 0.00	>250	Nil	66.60 ± 0.85	2.89E-04	1.61E-04	1.28E-04
2	C2	0.047 ± 0.012	>250	Nil	57.91 ± 0.74	2.58E-04	3.32E-04	1.85E-04
3	C3	0.047 ± 0.012	>250	Nil	58.43 ± 1.48	2.22E-04	2.95E-04	3.69E-05
4	C4	0.107 ± 0.012	>250	Nil	35.21 ± 0.63	1.03E-03	4.29E-04	5.15E-04
5	C5	0.10 ± 0.00	>250	Nil	36.36 ± 0.51	8.82E-04	4.01E-04	4.01E-04
6	C6	0.107 ± 0.012	>250	Nil	35.21 ± 0.63	1.12E-03	7.72E-04	2.57E-04
7	C7	0.147 ± 0.012	143.33 ± 6.50	Nil	19.89 ± 0.23	1.29E-03	5.85E-04	1.17E-03
8	C8	0.153 ± 0.012	158.00 ± 7.00	Nil	17.41 ± 0.22	9.82E-04	4.91E-04	7.36E-04
9	C9	0.147 ± 0.012	166.33 ± 6.11	Nil	18.82 ± 0.35	1.05E-03	7.03E-04	9.37E-04
10	P1	0.147 ± 0.012	24.66 ± 4.93	Nil	22.85 ± 0.23	4.68E-04	7.03E-04	8.20E-04
11	P2	0.133 ± 0.012	44.33 ± 7.09	Nil	26.08 ± 1.66	1.17E-03	5.33E-04	5.33E-04
12	P3	0.147 ± 0.012	25.33 ± 2.51	Nil	22.93 ± 0.12	1.05E-03	7.03E-04	2.34E-04
13	P4	0.173 ± 0.012	6.67 ± 1.15	Nil	22.13 ± 0.10	6.94E-04	5.55E-04	5.55E-04
14	P5	0.187 ± 0.012	13.33 ± 0.57	Nil	20.60 ± 1.36	1.05E-03	9.00E-04	1.05E-03
15	P6	0.167 ± 0.012	19.33 ± 2.51	Nil	21.92 ± 0.30	8.04E-04	5.36E-04	9.38E-04
16	P7	0.273 ± 0.012	4.33 ± 1.52	Nil	15.26 ± 0.31	1.77E-03	1.33E-03	1.33E-03
17	P8	0.287 ± 0.012	1.00 ± 0.00	Nil	14.90 ± 0.18	1.61E-03	6.88E-04	1.38E-03
18	P9	0.267 ± 0.012	2.00 ± 1.00	Nil	15.29 ± 0.19	1.07E-03	1.07E-03	1.07E-03
19	L1	0.073 ± 0.012	>250	Nil	37.33 ± 0.46	1.17E-04	1.17E-04	2.35E-04
20	L2	0.073 ± 0.012	>250	Nil	38.14 ± 0.69	5.29E-04	3.53E-04	3.53E-04
21	L3	0.073 ± 0.012	>250	Nil	21.74 ± 0.64	4.11E-04	1.17E-04	3.53E-04
22	L4	0.113 ± 0.012	238.66 ± 10.01	Nil	21.38 ± 0.13	7.47E-04	6.40E-04	9.60E-04
23	L5	0.113 ± 0.012	>250	Nil	24.80 ± 0.28	3.20E-04	5.33E-04	5.34E-04
24	L6	0.120 ± 0.00	61.66 ± 14.36	Nil	19.48 ± 0.12	1.92E-04	3.85E-04	5.77E-04
25	L7	0.147 ± 0.012	56.00 ± 5.56	Nil	20.63 ± 0.33	2.34E-04	5.85E-04	7.03E-04
26	L8	0.153 ± 0.012	58.00 ± 5.00	Nil	19.80 ± 0.21	3.68E-04	6.14E-04	7.36E-04
27	L9	0.160 ± 0.012	59.00 ± 5.686	Nil	18.53 ± 1.17	2.56E-04	1.41E-03	1.03E-03
28	S1	0.200 ± 0.00	13.67 ± 2.08	17	15.12 ± 1.96	3.21E-04	1.60E-04	1.60E-04
29	S2	0.193 ± 0.012	54.67 ± 5.68	Nil	13.99 ± 0.09	4.64E-04	7.74E-04	7.74E-04

30	S3	0.200 ± 0.00	>250	11	12.76 ± 0.62	8.02E-04	4.81E-04	3.21E-04
31	S4	0.213 ± 0.012	66.33 ± 16.50	24	12.15 ± 1.50	8.54E-04	1.03E-03	1.37E-03
32	S5	0.227 ± 0.012	>250	30	9.17 ± 0.05	5.44E-04	5.44E-04	9.06E-04
33	S6	0.227 ± 0.012	>250	31	8.51 ± 0.48	1.09E-03	5.44E-04	9.06E-04
34	S7	0.287 ± 0.012	>250	48	5.20 ± 0.33	6.88E-04	6.88E-04	1.61E-03
35	S8	0.293 ± 0.012	>250	51	4.85 ± 0.09	9.40E-04	7.05E-04	1.18E-03
36	S9	0.280 ± 0.00	>250	48	5.04 ± 0.20	8.98E-04	6.74E-04	1.12E-03

Table 3: Drug Loaded Film Trials

S.No	Code	Polymer		Drug (Ibuprofen) mg	Permeation Enhancer (%)	Plasticizer (%)	Solvent	
		Detail	Quantity (%)				Detail	Quantity (mL)
1	DC1	Chitosan	1	200	5	30	1 % Acetic Acid	20
2	DC2	Chitosan	1	200	10	30	1 % Acetic Acid	20
3	DC3	Chitosan	1	200	15	30	1 % Acetic Acid	20
4	DP1	Pectin	4	200	5	30	Distilled water	20
5	DP2	Pectin	4	200	10	30	Distilled water	20
6	DP3	Pectin	4	200	15	30	Distilled water	20
7	DL1	Locust Bean Gum	1	200	5	30	Hot Distilled water	20
8	DL2	Locust Bean Gum	1	200	10	30	Hot Distilled water	20
9	DL3	Locust Bean Gum	1	200	15	30	Hot Distilled water	20
10	DS1	Shellac	7.5	200	5	30	Ethanol	20
11	DS2	Shellac	7.5	200	10	30	Ethanol	20
12	DS3	Shellac	7.5	200	15	30	Ethanol	20

Table 4: Physico-Chemical Evaluation of Drug Loaded Films

S.No	Code	Thickness (cm) n = 3	Folding Endurance n = 3	% Elongation (%) n=2	Tensile Strength (Kg/cm^2) n=2	WVTR $g/cm^2/24$ hrs		
						KCl	NaCl	K_2CO_3
1	DC1	0.027 ± 0.002	> 250	9	25.93 ± 4.35	8.76E-04	1.31E-03	1.10E-03
2	DC2	0.027 ± 0.002	> 250	9	25.75 ± 3.35	1.53E-03	1.75E-03	1.31E-03
3	DC3	0.026 ± 0.000	> 250	10	24.36 ± 0.26	1.46E-03	1.67E-03	1.25E-03
4	DP1	0.039 ±0.002	3.33 ± 0.57	Nil	8.76 ± 0.08	1.86E-03	2.17E-03	1.24E-03
5	DP2	0.035 ± 0.001	4.00 ± 1.00	Nil	9.84 ± 0.09	1.67E-03	1.94E-03	1.39E-03
6	DP3	0.035 ± 0.001	3.66 ± 1.15	Nil	9.97 ± 0.24	1.40E-03	1.40E-03	1.40E-03
7	DL1	0.028 ± 0.002	> 250	Nil	12.38 ± 0.18	1.80E-03	3.15E-03	1.12E-03
8	DL2	0.027 ± 0.002	> 250	Nil	12.61 ± 0.06	1.10E-03	4.60E-03	8.76E-04
9	DL3	0.029 ± 0.001	> 250	Nil	12.29 ± 0.17	1.38E-03	4.13E-03	9.18E-04
10	DS1	0.040 ± 0.000	> 250	42	3.15 ± 0.29	2.25E-03	2.25E-03	1.61E-03
11	DS2	0.039 ± 0.001	> 250	41	3.38 ± 0.13	1.89E-03	1.26E-03	1.89E-03
12	DS3	0.039 ± 0.001	> 250	46	3.00 ± 0.10	9.46E-04	1.26E-03	1.58E-03

REFERENCES

1. Sharma K, Singh V, Arora A. Int J Drug Dev Res, 2011; 3: 85-103.
2. Beneke CE, Viljoen AM, Hamman JH. Molecules, 2009; 14: 2602-20.
3. Dhiman S, Singh TG, Rehni AK. Int J Pharm Sci, 2011; 3: 26-34.
4. Saroha K, Yadav B, Sharma B. Int J Curr Pharm Res, 2011; 3: 98-108.
5. Banu TS, Som M, Khaleel M, Havannavar NT. Res J Pharm Biol Chem Sci, 2010; 1: 412-21.
6. Sankavarapu V, Aukunuru J. J Glob Pharm Tech, 2009; 2: 51-8.
7. Rowe RC, Sheskey PJ, Quinn MN. Handbook of Pharmaceutical Excipients. 6th Ed., The Pharmaceutical Press, London: 2009.
8. Yadav V, Bhai SA, Mamatha Y, Prasanth VV. J Pharm Sci Inn, 2012; 1: 5-12.

9. Bharkatiya M, Nema RK, Bhatnagar M. Int J Pharm Sci Drug Res, 2010; 2: 35-9.
10. Hemant KSY, Shivakumar HG. Trop J Pharm Res, 2010; 9: 197-03.
11. Kumar M, Chauhan AK, Kumar S, Kumar A, Malik S. J Pharm Res Heal Care, 2010; 3: 244-7.
12. Kawamura Y, Carob (Locust) Bean Gum, Chemical and Technical Assessment (CTA) 2008; 1-6.
13. Farag Y, Leopold CS. Disso Tech, 2009; 5: 33-9.
14. Pandit V, Khanum A , Bhaskaran S, Banu V. Int J Pharm Tech Res, 2009; 1:799-04.
15. Mundada AS, Avari JG. Drug Dev Ind Pharm, 2009; 35:1147–54.
16. Mundada AS, Avari JG. Chem Ind Chem Eng Q, 2009; 15: 83−8.
17. Mundada AS, Avari JG. Acta Pharm Sci, 2010; 52:31-38.
18. Mundada AS, Satturwar PM, Fulzele SV, Joshi SB, Dorle AK. Iran J Pharm Res, 2011; 10: 35-42.
19. I. Utsumi T, Ida T, Takahashi N, Sugimoto. J Pharm Sci, 1961; 50: 592-7.