



Formulation and Evaluation of Nanoparticles types Transdermal patches of Curcumin

Priya Kanaujiya¹, Sonam Singh Parmar²

¹Research scholar, Kanpur Institute of Technology, Kanpur

²Assistant Professor, Kanpur Institute of Technology, Kanpur

supriya4214@gmail.com¹, sonam.parmar@kit.ac.in²

Corresponding Author: Priya Kanaujiya

ABSTRACT-

Curcumin has been the focus of several researches, all of which indicate that it has tremendous therapeutic potential. Curcumin's ability to heal cancer has long been the focus of intense investigation. Using the solvent casting approach, transdermal patches containing curcumin-loaded solid lipid nanoparticles were created using PEG-400 as a plasticizer and HPMC and PVP-K30 as polymeric matrix materials. The patches are stable and show no interaction between the medicine and the formulation components. The average weight of the patches was determined to be between 147 and 163 mg. The thickness of the patches ranged from 0.261 to 0.312 mm and was shown to be depending on the concentration of PVP-K30. The folding endurance test findings demonstrated that the thinner patches were more flexible, withstanding 67 to 94 folds at the same location without obvious cracking or breaking. All formulations were able to integrate a significant quantity of medication, ranging from 98.16 to 99.22 percent. The moisture content analysis found that increasing the concentration of PVP-K30 had an inverse effect on the moisture content in the patches, with SLNP-4 having the lowest moisture (6.03 percent) and SLNP-1 having the greatest (6.51 percent). The medication was released in several formulations at rates ranging from 67.3 to 59.7 percent. The regression coefficients of the mathematical models' graphical depiction show that the release of curcumin from the patches may be represented by the Korsmeyer-Peppas model. It expresses that the drug released from patches is due to drug diffusion from the patch matrix and is mostly diffusion regulated.

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KEYWORDS- Curcumin, Transdermal patches, Solid lipid nanoparticles, In vitro, Zeta-potential

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INTRODUCTION- Several drug delivery systems that give sustained release treatment through a subdermal implantation have now been formulated in current times. Drug - delivery methods appropriate for transdermal administration of drugs have also been

reported. Countless flavonoids have the characteristics requirements for use in a transdermal drug delivery method. High potency, appropriate physicochemical qualities, excellent skin penetration, and absence of cutaneous irritation are among the attributes.



The controlled release of medications via undamaged skin is referred to as a transdermal drug delivery mechanism. The transdermal route today ranks alongside oral therapy as one of the most successful creative research field in drug delivery, with around 40% of drug delivery candidate items undergoing clinical assessment associated with the transdermal or dermal system. A transdermal patch is a medicated adhesive patch that is applied to the skin to administer a time-released dosage of medicine via the skin for the treatment of topical or systemic sickness. This transdermal therapeutic system dosage form has been offered on the pharmaceutical market since early 1990.[1] Transdermal drug delivery is a preparation or technique that keeps the drug's blood concentration within such a therapeutic window, guaranteeing that drug concentrations do not drop underneath the MEC or surpass the minimum toxic dosage.[2] Because the transdermal dose method is consumer-friendly, simple, pain free, and allows for multiple days of administration, it typically contributes to increased patient satisfaction.[3] It has several benefits over oral drug delivery, such as GI and hepatic 1st pass metabolism, reduced alteration in delivery rates, eliminates interaction caused by food, limits rate of absorption, is best suited for patients who are not conscious, and allows for quick dismissal of drug delivery if necessary.[4]

Muller and his colleagues produced lipid nanoparticles in the 1900s. In broad sense, there are two forms of lipid nanoparticles with a solid substrate, the solid lipid nanoparticles (SLNs) and the nano structured lipid carriers (NLCs), that vary in their internal lipid structure. SLNs are made up of a solid lipid matrix which is rigid for both room and bodily temperatures and thus are made in the same way as an oil-in-water emulsion, but the oil phase is substituted at room temperature by a solid lipid or a mix of solid lipids. NLC matrices have a less organized lipid matrix with flaws caused by solid and liquid

lipid mixes. The imperfect, multiple, and amorphous are the three types of NLC.[5]

Curcumin, commonly known as diferuloylmethane, is a symmetric molecule. This compound's IUPAC name is (1E-6E) 1-, 7-Bis (4-hydroxy-3-methoxy phenyl)-1, 6- heptadiene-3, 5-dione. Curcumin has the chemical formula $C_{12}H_{20}O_6$ and a molecular mass of 368.385g/mole.[6] It's a wonderful yellow powder with a melting point between 1790 and 1830 degrees Celsius. Curcumin dissolves in ethanol and glacial acetic acid but not in ether or water. Curcumin inhibits lipid peroxidation and also peroxide-induced DNA damage by acting as a scavenger of oxygen species such as the hydroxyl radical, superoxide anion, and singlet oxygen. Curcumin modulates multiple signalling molecules to provide powerful anti-inflammatory and anti-carcinogenic effects. It suppresses a number of key elements in cellular signal transduction pathways pertinent to growth, differentiation, and malignant transformation; it was demonstrated in vitro that curcumin inhibits protein kinases, c-Jun/AP-1 activation, prostaglandin biosynthesis, and the activity and expression of the enzyme cyclooxygenase (COX)-2. Curcumin is well-known for its different biological activities such as Anti inflammatory, Anti-viral, Anti-oxidant, Anticancer, Anti-bacterial, Anti-asthmatic, Antiarthritis, Anti-diabetic, Anti-venom, Anti-obesity, Wound-healing, in depression and anxiety and other activities.

Curcumin has been the subject of various studies, all of which show that it has enormous medicinal potential. Curcumin's capacity to cure cancer has always been the subject of the greatest research. Numerous studies have shown that the formation of nanoparticles might be a promising strategy for increasing medication bioavailability. It was also planned to preload the SLNs onto transdermal patches in terms of maintaining the release and increase compliance of curcumin when applied topically.

METHODOLOGY-

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1. **Preformulation Studies [7]** The curcumin obtained from the source was subjected to the respective pre - formulation experiments. The preformulation experiments were performed to ensure the integrity and authenticity of the obtained curcumin as well as to investigate any potential interactions with the polymeric carrier to be employed in the research.
 - 1.1. **Organoleptic characterization-** A little amount of highly purified, powdered curcumin was placed on a butter paper and inspected in a well-lit area to determine its colour; the flavour and odour were determined by tasting and sniffing the medicine.
 - 1.2. **Solubility-** Curcumin solubility was tested qualitatively in water, methanol, and ethanol. Solubility tests were carried out by agitating a tiny quantity of curcumin placed in test tubes comprising the solvent and examining for insoluble particulates.
2. **Melting Point determination-** Curcumin's melting point was established using the opened capillary procedure, which involved loading a capillary tube with the curcumin and sealing one tip, then inserting it in a melting point device to examine the temperature where the melting occurred.

3. **Drug excipient compatibility Study-** FT-IR spectrophotometer was used to acquire Infrared spectrum of curcumin and a physiological combination of drug and lipids. Physical and chemical incompatibilities between the medication and the lipid under investigation were identified in the spectra.
4. **Calibration curve of curcumin[8]** - Curcumin stock solutions comprising 100 g/mL were formed in methanol and different concentrations were moved in a 10ml volumetric flask in varied fraction, and volumes had been prepared with methanol to produce various standard dilutions (5-25 g/mL). The solution was scanned from 1100 to 200 nm with a UV-Visible spectrophotometer, and the absorption maximum (max) was found to be 421 nm. To create a concentration-by-absorbance calibration curve, the standard dilutions' absorption was measured at 421 nm. Curcumin concentrations in formulations were calculated using the linearity equation:

$$y = mx + c$$

5. **Formulation of SLNs-** The solid-lipid nanoparticles were made using the nano precipitation technique. The SLNs were made using a variety of lipid compositions. **(Table 1).**

Table 1- Formula for preparation of SLNs

Ingredients	SLNC1	SLNC2	SLNC3	SLNC4
Curcumin (mg)	200	200	200	200
Oleic acid (mmol)	0.1	0.12	0.14	0.16
Tween 80 (%)	5	5	5	5

In a combination of 18 mL ethyl acetate and 2 mL ethanol, the exact amount of oleic acid and curcumin was mixed. The emulsifier solution was made with a 5% solution of Tween 80 in distilled water. At room temperature, the drug-containing organic solution was introduced drop - wise to the emulsifier solution while stirring at 700 rpm. The turbid nanoparticle suspension was agitated for 5–10 minutes

before the organic solvents were eliminated by vacuum evaporation and the dispersion was cooled to room temperature. The pH of the dispersion was corrected to 1.2 by adding 0.1 M Hcl solution to the SLNs, which was then centrifuged at 12,000 rpm to obtain the precipitate. The precipitate was re-dispersed in distilled water under sonication (13 mm probe,



35% amplitude and 2 min cycles) for 10 minutes.

Characterization of SLNs

5.1. Particle size and zeta potential determination[9] - A particle size analyzer was used to evaluate particle size, and a zeta sizer was used to estimate zeta potential.

5.2. Entrapment Efficiency [10] - After centrifuging the drug-loaded nanoparticles

$$\text{Entrapment Efficiency (\%)} = \frac{\text{Amount of drug in nanoparticles}}{\text{Initial amount of drug taken}} \times 100$$

5.3. In vitro drug release[11] - The dialysis technique was used to quantify the in vitro release of curcumin from the SLNs. 1 mL curcumin-loaded SLN was inserted in a dialysis bag and dropped into a beaker with the dissolving medium (simulated stomach juice (phosphate buffer saline modified to pH 2.0 with HCl). The medium was kept at 37°C with 100 rpm stirring. A pipette was used to remove 1 mL of sample at predetermined intervals, and the medium was refilled with the similar amount of medium. For estimating the content of curcumin, the samples were then centrifuged (10000 rpm for 5 minutes), the supernatant was properly diluted, and the absorbance was recorded at 421 nm with the help of UV-visible spectrophotometer.

at 15,000 rpm for 15 minutes and separating the supernatant, the proportion of drug incorporated during nanoparticle manufacturing was evaluated. The pellet was rinsed two or three times using water and dissolved in acetonitrile, and then the drug was estimated using a UV-visible spectrophotometer by detecting the absorbance at 421 nm.

6. Formulation of transdermal Patches

A petridish with an area of 44.15 cm² was used to produce SLN-loaded transdermal patches using the solvent casting process. The polymers were precisely taken and mixed in a 10 mL water/methanol (1:1) solution, which was then set aside to produce a clear solution (**Table 2**). The curcumin-loaded SLN (SLNC-) was dissolved in the aforesaid solution and agitated until it became clear. Plasticizer was polyethylene glycol 400 (30 percent w/w of total polymer) and permeation enhancer was propylene glycol (15 percent w/w of total polymer). The homogenous solution was cast on a petri plate greased using glycerin and dried for 24 hours at room temperature. To prevent the solvent from evaporating too quickly, an upturned funnel was positioned over the petridish.

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Table 2- Formula for SLN loaded transdermal patches

Ingredients	SLNP1	SLNP2	SLNP3	SLNP4
SLNC (mg)	45	45	45	45
HPMC (mg)	100	100	100	100
PVP K30 (mg)	0.1	1	1.5	2
PEG-400	30	30	30	30
Propylene glycol	15	15	15	15

7. Evaluation of Transdermal Patches

7.1. Uniformity of weight test- Individually weighing randomly chosen patches were exposed to notice the mass fluctuation of

patches (44.15 cm²). This analysis was repeated three times for each formulation.

7.2. Thickness- Each patch's thickness was measured with a vernier calliper at several



points on the patch, and the average was computed.

7.3. Folding endurance- Folding endurance was measured by folding the same patch again and over until it cracked or broke. The value of folding endurance was determined by the frequency of the film could be folded from that very same location without breaking or cracking.

7.4. Drug content test- Three pieces of 4 cm in which 2 were collected by cutting off zones from different parts of patch from each patch. These pieces were dissolved in 10 ml ethanol and were placed on vortex shaker for 1 hr to dissolve completely the patches. The resultant solutions were

$$\text{Percentage of moisture content} = \frac{\text{Initial weight} - \text{Final weight}}{\text{Initial weight}} \times 100$$

7.6. In-vitro permeation study- In-vitro permeation studies of the transdermal patches were carried out by using Franz diffusion cell with a receptor compartment capacity of 30 ml. The formulated patch of surface area of 4 cm in which 2 was placed in between the dialysis membrane and the donor compartment and then dialysis membrane was mounted between the donor and receptor compartment of diffusion cell. The receptor compartment of diffusion cell was filled with phosphate buffer saline pH 7.4. The whole assembly was fixed on a magnetic stirrer and the solution in the receptor compartment was constantly and continuously stirred magnetic beads at 50 rpm; the temperature was maintained at 37±0.5°C.

1.1. Organoleptic properties and melting point of Curcumin

Test	Specification	Observation
Color	Orange- yellow needles	Pale Yellow
Odor	Characteristic	Characteristic
Taste	Bitter	Bitter
Melting Point	183°C	181-185°C

The melting point was determined using the open capillary method and is uncorrected for the variations due to atmospheric conditions.

filtered through the Whatman paper and then 0.1 ml solution was withdrawn into another volumetric flask (10 ml) and dilution was made up to 10 ml. The absorbance of this solution was observed at 421 nm using UV-Visible spectrophotometer and the drug content was calculated.

7.5. Percent moisture content- The prepared transdermal films were weighed individually and kept in desiccators containing fused calcium chloride at room temperature for the duration of 24 hours. After 24 hours, the films were re-weighed, and the percentage moisture content was determined by the given formula:

The 1 ml aliquots were withdrawal at different time intervals (0, 1, 2, 3, 4, 6 and 12 h) and analyzed the drug content by UV at 421 nm by appropriated dilution with ethanol. The receptor phase was replenished with an equal volume of phosphate buffer (37°C) at each sample withdrawal, the cumulative amount of drug permeated per square centimeter of patches were plotted against time.

RESULTS

1. Preformulation Studies-

The results of organoleptic characterization and melting point are presented in (Table 1.1) whereas the result of solubility analysis is presented in (Table 1.2).



1.2. Solubility profile of curcumin

Solvent	Solubility
Water	Insoluble
Methanol	Soluble
Ethanol	Freely soluble

3. Drug excipient compatibility Study(FT-IR study)-

The FT-IR spectrum of curcumin (Figure 3.1), and a physical mixture of curcumin and oleic acid (Figure 3.2) were obtained and observed for any deletion of the peaks of the pure drug. The spectrum of curcumin exhibited peaks at 3341 cm^{-1} (OH stretching), 3056 cm^{-1} (CH aromatic stretching), 2923 cm^{-1} (CH_2 stretching), 1647 cm^{-1} (C=O stretching), 1574 cm^{-1} (C=C aromatic stretching), 1441 cm^{-1} (CH_2 bending), 1146 cm^{-1} (C-O stretching).

All the peaks were present in the physical mixture indicating a compatibility between the both the components.

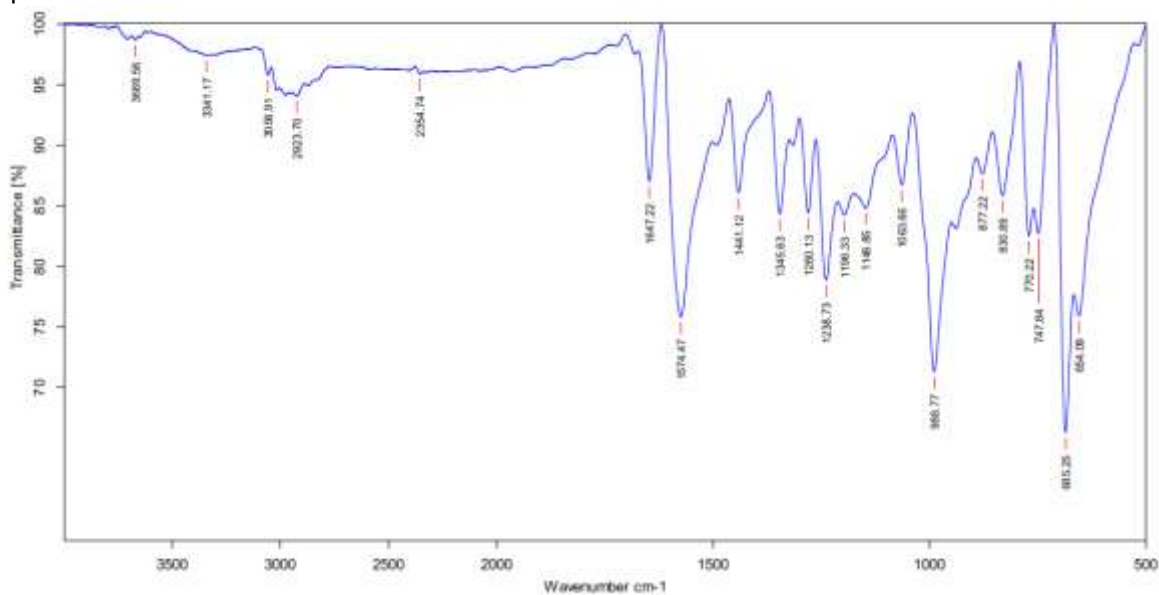


Figure 3.1 FT-IR spectrum of Curcumin



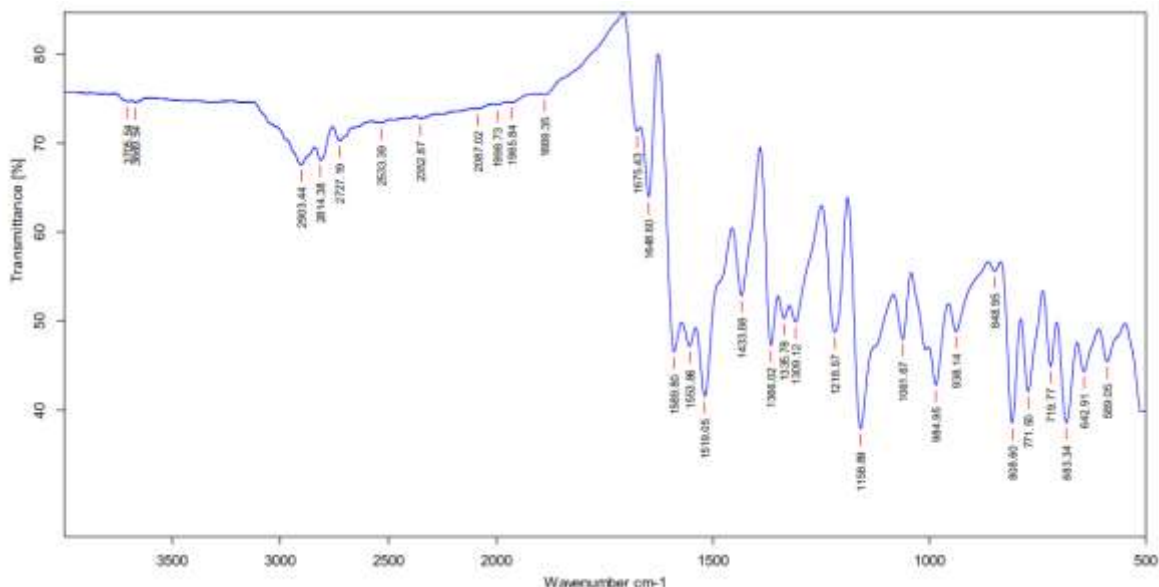


Figure 3.2 FT-IR spectrum of physical mixture of oleic acid and curcumin

4. Calibration curve of curcumin

The calibration curve of curcumin was prepared in methanol using UV-Visible spectrophotometer at 421 nm by plotting the absorbance against concentration (Table 4, Figure 4). The linearity equation was found to be Absorbance (y) = 0.029 concentration (x) + 0.005 with a regression coefficient value of 0.999 (R²). This equation was used to calculate the concentration of curcumin in various stages of the study.

Table 4- Absorbance of curcumin at 421 nm

Concentration (µg/mL)	Absorbance*
5	0.157 ± 0.000577
10	0.297 ± 0.001732
15	0.446 ± 0.002
20	0.596 ± 0.001528
25	0.745 ± 0.002517

*Average ± standard deviation; Average of three readings

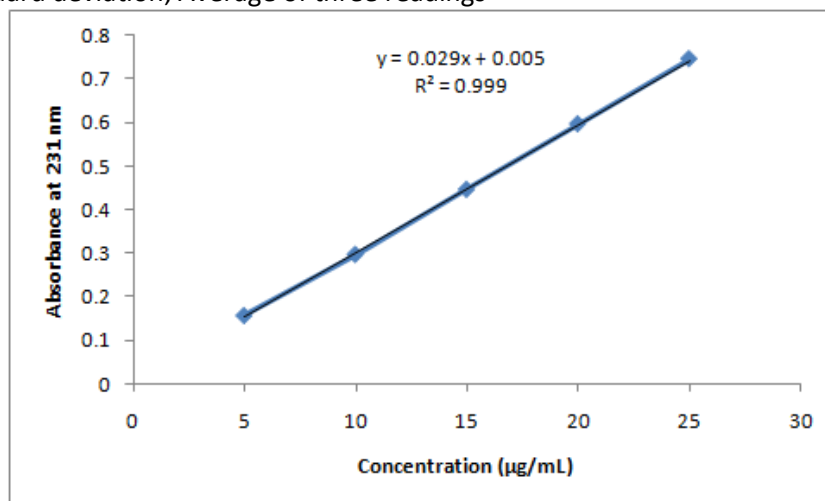


Figure 4- Calibration curve of curcumin in methanol



5. Preparation of SLNs

The SLNs loaded with curcumin were prepared by using different ratios of oleic acid as the lipid and Tween 80 as the surfactant using nanoprecipitation method. The surfactant (Tween 80) helps in steric stabilization.

Characterization of SLNs

5.1. Particle size and zeta potential

(Table 5.1.1) presents the average size of curcumin loaded SLNs prepared. All readings are reported as mean \pm standard deviation. The sonication time of 15 min decreased the size of particles to the desired nano range that would be effective for higher permeation through the membrane. The size range of SLNs obtained on sonicating for 15 was found to be 334 ± 11 nm to 482 ± 20 nm (Figure 5.1.1, 5.1.2).

Table 5.1.1 Particle size and zeta potential of SLNs

Formulation Name	Particle Size	Zeta Potential
SLNC1	482 ± 20	-19.4 ± 1.5
SLNC2	449 ± 114	-17.1 ± 2.9
SLNC3	358 ± 59	-18.4 ± 5.9
SLNC4	334 ± 11	-15.3 ± 3.6

The results of particle size show that 0.16 mmol of lipid in solution resulted in the smallest particles whereas lower ratio increased the particle size of the SLNs.

The zeta potential of all the SLNs ranged from -15 to -20 mV suggesting a stable formulation (Figure 5.1.3). SLNs with zeta potential of around -20 mV can be considered optimum for a formulation to be stable enough for long term.

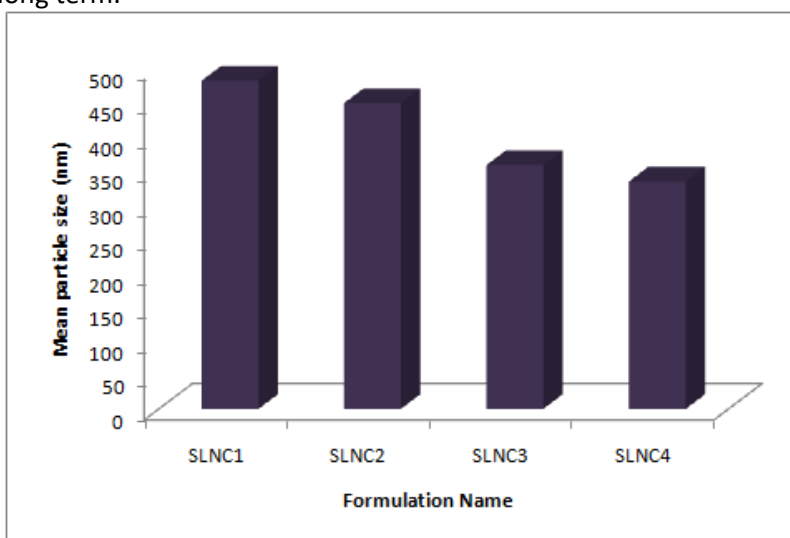


Figure 5.1.1 Particle size of curcumin loaded SLNs



	Diam. (nm)	% Intensity	Width (nm)
Z-Average (μm): 482.7	Peak 1: 137.2	71.1	54.78
PdI: 0.497	Peak 2: 491.6	26.9	137.0
Intercept: 0.972	Peak 3: 5451	2.0	243.4
Result quality Good			

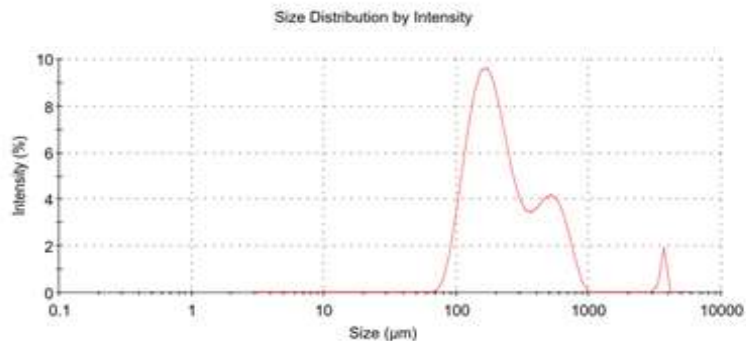


Figure 5.1.2 Particle size and distribution of SLCN-1

	Mean (mV)	Area (%)	Width (mV)
Zeta Potential (mV): -19.4	Peak 1: -19.4	100.0	3.36
Zeta Deviation (mV): 3.36	Peak 2: 0.00	0.0	0.00
Conductivity (mS/cm): 0.0891	Peak 3: 0.00	0.0	0.00
Result quality Good			

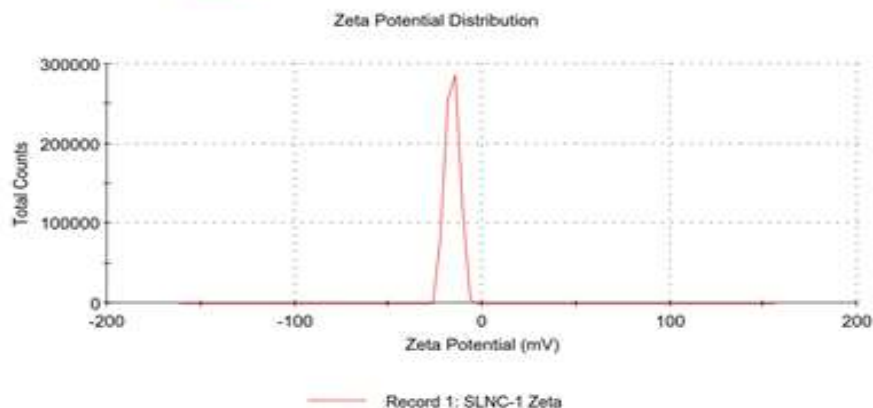


Figure 5.1.3 Zeta potential of SLNC-1

5.2. Entrapment efficiency

The entrapment efficiency was found to increase initially on increasing the concentration of the lipid. The highest encapsulation of curcumin (66.7%) was obtained when the concentration of oleic acid was 0.16 mmol. The entrapment efficiency of the prepared SLNs is presented in (Table 5.2)

Table 5.2 Entrapment of curcumin in SLNs

Formulation Name	Entrapment Efficiency
SLNC1	54.5 \pm 7.3
SLNC2	56.2 \pm 2.3



SLNC3	61.1 ± 1.2
SLNC4	66.7 ± 11.1

5.3. In vitro release from SLNs

In vitro release kinetics studies for Curcumin loaded SLNs exhibited a sustained release pattern. Sustained release was observed over a period of 24 hours.

Table 5.3 *In vitro* release of curcumin from SLNs

Formulation Name	% release of curcumin					
	0	1	2	4	8	24
CSLN1	0	17.1	21.4	31.5	49.8	70.2
CSLN2	0	14.9	16.2	26.1	39.1	62.8
CSLN3	0	14.1	14.8	20.6	37.2	56.9
CSLN4	0	13.4	14.3	19.8	32.7	51.4

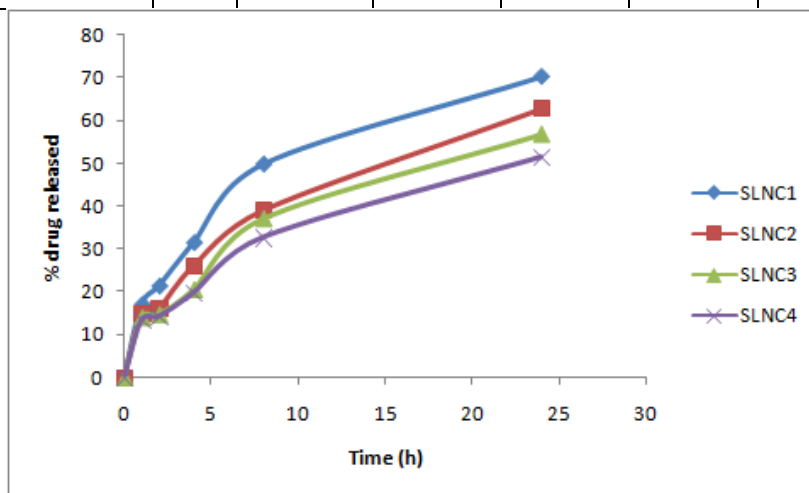


Figure 5.3 Release of curcumin form SLNs

As evident from the result, the SLNs were able to produce sustained release with highest amount of drug released form SLNC-1 and the lowest in SLNC-4. This presents a clear indication that the concentration of oleic acid related inversely with the release of curcumin from the SLNs.

From the overall results obtained, it was concluded that SLNC-1 was the most stable of all the SLNs and hence it was utilized for formulation of transdermal patches.

6. Preparation of transdermal patches

Table 7 Physiochemical features of Transdermal Patches

	Thickness (mm)	Average weight (mg)	Moisture content (%)	Drug content (%)	Folding Endurance
SLNP1	0.312	163	6.51	98.16	67

Transdermal patches were prepared using HPMC as the hydrophilic matrix and PVP-K30 as the lipophilic component. The elasticity of the patches was attained using PEG-400 (30% polymeric weight) as the plasticizer and propylene glycol (15% polymer weight) was used as the permeation enhancer to assist permeation of drug into the dermis.

7. Evaluation of transdermal patches

The evaluation of the patch was performed as per reported procedures and the result is reported in (Table 7)



SLNP2	0.301	161	6.37	99.01	79
SLNP3	0.275	152	6.24	99.22	85
SLNP4	0.261	147	6.03	99.24	94

The average weight of the patches was found to be ranging from 147 to 163 mg. The thickness of the patches ranged from 0.261 to 0.312 mm and was found to be dependent on the concentration of PVP-K30. A higher concentration of PVP-K30 in the polymeric matrix resulted in reduced thickness of the patches.

The folding endurance test results revealed that the thinner patches were more flexible withstanding 67 to 94 folds at same place without any visible cracking or breaking.

All the formulations were able to incorporate good amount of drug in them ranging from 98.16 to 99.22 %. The complete loading of drug in the patches was evident that the method used for preparing the patches produced patches with minimum variability.

The results of moisture content study revealed that increase in concentration of PVP-K30 inversely affected the moisture content in the

patches with SLNP-4 exhibiting the lowest moisture (6.03 %) while SLNP-1 exhibiting the highest (6.51 %).

The *in vitro* release profile of curcumin from the SLN loaded patches was materialized using Franz diffusion apparatus. The result revealed that the patches could maintain and control the release of drug for more than 12 h during the period of study. The drug was released ranging from 67.3 to 59.7 % in various formulations. It was found that as the concentration of PVP-K30 increased in the formulation, the release of drug increased from the patches which could be easily related to better solubility and movement of poorly soluble drug through the patch (**Table 7.1**). The release data was mathematically and graphically explored for studying the type of release that the drug might follow from the patches. The data was subjected to kinetic modeling using first order, Higuchi and Kosemeyer-Peppas models.

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Table 7.1 Release data of curcumin from SLN loaded patch

Time (h)	1	2	3	4	6	12
SLNP1	2.94	10.58	18.34	38.81	54.11	59.7
SLNP2	4.86	12.18	17.68	40.58	61.04	63.6
SLNP3	4.33	11.45	19.18	43.85	58.96	65.1
SLNP4	5.08	14.07	20.58	41.16	64.25	67.3



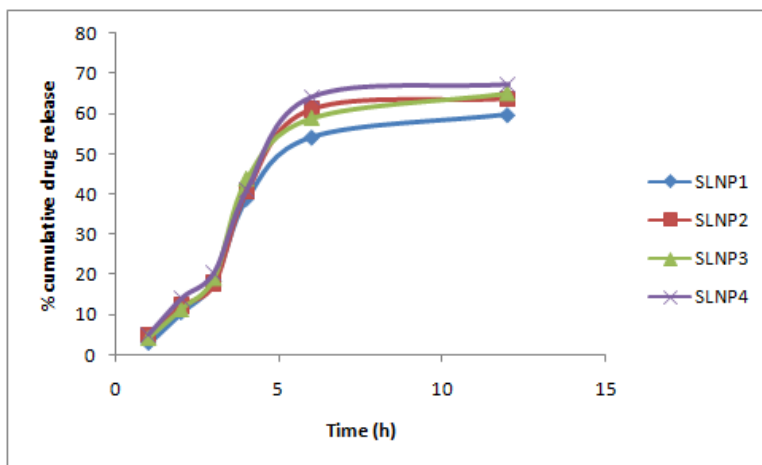


Figure 7.1 Zero order release graph of curcumin from SLN from patches

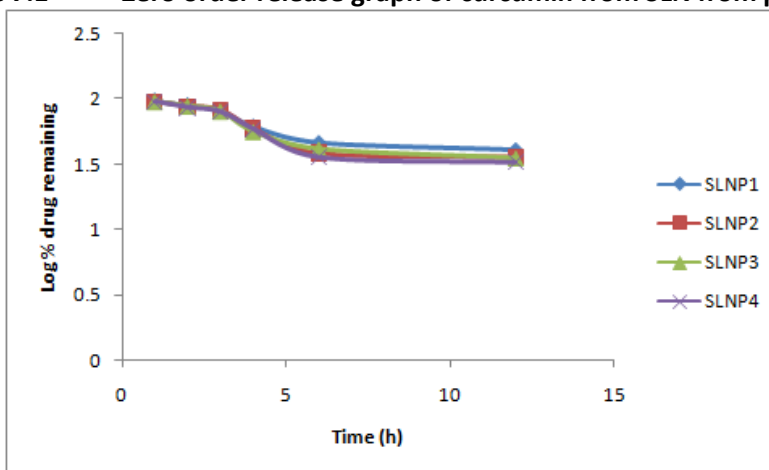


Figure 7.2 First order release graph of curcumin from SLN from patches

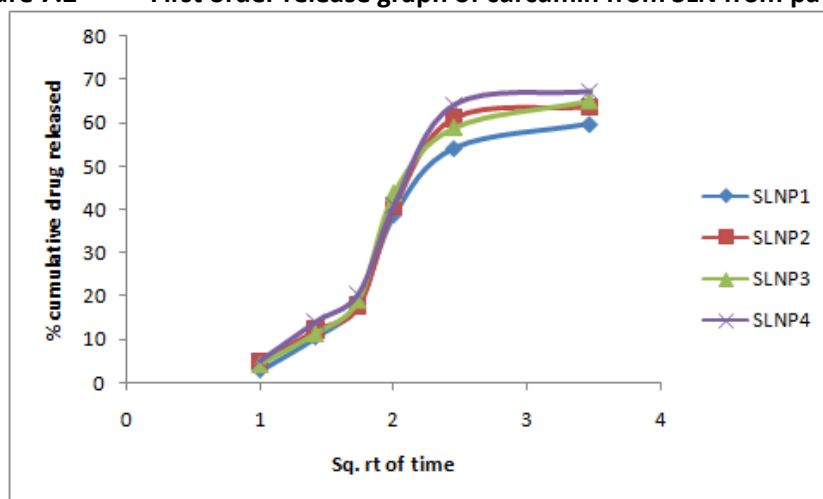


Figure 7.3 Higuchi release graph of curcumin from SLN from patches



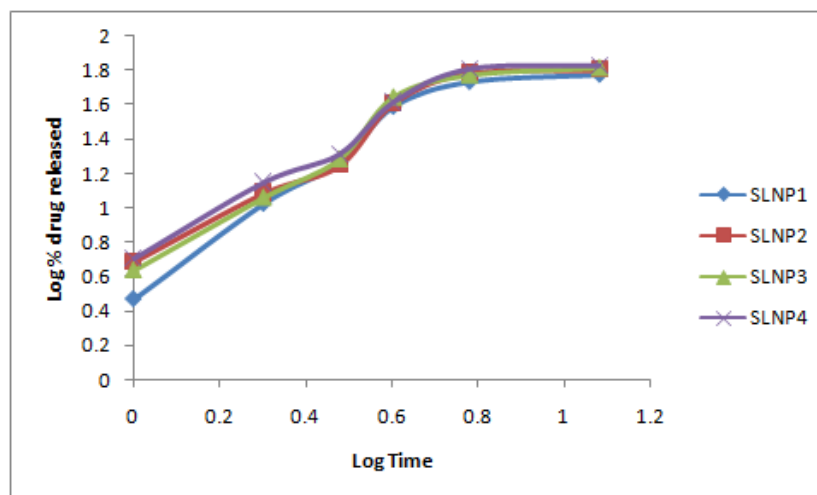


Figure 7.4 Korsmeyer-Peppas release graph of curcumin from SLN from patches

The slope and regression coefficient of the drug released, and the various applied kinetic models has been presented in (Table 7.2)

Table 7.2 Statistical data of kinetic modeling of drug release from patch

	Zero Order		First Order		Higuchi		Korsmeyer-Peppas	
	Slope	R ²	Slope	R ²	Slope	R ²	Slope	R ²
SLNP1	5.225	0.778	-0.036	0.83	25.48	0.877	1.271	0.898
SLNP2	5.558	0.756	-0.04	0.793	27.08	0.851	1.125	0.909
SLNP3	5.652	0.769	-0.042	0.83	27.55	0.866	1.175	0.905
SLNP4	5.814	0.771	-0.045	0.81	28.31	0.866	1.11	0.915

The regression coefficients of the graphical representation of the mathematical models reveal that the release of curcumin from the SLN loaded transdermal patches can be described by the Korsmeyer-Peppas model. It expresses that the drug released from the patches is due to diffusion of drug from the matrix of the patch and is largely diffusion controlled.

DISCUSSION-

The following conclusions were drawn out of the results that were obtained from the study. Transdermal patches loaded with curcumin loaded solid lipid nanoparticles were formulated with PEG-400 as plasticizer and HPMC and PVP-K30 as the polymeric matrix

materials using solvent casting method. The patches are stable and exhibit no interaction between drug and formulation ingredients. The average weight of the patches was found to be ranging from 147 to 163 mg. The thickness of the patches ranged from 0.261 to 0.312 mm and was found to be dependent on the concentration of PVP-K30. The folding endurance test results revealed that the thinner patches were more flexible withstanding 67 to 94 folds at same place without any visible cracking or breaking. All the formulations were able to incorporate good amount of drug in them ranging from 98.16 to 99.22 %. The results of moisture content study revealed that increase in concentration of PVP-K30 inversely affected the moisture content in the patches with SLNP-4 exhibiting the lowest moisture



(6.03 %) while SLNP-1 exhibiting the highest (6.51 %). The drug was released ranging from 67.3 to 59.7 % in various formulations. The regression coefficients of the graphical representation of the mathematical models reveal that the release of curcumin from the patches can be described by Korsmeyer-Peppas model. It expresses that the drug released from the patches is due to diffusion of drug from the matrix of the patch and is largely diffusion controlled.

CONCLUSION

Curcumin is a good candidate for topical delivery and the use of solid lipid nanoparticles in transdermal patches presents a good means to improve the extend of release duration of poorly soluble drugs. In present investigation was SLNs containing curcumin were prepared using oleic acid as the lipid component and the SLNs were loaded in to transdermal patches. The transdermal patches of curcumin loaded SLNs were evaluated for their applicability to reduce the dose of the drug and increase the duration of drug released from the patches. It might be inferred from the study that transdermal drug delivery system containing curcumin SLNs could be formulated, and provides higher compliance than conventional topical applications of curcumin.

REFERENCE

1. Iman IS, Nadia AS, Ebtsam MA. Formulation and stability study of chlorpheniramine maleate transdermal patch. *Asian Journal of Pharmaceutics (AJP)*. 2010;4(1).
2. Shah SS, Rahul J, Prabhakar P. Formulation and evaluation of transdermal patches of papaverine hydrochloride. *Asian Journal of Pharmaceutics (AJP)*. 2010;4(1).
3. Ren C, Fang L, Ling L, Wang Q, Liu S, Zhao L, He Z. Design and in vivo evaluation of an indapamide transdermal patch. *International Journal of Pharmaceutics*. 2009 Mar 31;370(1-2):129-35.
4. Shinde AJ, Shinde AL, More HN. Design and evaluation of transdermal drug delivery

system of gliclazide. *Asian Journal of Pharmaceutics (AJP)*. 2010;4(2).

5. Smola M, Vandamme T, Sokolowski A. Nanocarriers as pulmonary drug delivery systems to treat and to diagnose respiratory and non respiratory diseases. *International journal of nanomedicine*. 2008 Mar;3(1):1.
6. Wang Y, Bryant SH, Cheng T, Wang J, Gindulyte A, Shoemaker BA, Thiessen PA, He S, Zhang J. Pubchem bioassay: 2017 update. *Nucleic acids research*. 2017 Jan 4;45(D1):D955-63.
7. Gupta DK, Shende R, Kumar A, Ghatuary SK. *JOURNAL OF PHARMACOLOGY AND BIOMEDICINE*.
8. Hazra K, Kumar R, Sarkar BK, Chowdary YA, Devgan M, Ramaiah M. UV-visible spectrophotometric estimation of curcumin in nanoformulation. *Int. J. Pharmacogn*. 2015 Jan;2:127-30.
9. Mishra BJ, Kaul A, Trivedi P. L-Cysteine conjugated poly L-lactide nanoparticles containing 5-fluorouracil: formulation, characterization, release and uptake by tissues in vivo. *Drug Delivery*. 2015 Feb 17;22(2):214-22.
10. Chirio D, Peira E, Dianzani C, Muntoni E, Gigliotti CL, Ferrara B, Sapino S, Chindamo G, Gallarate M. Development of solid lipid nanoparticles by cold dilution of microemulsions: curcumin loading, preliminary in vitro studies, and biodistribution. *Nanomaterials*. 2019 Feb 8;9(2):230.
11. Ji H, Tang J, Li M, Ren J, Zheng N, Wu L. Curcumin-loaded solid lipid nanoparticles with Brij78 and TPGS improved in vivo oral bioavailability and in situ intestinal absorption of curcumin. *Drug delivery*. 2016 Feb 12;23(2):459-70.

