

## **RP-HPLC METHOD DEVELOPMENT, VALIDATION, AND QUANTIFICATION OF LORNOXICAM IN LIPID NANOPARTICLE FORMULATIONS**

**SANDIPAN DASGUPTA<sup>1,3</sup>, SANJAY DEY<sup>2</sup>, PAULOMI PAL<sup>3</sup>, BHASKAR MAZUMDER<sup>\*3</sup>**

<sup>1</sup>Department of Pharmacology, NSHM College of Pharmaceutical Technology, Kolkata, India, 700053, <sup>2</sup>Assistant Professor, School of Pharmacy Techno India University, EM-4/2, Sector-V, Salt Lake, Kolkata, West Bengal, India, <sup>3</sup>Department of Pharmaceutical Sciences, Dibrugarh University, Dibrugarh, Assam, India, 786004, India  
Email: bhmaz@dibru.ac.in

Received: 22 Jul 2016 Revised and Accepted: 09 Sep 2016

### **ABSTRACT**

**Objective:** A simple, reliable, sensitive and validated reversed phase-high performance liquid chromatography (RP-HPLC) method was developed for quantification of *lornoxnicam* (LX) in rat plasma.

**Methods:** Solid lipid nanoparticle (SLN) and nanostructured lipid carriers (NLC) gel formulations containing *lornoxnicam* were prepared using high-speed homogenization followed by ultra-sonication. Pharmacokinetic study of formulated LX loaded SLN and NLC were performed on Wister albino rats.

**Results:** The chromatographic separation was performed on *hypersil octadecylsilane* (ODS)-18 column using a mobile phase of 10 mmol. Phosphate buffer (pH, 4.5) and *acetonitrile* (65:35 v/v). Elute was monitored at 377 nm with a flow rate of 1 ml/min. Calibration curve was linear over the concentration range of 25.38–2046.45 ng/ml. Retention times of LX and internal standard (piroxicam) were 9.3 and 10.2 min, respectively. Maximum plasma drug concentration, the area under the plasma drug concentration *versus* time curve and elimination half-life for LX loaded SLN gel were found 6381.51±971.27ng/ml, 19917.21±7111.24 ng h/ml and 7.27±1.21h and 8558.13±1564.08 ng/ml, 21317.99±4568.71 ng/ml and 6.22±2.16 h. respectively. *In vivo in vitro* correlation study, the fraction of drug dissolved from nanoparticle in pH 7.4 was plotted against the fraction of drug absorbed and a linear correlation ( $R^2= 0.9987$ ) was obtained.

**Conclusion:** A novel simple, sensitive, precise, rapid, accurate, and economical and reliable RP-HPLC method was developed and validated for the estimation of LX in rat plasma.

**Keywords:** Lornoxicam, SLN, NLC, RP-HPLC, Pharmacokinetic

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DOI: <http://dx.doi.org/10.22159/ijpps.2016v8i11.14256>

### **INTRODUCTION**

*Lornoxicam* (LX), chemically *6-chloro-4-hydroxy-2-methyl-N-2-pyridinyl-2H-thienol [1, 2]-1,2-thiazine-3-carboxamide1,1-dioxide*, is a member of the oxycam class of non-steroidal anti-inflammatory drugs (NSAIDs) with having analgesic, anti-inflammatory and antipyretic properties [1, 2]. LX also shows a significant therapeutic effect in pain like osteoarthritis and rheumatoid arthritis [3, 4]. LX acts by non-selective inhibition of cyclooxygenase-1 and-2. Quantification of the active component in a dosage form is essential to the quality control of these systems. Quality control checks the suitability of a drug delivery system for the intended application. It serves as a marker for the consistency and predictability of the performance of dosage forms. RP-HPLC methods are widely reported for the quantitative estimation of LX but to this day, no reports are available on the quantification of LX in nanostructured delivery systems such as solid lipid nanoparticles (SLN) and nanostructured lipid carriers (NLC) gel. Reversed phase high performance liquid chromatography (RP-HPLC) assembled with photodiode array (PDA) detector is most widely used in industries and research base organization for quantification of drugs present in the plasma sample. Several analytical methods for determination of LX in plasma and pharmaceutical formulation using UV spectroscopy [5, 6], RP-HPLC [7, 8] and polarography [9] have been reported. Several modern analytical techniques like liquid chromatographic-electrospray ionization tandem mass spectrometry for the quantification of LX in the biological sample have been described in different research article [10]. However, the reported methods suffer from drawbacks such as poor resolution, cumbersome, complex sample preparation; require a sophisticated instrument, and more analytical expenses. Several RP-HPLC methods were reported in the literature for the quantitative determination of LX in

biological samples. However, most of the published methods described the quantification of LX along with other drugs by RP-HPLC technique. To best our knowledge, a validate RP-HPLC method for the determination of LX loaded SLN and NLC in a biological sample have not been reported.

Hence in this paper, we reported a simple, sensitive, precise, rapid, accurate, and economical, reliable, and validated RP-HPLC method requiring simple sample preparation and short running time for the determination of pharmacokinetic profile of LX after transdermal administration of SLN and NLC in rats.

### **MATERIALS AND METHODS**

LX was obtained as gift sample from Akumbs Drugs, (Hridwar, India). Stearic acid, pluronicF68, carbopol 940 P, and oleic acid were purchased from Himedia, Mumbai, India. phospholipon90G (phosphatidylcholine 90%) was collected as gift sample from GmbH, Germany. HPLC grade acetonitrile, methanol, and dichloromethane were procured from E-Merck, Mumbai. Potassium dihydrogen phosphate ( $KH_2PO_4$ ) and orthophosphoric acid ( $H_3PO_4$ ) were purchased from SD Fine Chem. Ltd., Mumbai, India. All other chemicals and solvents used were of analytical grade. Water used in the HPLC analysis was prepared by the water purifier (AriumR, 611UF, Sartorius, Germany). The mobile phase and all the solutions were filtered through a 0.45 µm ultipor®N66®membrane filter (Pall Life Sciences, USA) prior to use.

### **Instruments**

HPLC system (Waters, USA) consisting of the quaternary pump (WaterTM600), 7725i rheodyne manual injector, PDA detector, and empower-II software and these assembled were used for analysis. They were processed by using of micropipettes (Ependruff, USA), spinix

vortexer (M37610-33, Barnstead International, USA), biofuge fresco centrifuge (Heraeus, Germany), ultra-sonicator (LobaChem, Mumbai), nitrogen gas evaporator, and multi-pulse vortexed (Glas-COL, USA).

### Experimental animals

Wister rats of either sex weighing 130-140 gm, housed at a temperature of  $22\pm 1$  °C and relative humidity of  $55\pm 10\%$  in controlled room were used in the experiments. The pharmacokinetic studies were conducted under protocol number MC/UCMS/IAEC/DU/12 of the Institutional Animal Ethical Committee of Department of Pharmaceutical Sciences, Dibrugarh University, Dibrugarh, Assam. The experiments were conducted in accordance with the guidelines provided by the Committee for the Purpose of Control and Supervision of Experiments on Animals (CPCSEA, Govt. of India).

### Preparation of Lx-loaded SLN and NLC

SLN and NLC were prepared by high-speed homogenization and ultrasonication method [11]. Briefly, LX and phospholipon 90G were dissolved in methanol. Stearic acid was dissolved in acetone and mixed with methanol containing LX and phospholipon 90G. The mixture was added dropwise to an aqueous solution of pluronic F68 and maintained at 75°C (5 °C above the melting point of the lipid). A pre emulsion thus obtained was stirred using an ultra-turrax T25 (IKA-Werke GmbH, Germany) at 15000 rpm for 3 min. This preemulsion was immediately placed in a probe-type sonicator (6 mm diameter, 20 W; Malvern Instruments, UK) by an ultrasonic processor to prevent crystallization. After 15 min of ultrasonication, the nanodispersion was kept for cooling under continuous stirring. During this process, SLN was formed by recrystallization. The prepared SLN dispersions were lyophilized for further studies. NLC was prepared in a similar manner wherein only the "solid lipid" (Stearic acid) was replaced by oleic acid in different proportions [12]. The formulated nanoparticles were evaluated for drug entrapment efficiency, particle size measurement, X-Ray diffraction study, scanning electron microscopy and *in vitro* drug release study. The *in vitro* drug release study was performed in Franz diffusion cell with the magnetic stirring rate at 800 rpm. The release medium was contained 25 ml of phosphate buffer (pH 7.4). At predetermined intervals 2 ml of samples were withdrawn from receptor compartment and replaced with equal volume of release medium [11].

### Chromatographic conditions

HPLC analysis was performed using a hyper sim ODS C18 column (250 mm × 4.6 mm, particle size 5 µm). The mobile phase consisted of phosphate buffer (pH, 4.5) and acetonitrile in the ratio of 65:35 %v/v. Eluent was monitored with the PDA detector at 377 nm with a flow rate of 1 ml/min and sample of 20 µl was injected in the column and the temperature of the RP-HPLC system was maintained at a temperature of  $30\pm 2$  °C all over the study.

### Preparation of standard solution

A stock solution of LX (50µg/ml) and piroxicam (PX) (internal standard, 50µg/ml) were prepared in acetonitrile. Further dilution of a stock solution of LX was carried out using mobile phase for the preparation of working standard solution. Calibration standards were prepared freshly by spiking working standard solution of LX into the blank plasma to get the final concentration of 25.38, 50.77, 101.53, 203.06, 406.12, 846.09, 1244.24, 1637.16, 2046.45 ng/ml. All the solutions were prepared once and analyzed daily over a period of 3 d for the inter-day precision of the method. These solutions were stored at  $-20$  °C until further study [13].

### Quality control standards

Lowest quality control standards, median quality control standards, and highest quality control standards were prepared by spiking drug-free plasma with LX to give solutions containing 101.53, 406.12 and 1244.24 ng/ml, respectively. They were stored at  $-20$ °C till analysis.

### Sample preparation

An aliquot quantity of 100 µl of rat plasma spiked with 10 µl of calibration standard solution of LX was taken in a 2 ml stopper centrifuge tube and mixed for 10 s. To this, 10 µl of internal standard (IS) solution (50µg/ml) was added and mixed for 20 s. The drug was

extracted by vortexing with 1.5 ml of selected extracting solvents (acetonitrile, methanol and di-chloromethane) in a spinix vortexer for 10 min. followed by centrifugation at 10,000 rpm for 5 min at 4 °C. The supernatant was withdrawn and dried under nitrogen at 25 psi for 10 min at 40 °C. The residue was reconstituted with 100 µl of mobile phase and 20 µl was injected onto the RP-HPLC column [13].

### Validation of method

The validation of an analytical method confirms the characteristics of the method to satisfy the requirements of the application domain [13]. The method was validated according to ICH guidelines [14, 15] for specificity, recovery, linearity, precision and stability. Under the validation programme the following parameters were studied:

### Specificity

The specificity criterion demonstrates that the result of the method is not affected by the presence of interferences, i.e. whether the compound of interest elutes without interfering with other compounds and components of plasma. The specificity of the method was determined by comparing the chromatograms obtained from the aqueous samples of LX and IS with those obtained from blank plasma. Blank plasma samples from each of five rats were processed in the presence of IS and another set of five samples processed with LX and IS to evaluate the presence of interference around the peak of LX. The median quality control solution (406.12 ng/ml) of LX was injected into the column under the optimized chromatographic conditions to obtain the chromatographic peaks of LX and I. S. so as to differentiate them from the interfering peaks of plasma components.

### Selection of solvent for recovery of drug

The recovery of an analyte is the extraction efficiency of an analytical process, reported as a percentage of the known amount of an analyte carried through the sample extraction and processing steps of the method. Different organic extraction solvents (acetonitrile, methanol, ethanol, hexane, dichloro methane and chloroform) were tried in the experiment to recover LX from plasma samples. Quality control samples were prepared in triplicate at three levels of 101.53, 406.12 and 1244.24 ng/ml of LX and assayed by HPLC method as described as above. The extraction efficiency of LX was determined by comparing the peak areas obtained from extracted quality control samples with the peak area of an aqueous working solution containing the same concentration of LX at three levels.

### Linearity

Quantitative analytical results are highly influenced by the quality of the calibration curve [16, 17]. Nine different concentrations of LX with a fixed concentration of IS in blank plasma were processed, and a calibration curve was constructed in the specified concentration range (25.38, 50.77, 101.53, 203.06, 406.12, 846.09, 1244.24, 1637.16, and 2046.45 ng/ml). The calibration curve was plotted between the ratio of peak areas of LX to IS and concentration of LX by replicate analysis (n=6) at all concentration levels and the linear relationship was evaluated using the least square method using Microsoft excel® (Microsoft Corporation, USA) program.

### Precision and accuracy

Both repeatability (within a day precision) and reproducibility (between days precision) were determined as follows. Three quality control samples (lowest, median, and highest) were subjected for the study. Each of the specified quality control samples was injected five times for determination of repeatability (five different time intervals) and repeatability (over a period of 5 d). Mean and relative standard deviation were calculated and used to predict the accuracy and precision of the method.

### Stability studies

The quality control standards containing 101.53, 406.12, and 1244.24 ng/ml (n=6) of LX were subjected for detection of stability of LX in rat plasma. The initial assay of the samples was conducted. The quality control samples were divided into three set each set

contained five samples. The first set was kept in polypropylene tubes and subjected to three freezes (-20 °C for 24 h)–thaw (room temperature for 24 h) cycles. The second set was kept at room temperature for 24 h and the third set was kept at room temperature for 1 mo. All the samples were analyzed by standard chromatographic conditions to determine their peak areas. Samples were considered to be stable when the final assay values of samples were found similar to that of the initial assay value of the drug.

### Pharmacokinetic study in rats

The method described above was applied to quantify the plasma concentration of LX in a single-dose pharmacokinetic study conducted on six Wister rats. The protocol was approved by the Institutional Ethical Committee at the Dibrugarh University, Dibrugarh, India. The experiments were conducted as per CPCSEA (Committee for Prevention, Control and Supervision of Experimental Animals) guidelines. The rats weighing 130-150 gm were housed with free access to food and water, except for the final 12 h before experimentation. After transdermal application of formulated nanoparticle containing 2.5 mg of LX, 2 ml of blood samples were collected from the tail vein at 0, 0.25, 0.5, 1, 2, 3, 4, 6, 9, 12 and 24 h time points into heparinized collection tubes. The blood was immediately centrifuged (1000 × g) for 10 min at an ambient temperature. The supernatant plasma layer was separated and stored at -20 °C until analyzed. The plasma samples were analyzed for LX concentrations by validated RP-HPLC method. The first order elimination rate constant ( $k_{el}$ ) was estimated by the least square regression of plasma concentration–time data points of the curves describing the terminal log-linear decaying phase. The plasma half-life ( $t_{1/2}$ ) was calculated from  $k_{el}$  ( $t_{1/2} = 0.693/k_{el}$ ). The area under the plasma concentration–time curve from zero to the last measurable plasma concentration at time  $t$  ( $AUC_{0-t}$ ) was calculated by applying the trapezoidal rule. The area was extrapolated to infinity ( $AUC_{0-\infty}$ ) by the addition of  $C_t/k_{el}$  to  $AUC_{0-t}$ , where  $C_t$  is the last detectable drug concentration. The absorption rate constant ( $k_a$ ) was determined by the residual method. The maximum observed LX concentration ( $C_{max}$ ) and the time at which  $C_{max}$  was observed ( $T_{max}$ ) were obtained directly from the profile. The AUMC  $AUC_{0-\infty}$  is the area under the plot of time vs. the product of time and concentration extrapolated to infinity and was calculated by trapezoidal rule. The mean residence time (MRT) was determined by AUMC divided by AUC. All the pharmacokinetic parameters were calculated using microsoft® office excel 2003 (Microsoft Corporation, USA) software application. [12]

The Wagner–Nelson method [18] was applied to deconvolute the percentage of the LX absorbed using Eq. (1).

$$F_t = C_t [C_t + K_{el} AUC_{(0-\infty)}] \dots \dots \dots (1)$$

Where,  $F_t$  is the amount of drug absorbed. The fraction absorbed (FRA) was calculated using eq. (2) and was plotted against the fraction of drug dissolved (FRD) at the same time and the linear regression analysis was used to examine the *in vitro*–*in vivo* relationship.

$$\text{Fraction absorbed (FRA)} = C_t + K_{el} AUC_{(0-t)} / K_{el} AUC_{(0-\infty)} \dots \dots \dots (2)$$

### Establishment of *in vivo* *in vitro* correlation (IVIVC)

An IVIVC refers to the predictive mathematical model describing the relationship between *in vitro* property of a controlled-release dosage form (usually the rate or extent of drug dissolution or release) and a relevant *in vivo* response, such as plasma drug concentration or amount of drug absorbed. A level A correlation is usually estimated by a two-stage procedure: deconvolution followed by comparison of the fraction of drug absorbed (FRA) to the fraction of drug dissolved (FRD). A correlation of this type represents a point-to-point relationship between *in vitro* dissolution and the *in vivo* input rate [19]. Accordingly, the deconvolution procedure was done on nanoparticles using mean LX plasma concentration vs. time profile using the method of wagner–nelson. The data of FRA (obtained by deconvolution) and FRD for each formulation were then plotted to develop an IVIVC model. The linear, quadratic, and cubic models (Eq. (2) bearing the following forms were tested to obtain the best fit:

$$Y = a + bX, Y = a + bX + cX^2, Y = a + bX + cX^2 + dX^3 \dots \dots \dots (2)$$

where a, b, c, d represent regression parameters associated with each function, Y is the FRA *in vivo* and X is the FRD *in vitro*. The coefficients of determination ( $r^2$ ) for all developed models were determined. The highest  $r^2$ -value equation was considered as the best fitting model.

### Statistical analysis

The linearity of the proposed method was evaluated by measuring the single factor analysis of variance (ANOVA) of the linear regression data. Statistical significance was established by a P-value < 0.05, which indicates that the model is explained by the proposed regression at a 95% confidence interval.

## RESULTS AND DISCUSSION

### Preparation of SLN and NLC

Both SLN and NLC formulations were successfully prepared using high-speed homogenization method. The particle size, zeta potential, and poly dispersity index were found to be within the range of 140–193 nm ± 0.220, -22 to -32 mV, and 0.354–0.301 for SLN formulations and 146–201 nm ± 0.232, -23 to -30 mV, and 0.355–0.354 ± 0.145 for NLC formulations, respectively. The entrapment efficacy of the SLN formulations was found within the range of 42%–72% and that for the NLC formulations was 61%–79%. Thermal analyses such as DSC, XRD showed good results. *In vitro* permeation rate and controlled release property of carbopol-loaded SLN, NLC gel was studied.

### Selection and development of chromatographic method

Normal phase chromatography can be used for the separation of non-ionic and non-polar substances, while reversed-phase chromatography ( $C_8$  and  $C_{18}$  column) can be used for the separation of non-ionic as well as ionic non-polar to semi-polar substances. Thus, LX (an ionizable semi-polar weak acid) can satisfactorily separated by reversed phase chromatography. However, *octylsilane* columns are less retentive as compared to octadecylsilane. The majority of the ionizable pharmaceutical compounds can be very well separated in *octadecylsilane* reversed phase columns [16]. Therefore, *octadecylsilane* column was considered for isolation of LX from the plasma sample. A mixture of methanol and phosphate buffer (pH 4.5) was used as a mobile phase for the analysis of LX [14]. The optimum ratio of acetonitrile to phosphate buffer (pH 4.5) used in the current investigation was 65:35 %v/v, which was selected on the basis of best resolution and absence of tailing and fronting. The best resolution and sensitivity of the peaks of LX and IS were obtained at 377 nm and flow rate of 1 ml/min of the mobile phase.

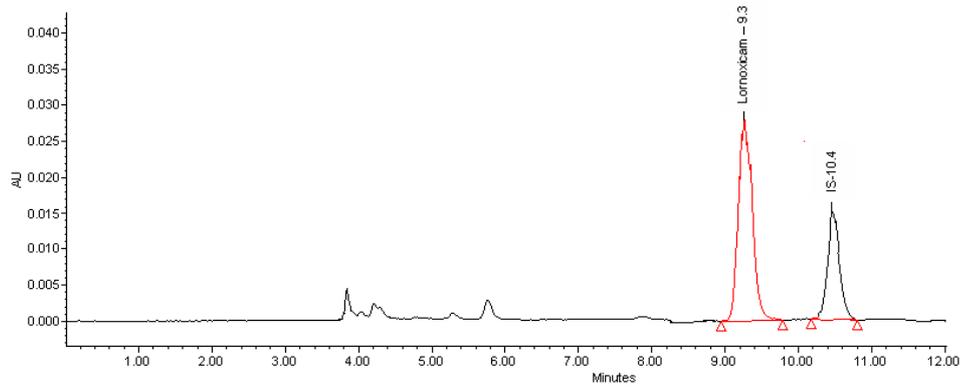
### Validation of methods

#### Specificity

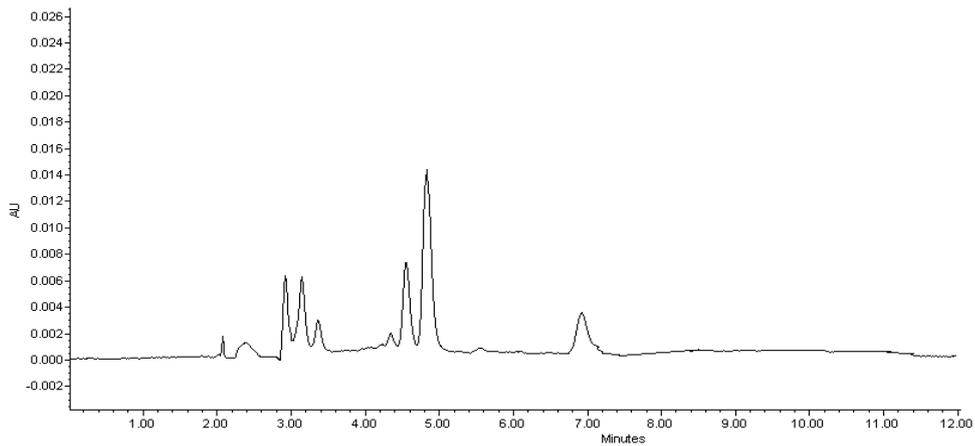
Typical chromatogram (fig. 1) of a mixture of LX and IS revealed that they are well separated under the RP-HPLC conditions applied. A chromatogram of blank plasma sample is shown in fig. II. Retention time was found 9.3 min for LX and 10.4 min for IS. In the comparison of a chromatogram of LX and IS (fig. 1) with the chromatogram of blank plasma (fig. 2), the absence of interference of plasma components is observed around the zone of the retention time of LX and IS. The chromatogram of the medium level quality control sample (*i.e.* 406.12 ng/ml) of LX spiked with rat plasma (fig. 3) showed a good resolution peaks for LX and IS which are well differentiated from the peaks of plasma components.

### Selection of extracting solvent for recovery of drug

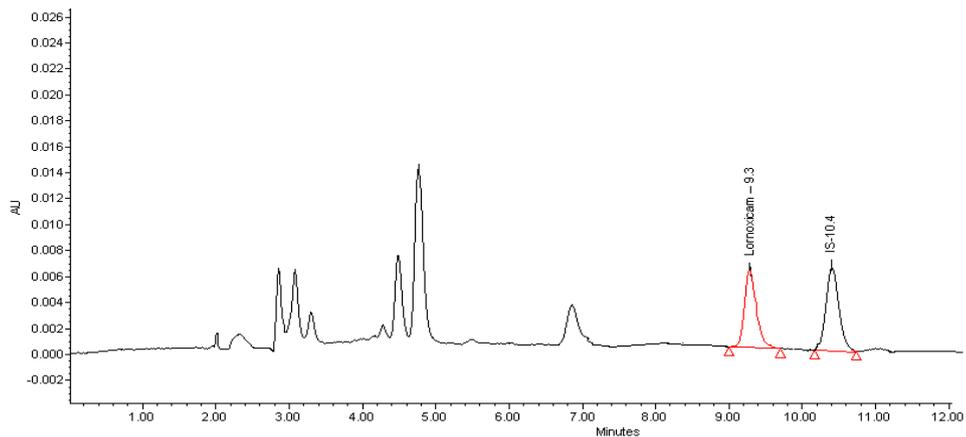
On the basis of capability of solvent to extract the maximum amount of drug from plasma was selected for extracting of LX from rat plasma. The recovery efficiency of LX from rat plasma was found to be 83.52 ± 0.78, 26.26 ± 1.46, 59.04 ± 1.68, 76.46 ± 0.89, 62.88 ± 1.05, and 71.08 ± 1.25% in acetonitrile, ethanol, methanol, hexane, dichloromethane and chloroform, respectively. Among the different solvents, acetonitrile showed maximum recovery efficiency, and therefore, acetonitrile was selected as the extracting solvent for extraction of LX from rat plasma.



**Fig. 1: Chromatogram of the mixture of LX and internal standard in mobile phase**



**Fig. 2: Chromatogram of blank plasma sample**



**Fig. 3: Chromatogram of drug along with IS in plasma sample**

### Linearity

The ratio of peaks area of LX to IS at various concentrations of LX in plasma was determined. The chromatographic responses (ratio of peaks area of LX to IS vs. LX concentration) were found to be linear over an analytical range of 25.38–2046.45 ng/ml with regression coefficient ( $r^2$ ) value 0.999 which showed good linearity. The linear regression equation obtained was  $Y = 0.001X + 0.013$ .

### Precision and accuracy

The accuracy of the proposed RP-HPLC method was determined by using three quality control samples, and the results are reported in

table 1. The relative standard deviation (RSD) of the intra-day assay of the drug was ranged from 3.51 to 5.35 % and for the inter-day assay was from 2.77 to 3.16% (table 2).

### Stability

The result of the stability of LX in rat plasma at different conditions is presented in table 3. The result revealed that the final drug concentration of each quality control sample at three freeze-thaw cycles and the sample stored at room temperature for 24 h and 1 mo were almost similar with the initial concentration. The RSD value ( $n = 6$ ) of final concentration of LX after three freeze-thaw cycles, 24 h and 1 mo was <10.87, <9.69 and <7.01, respectively.

Table 1: Peak area of the chromatogram of lornoxicam and I. S. at different concentration of lornoxicam

Concentration of LX (ng/ml)	Peak area of the chromatogram		Ratio of peak area
	Lornoxicam	I. S. (Piroxicam)	
25.38	10590	315383	0.0336
50.77	19414	326485	0.0595
101.53	48744	330127	0.1477
203.06	90937	296772	0.3064
406.12	189793	298161	0.6365
846.09	417630	340716	1.2257
1244.24	580504	333671	1.7397
1637.16	799309	333077	2.3998
2046.45	960772	335589	2.8629

LX: Lornoxicam IS: internal standard, ng/ml: nanogram per milliliter

Table 2: Intra-and inter-day precision and accuracy for lornoxicam

QC sample (ng/ml)	Intra-day variation			Inter-day variation		
	Observed value*	R. SD%	Accuracy %	Observed value*	R. SD%	Accuracy %
101.53	96.42±5.16	5.35	94.97	103.14±3.26	3.16	101.59
406.12	428.31±12.63	2.95	105.46	395.49±10.72	2.71	97.38
1244.24	1115.18±39.17	3.51	89.63	1106.47±30.69	2.77	88.93

(mean±SD; n = 6), QC: Quality control, RSD: relative standard deviation ng/ml: nanogram per milliliter

Table 3: Stability of LX in rabbit plasma

Stability	QC sample (ng/ml)	Observed value*	R. SD%	Accuracy %
Freeze-thaw stability	101.53	105.23±9.38	8.91	103.64
	406.12	384.75±41.81	10.87	94.74
	1244.24	1121.47±68.58	6.12	90.13
Short term (24 h)	101.53	96.98±6.69	6.90	95.52
	406.12	374.09±36.24	9.69	92.11
	1244.24	1167.57±81.14	6.95	93.84
Long term (30 d)	101.53	109.08±7.14	6.55	107.44
	406.12	384.57±26.94	7.01	94.69
	1244.24	1178.41±101.65	8.63	94.71

(mean±SD; n = 6). ng/ml: nanogram per milliliter RSD: relative standard deviation LX: Lornoxicam

#### Pharmacokinetic study in rats

The validated RP-HPLC method was applied to carry out a pharmacokinetic study of LX in rats. The mean plasma concentration of LX versus time profile following a single transdermal application of prepared LX loaded SLN and NLC on six rats is presented in fig. 4. The various pharmacokinetic parameters are summarized in table 4.

#### In vitro-in vivo correlation (IVIVC)

To assess the viability and validity of the sustaining nature of nanoparticles, IVIVC study is essential, since prolonged release products may be especially suited for this kind of study. When the FRD from nanoparticles in pH 7.4 was plotted against the FRA, a linear correlation was obtained (fig. 5).

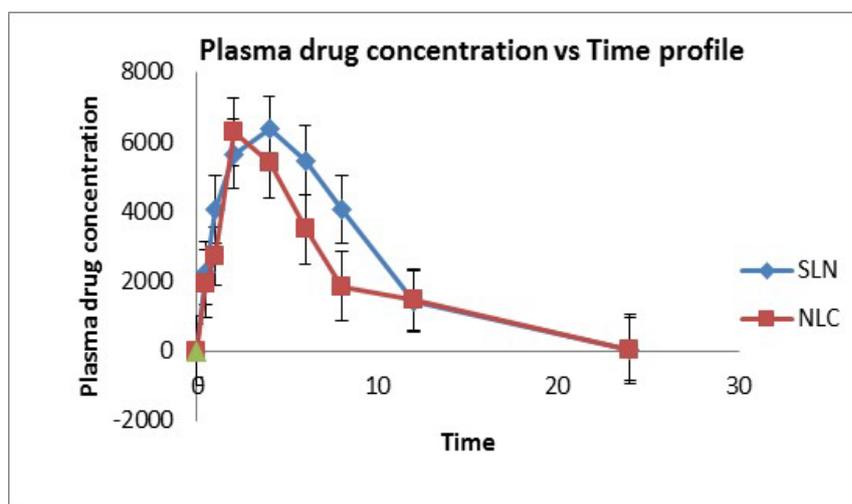


Fig 4: Mean plasma concentration versus time profile of lornoxicam following transdermal delivery of lipid nanocarrier to rats (n = 6).

Table 4: Pharmacokinetic parameters of Lornoxicam as lipid nanocarrier to healthy rabbit volunteers

Pharmacokinetic parameter	Observed value	
	SLN	NLC
Maximum plasma concentration, $C_{max}$ (ng/ml)	6381.51±971.27	8558.13±1564.08
Time required to reach maximum plasma concentration, $T_{max}$ (h)	4.00±0.00	2.00±0.00
Area under the curve, $AUC_{0-\infty}$ (ng h/ml)	19917.21±7111.24	21317.99±4568.71
Area under momentum curve, $AUMC_{0-\infty}$ (ng h <sup>2</sup> /ml)	122052.26±25847.08	124310.20±19989.26
Elimination half-life, $t_{1/2}$ (h)	7.27±1.21	6.22±2.16
Elimination rate constant, $K_{el}$ (h <sup>-1</sup> )	0.095±0.101	0.111±0.086
Mean residence time, MRT (h)	6.128±1.057	5.831±1.213

(mean±SD; n = 6). SLN: solid lipid nanoparticle formulation, NLC: nanostructured lipid carrier formulation.

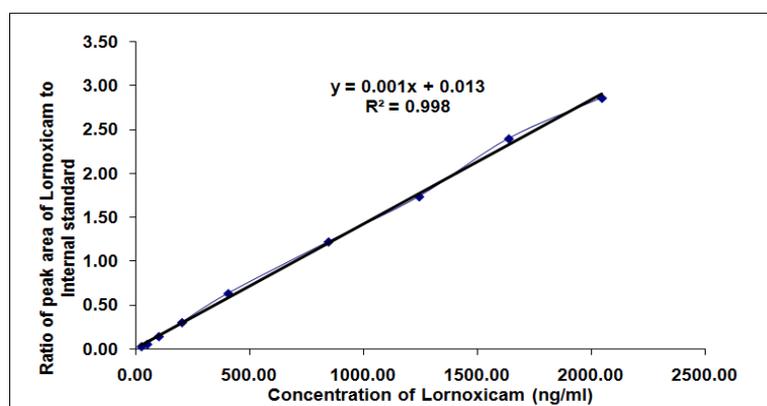


Fig. 5: Standard curve for In vitro & In vivo co-relation between LX & Internal standard VS. Conc. of LX

## DISCUSSION

To develop a suitable and robust RP-HPLC method for the determination of lornoxicam from nanoparticles different mobile phases and columns were employed to achieve the efficient separation and resolution. The result shows that within the concentration range mentioned above, there was an excellent correlation between peak area and concentration of drug [20]. The chromatogram of medium level quality control sample (i.e. 406.12 ng/ml) of LX spiked with rat plasma (fig. 3) showed a good resolution peaks for LX and IS which are well differentiated from the peaks of plasma components, which shows that the analyte peaks were pure, and there were no interferences from formulation excipients in the analyte peak. Accuracy data ranged from 94.97 % to 89.63 % for both the conditions indicated that there was no interference from endogenous plasma components [21]. Inter-day, as well as intra-day replicates of LX, resulted an RSD value less than 5.35 %, which revealed that the high degree of precision of the proposed method. The accuracy of stored samples was found to be equivalent to 100%. Hence, it can be inferred that LX was stable in rat plasma up to one month at room temperature. In the IVIVC study, a higher value of correlation coefficient suggested that a good correlation existed between *in vitro*-*in vivo* data. Finally a novel simple, simple, sensitive, precise, rapid, accurate, and economical and reliable RP-HPLC method was developed and validated for the estimation of LX in rat plasma using PDA detector. A maximum recovery of drug from plasma resulted by using acetonitrile as extracting solvent in comparison to other solvents. The results obtained proved that the method was accurate and reproducible, and drug was stable in rat plasma

## CONCLUSION

Therefore, it can be concluded that the validated chromatographic condition is suitable for determination of pharmacokinetic profile of LX in rat plasma after transdermal application of SLN and NLC on rat and is also applicable to the routine therapeutic monitoring of the LX. A linear relationship was observed between FRD and FRA in IVIVC study.

## ACKNOWLEDGEMENT

We acknowledge the financial support provided by University Grants Commission (UGC). We also acknowledge Akumbs Drugs,

Hridwar, India for supplying Lornoxicam. We also acknowledge Lipoid, GmbH Germany for supplying phospholipon 90G.

## CONFLICTS OF INTERESTS

Declared none

## REFERENCES

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**How to cite this article**

- Sandipan Dasgupta, Sanjay Dey, Paulomi Pal, Bhaskar Mazumder. RP-HPLC Method development, validation and quantification of lornoxicam in lipid nanoparticle formulations. *Int J Pharm Pharm Sci* 2016;8(11):152-158.