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Formulation and evaluation of Moxifloxacin hydrochloride ocular nanoparticles

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ABSTRACT

The objective of the present study was to prepare controlled release formulation of Moxifloxacin hydrochloride ocular nanoparticles. The nanoparticles were prepared by solvent displacement method using Eudragit RL 100 as a polymer. Different formulations were prepared by varying the ratios of drug and polymer and varying the ratios of organic and aqueous phase. The formulations were evaluated in terms of particle size, FTIR, drug entrapment efficiency and *in vitro* drug release profile was examined. The anti bacterial activity against gram positive and gram negative bacteria were determined. *In vivo* studies were carried out by Draize test. The mean particle size for drug loaded formulations was found to be below 200 nm. The zeta potential remained in the range of positive values for all batches +10 mV to +40mV. The formulation possesses good antibiotic activity against *Escherichia coli*, *Bacillus subtilus* and *Staphylococcus aureus* microorganism and no eye irritation on *in-vivo* testing.

Keywords: *Nanoparticle; Ocular; Moxifloxacin hydrochloride; Eudragit RL100.*

INTRODUCTION

Ophthalmic drug delivery is one of the most attractive and challenging areas of research in the field of formulation development. Eye is a small but complex organ. Topical application of drugs is the method of choice under most circumstances because of its convenience and safety for ophthalmic chemotherapy. The specific aim of designing such a therapeutic system is to achieve an optimal concentration of a drug at the active site for appropriate duration. Ocular disposition and elimination of a therapeutic agent is dependent upon its physicochemical properties as well as the relevant ocular anatomy and physiology. Bacterial conjunctivitis is a common type of pink eye, caused by those bacteria which infect the eye through various sources of contamination.

The bacteria can be spread through contact with an infected individual, exposure to contaminated surfaces or through other means such as sinus or ear infections. The most common types of bacteria that cause bacterial conjunctivitis include *Staphylococcus aureus*, *Haemophilus influenza*, *Streptococcus pneumoniae* and *Pseudomonas aeruginosa*. Moxifloxacin hydrochloride is an 8-methoxy fluoroquinolone having half life nearly 12 hours. Moxifloxacin is bactericidal and its mode of action depends on blocking of bacterial DNA replication by binding itself to an enzyme called DNA gyrase, which allows the untwisting required to replicate one DNA double helix into two[1-4]. Drug has 100 times higher affinity for bacterial DNA gyrase than for mammalian. Moxifloxacin is a broad-spectrum antibiotic which is active against both Gram-positive and Gram-negative bacteria. It has a broad-spectrum antibiotic activity, with efficacy against various gram-positive and gram-negative microorganisms through inhibition of DNA gyrase and topoisomerase IV and is indicated for treating bacterial conjunctivitis.

Nanoparticulate drug delivery systems have been studied for several decades now, and many of the features that make them attractive drug carriers are well known. Polymeric nanoparticle formulation is one of the strategies currently used to improve drug absorption across biological membranes [5, 6]. Nanoparticles made up of various synthetic polymers like poly lactides (PLAs), poly cyano acrylate, poly lactide co glycolide (PLGA), methyl methacrylate copolymer (Eudragit RL 100) and natural polymers like chitosan, gelatin, sodium alginate and albumin can be used effectively for efficient drug delivery to the ocular tissues [7].

Eudragit RL100 is a suitable inert carrier for ophthalmic drug delivery due to the capability to form nanodispersion with smaller particle size, positive surface charge, good stability, biocompatibility and absence of any irritant effect on the cornea, iris, and conjunctiva. Piroxicam nanoparticles for ocular delivery was prepared using Eudragit RS 100 resulted in nano- range size particles and displayed spherical smooth morphology with positively charged surface. The *in vivo* examinations revealed that the inflammation can be inhibited by the drug: polymer nanosuspension more significantly than the micro suspension of drug alone in the rabbits with endotoxin induced uveitis.

Ciprofloxacin loaded Eudragit RS100 or RL 100/ PLGA nanoparticles were prepared by w/o/w emulsification and solvent evaporation, followed by the high-pressure homogenization. The mean diameter of nanoparticles was dependent on the presence of Eudragit and on the viscosity of the organic phase. The zeta potential of all Eudragit containing nanoparticles was found to be positive (around +21/+25). Eudragit RL 100 polymeric nanoparticles have been investigated as carrier systems for the ophthalmic release of anti-inflammatory agents such as Flubriprofen, Ibuprofen and Piroxicam. Antibiotics like Gatifloxacin and Ciprofloxacin. Antifungal agent, Amphotericin B and anti-thromobolytic agent Cloricromene [8-14].

The present investigation is intended to formulate and evaluate the ocular nanoparticles of Moxifloxacin Hydrochloride using Eudragit RL 100 as polymer to increase precorneal residence time and to improve the bioavailability of drug in the treatment of bacterial conjunctivitis.

EXPERIMENTAL

Moxifloxacin hydrochloride was a kind gift from Matrix laboratories (Hyderabad, India). Eudragit RL 100 was obtained from Evonik Degussa India private limited. Poly vinyl alcohol (PVA; MW 95,000), Acetone, Dimethyl sulfoxide (DMSO), and Methanol were purchased from SD Fine Chem Ltd (Mumbai, India). Sodium chloride, sodium bicarbonate, calcium chloride dihydrate and magnesium chloride were purchased from Merck Ltd (Mumbai, India).

Preparation of nanoparticles

Moxifloxacin hydrochloride nanoparticles were prepared by Solvent displacement technique Drug (10mg) and polymer (100mg) were dissolved in organic phase consisting of acetone and methanol (3:1) by sonication. This solution was poured into aqueous phase containing 1% PVA as hydrophilic surfactant under moderate magnetic stirring [15]. The organic solvents were evaporated under reduced pressure at 65°C using Flash evaporator. The process variables involved in the

preparation of MOXI NPs were represented in Table1.

Table 1. Formulation code and variables used in the preparation of MOXI nanoparticles

Formulation code	Drug: polymer	Organic phase: aqueous phase
D1	1:2	1:2
D2	1:4	1:2
D3	1:6	1:2
D4	1:8	1:2
F1	1:10	1:2
F2	1:10	1:3
F3	1:10	1:4
F4	1:10	1:5

Evaluation of nanoparticles

- **Surface morphology**

Scanning electron microscopy (JSM-5200, Tokyo Japan) was used to analyze particle size and surface topography. The Instrument was operated at 15KV acceleration voltage. A concentrated aqueous suspension was spread over a slab and dried under vacuum. The sample was shadowed in a cathodic evaporator with a gold layer 20nm thick. Photographs were elaborated by an image processing program and individual NP diameters were measured to obtain mean particle size.

- **Particle size and zeta-potential**

Nanoparticle size distribution was determined using photon correlation spectroscopy (PCS) with Zetasizer 3000 (Malvern instruments Ltd., Malvern, Worcestershire United Kingdom). The size distribution analysis was performed at a scattering angle of 90 degrees and at a temperature of 25ºC using samples appropriately diluted with filtered water. The mean particle size Z_{avg} of each sample was determined three times and the average values were calculated.

Zeta potential values were determined by electrophoretic light scattering (ELS) using the same instrument. Nanoparticles were suspended in filtered water and diluted with water. For each preparation, three samples were injected in the capillary cell of the Zetasizer 3000 and each of them was determined 20 times. Then the average values of three replicates were calculated.

- **Drug polymer interaction**

Fourier transform infrared analysis (FT-IR) was conducted to verify the possibility of interaction of chemical bonds between drug and polymer. Moxifloxacin hydrochloride nanoparticles FT-IR transmission spectra were obtained using a FT-IR-8300 spectrophotometer (Shimadzu, Tokyo, Japan). A total of 2% (w/w) of sample, with respect to the potassium bromide (KBr; S.D. Fine Chem Ltd., Mumbai, India) disc, was mixed with dry KBr. The mixture was ground into fine powder using an agate mortar before compressing into KBr disc under a hydraulic press at 10,000 psi. Each KBr disc was scanned at 4 mm/s at a resolution of 2 cm over a wave number in the region of 400–4000 cm^{-1} using IR solution software (ver.1.10). The characteristic peaks were recorded for different samples.

- **Determination of drug entrapment efficiency**

One milliliter of formulation was taken and dissolved in a minimum quantity of DMSO. This solution was centrifuged at 13,000 rpm for 20 minutes. One milliliter of supernatant was taken and adjusted to 10 mL with methanol: water (1:1vol/vol) system. From this stock solution, again 1 mL solution was withdrawn and adjusted to 10 mL. The solution was analyzed spectrometrically at 296 nm. Each experiment was repeated in triplicate. Percentage drug entrapment was determined by the following formula:

$$\text{Drug entrapment efficiency} = \frac{\text{Amount of MOXI actually present in nanoparticles}}{\text{Amount of MOXI actually used}} \times 100$$

- **In-vitro drug release profile**

Moxifloxacin hydrochloride release from NPs was evaluated using Franz diffusion cells, using dialysis membrane with a molecular weight cutoff 12,000 to 14,000Da which separated the acceptor from the donor compartment, consisting of 20 mL of formulation. The acceptor compartment was filled with 20 mL Simulated Tear

Fluid (STF) and stirred magnetically at 200 rpm. The temperature was maintained at 37 ± 0.5°C. At regular time intervals within 24hours, samples of 5 mL were withdrawn from the acceptor compartment and replaced by the same volume of fresh STF solution. The samples were analyzed spectrometrically at 296 nm.

- **Drug-release kinetics**

To study the release kinetics, data obtained from in vitro drug-release studies was plotted in various kinetic models: zero order (Eq. 1) as cumulative amount of drug released versus time, first order (Eq. 2) as log cumulative percentage of drug remaining versus time, and Higuchi's model (Eq. 3) as cumulative percentage of drug released versus square root of time:

$$Q = K_0 t \quad (1)$$

Where K_0 is the zero-order rate constant expressed in units of concentration/time, and t is the time in hours. A graph of concentration versus time would yield a straight line with a slope equal to K_0 and intercept the origin of the axes.

$$\log Q = \log Q_0 - k_1 t/2.303 \quad (2)$$

Where Q_0 is the initial amount of drug, k_1 is the first-order constant, and t is the time.

$$Q = K_H \sqrt{t} \quad (3)$$

Where K_H is the constant reflecting the design variables of the system and t is the time in hours. Hence, drug-release rate is proportional to the reciprocal of the square root of time.

- **Microbial studies**

The microbial studies ascertained the biological activity of the optimized formulation and of the marketed eye drops (Moxicip eye drops mfg. by Cipla pvt ltd.) against *Bacillus subtilus* (NCIM 2063), *Escherichia coli* (NCIM 2563), and *Staphylococcus aureus* (NCIM 2079) microorganisms. Microbiological studies were performed by standard paper disk diffusion method.

Nutrient agar (20 mL) seeded with the above test microorganism (0.2 mL) was allowed to solidify in the Petri plate. Paper disk (Watt man filter no. 40, diameter of 4mm), which were soaked in an antibiotic solution were carefully placed on the surface of agar at suitable distance with the help of sterile pointed forceps. Then the plates were incubated in incubator at 37^0C for 24 hours. The zones of inhibition were obtained. The diameter of the zone of inhibition was measured by an antibiotic zone finder. Readings were taken in triplicate.

- **Sterility Test**

The sterility test was performed according to Indian Pharmacopoeia. Direct inoculation method was used. 2 ml of liquid from test container was removed with a sterile pipette or with a sterile syringe or a needle. The test liquid was aseptically transferred to the fluid thioglycollate medium (20 ml) and soybean-casein digest medium (20 ml) separately. The liquid was mixed with the media. The inoculated media were incubated for 14 days at 30ºC to 35ºC in the case of fluid thioglycollate medium and 20ºC to 25ºC in the case of soybean-casein digest medium.

- **In-vivo test**

NPs containing, Moxifloxacin hydrochloride as an active ingredient were prepared, and their eye-irritating effects were evaluated by Draize test. Six New Zealand albino rabbits (average body weight, 2 kg) of either sex were used in the experiment. The animal studies were performed after due approval from the institutional ethical committee (vide protocol no. SVCP /IAEC/2011/10).The animals were housed and fed in accordance with CPCSEA guidelines.

Test substance (0.01 mL) was instilled directly to the cornea in the right eye every2.5hrs through a period of 7.5 hrs per day for three successive days. Left eyes served as control and were left untreated. After 1 and 24 hr from the last instillation, eyes were examined. The cornea, iris, conjunctiva and anterior chamber were inspected for any inflammation. The corneal opacity, iritis, conjunctival redness was graded on a scale from 0 to 4, 0 to 2, and 0 to 3, respectively.

- **Stability studies**

Optimized formulation F1 was subjected to the stability studies at 4ºC, ambient temperature and 37º C±2ºC/65% ± 5%RH for a

period of one month. The samples were withdrawn after one month and *in vitro* drug release studies were carried out and analyzed spectrophotometrically by UV at 296nm.

RESULTS AND DISCUSSION

Surface Morphology

SEM micrographs of optimized Eudragit RL 100 ocular nanoparticles formulation under 750X magnification and 1000X magnification were shown in Figure1. SEM micrographs of Moxifloxacin hydrochloride ocular nanoparticles formulation showed the smooth surfaced nanoparticles with spherical shape and uniformly distributed.

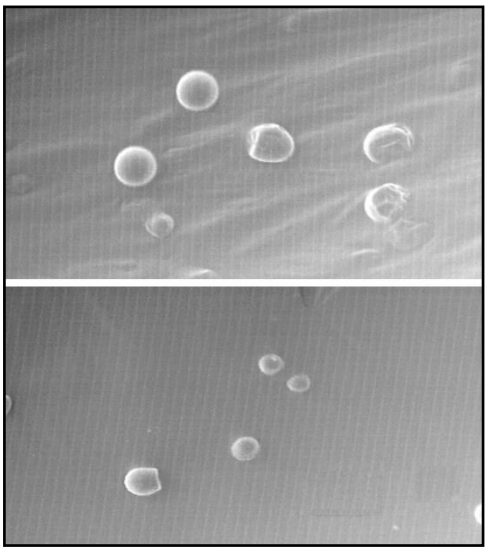

Fig. 1. SEM micrographs of MOXI nanoparticles

Particle Size and Zeta potential

All the formulations showed a small mean size, well suited for ocular administration and provided a good drug diffusional release. Particle size for ophthalmic applications should not exceed 10 µm because with larger sizes a scratching feeling might occur [16]. Reduced particle size improves the patient comfort. The effect of drug: polymer ratio and organic phase: aqueous phase ratio has an immense effect on particle size and distribution. A size increase from 155 to 197 nm was measured. The results were shown in Table 2. Increase in drug: polymer ratio increased particle size proportionately. Increase in aqueous phase volume decreases the particle size due to the increased diffusion of the water-soluble solvent (acetone) in the aqueous phase. Thus, larger particle size was obtained for formulations containing more polymer and less aqueous phase.

The zeta potential values for Moxifloxacin containing nanoparticles were remained in the range of positive values for all batches (+10mV to + 40mV). The positive surface charge of the nanoparticles was observed due to the presence of the quaternary ammonium groups of Eudragit RL100.A positive charge can facilitate an effective adhesion to the cornea surface and account for a strong interaction with the negatively charged mucosa of the conjunctiva and anionic mucin present in the tear film, prolonging the effective residence time of the formulation [17].

Fourier Transform Infrared Analysis (FTIR)

Fourier transform infrared analysis was conducted to verify the possibility of interaction of chemical bonds between drug and polymer. In the present investigation, FTIR spectra of pure drug, polymer and drug loaded formulation of Eudragit RL 100 nanoparticles were analyzed using FT-IR spectrophotometer for characteristic absorption bands, indicative of their interaction.(Figure 2) There was no interaction found between drug and polymer.

Determination of drug entrapment efficiency

The drug entrapment efficiency varied from 60% to 80% for the formulations prepared as shown in Figure 3. The entrapment efficiency was affected by drug: polymer ratio and organic phase (solvent): aqueous phase (non solvent) ratio. The entrapment efficiency was found to vary with drug and polymer ratio for both batches. It was observed that increase in polymer concentration in organic phase increases drug entrapment due to increase in organic phase viscosity. This might have increased the diffusional resistance to drug molecules from organic phase to aqueous phase, thereby entrapping more drugs in the polymer NPs. It is also found that the drug entrapment depends on organic phase and aqueous phase volume ratio. The change in phase volume ratio changed the entrapment efficiency. This may be attributed to solvent-drug interaction.

Table 2. Mean particle size, poly dispersity index and zeta potential values of all MOXI nanoparticle formulations.

Formulation code	Drug: polymer	Organic: aqueous	Particle size (nm)	Poly Dispersity Index	Zeta Potential (mv)
D1	1:2	1:2	155.2±0.8	0.476±0.07	+10.16±1.1
D2	1:4	1:2	169.4±1.8	0.398±0.02	+13.5 ±1.8
D3	1:6	1:2	165.6±1.1	0.359±0.03	+18.2 ±1.3
D4	1:8	1:2	171.2±1.4	0.325±0.05	+20.6 ±0.8
F1	1:10	1:2	184.3±1.2	0.267±0.08	+24.1±1.4
F2	1:10	1:3	188.5±0.9	0.346±0.03	+30.3±1.1
F3	1:10	1:4	193.2±1.5	0.432±0.07	+38.6±1.5
F4	1:10	1:5	197.3±1.6	0.567±0.02	+39.9±1.8

Values are mean ± SD (n=3).

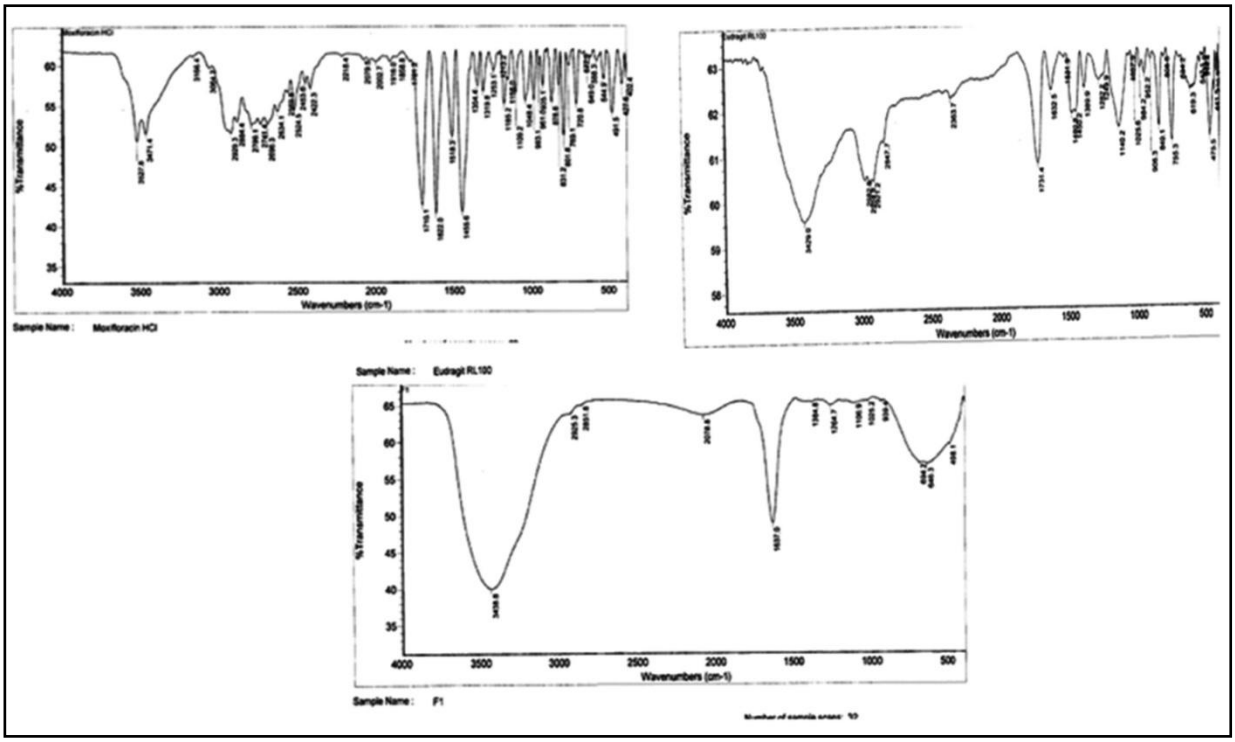

Fig. 2. FTIR spectra of MOXI pure drug, polymer and drug loaded formulation

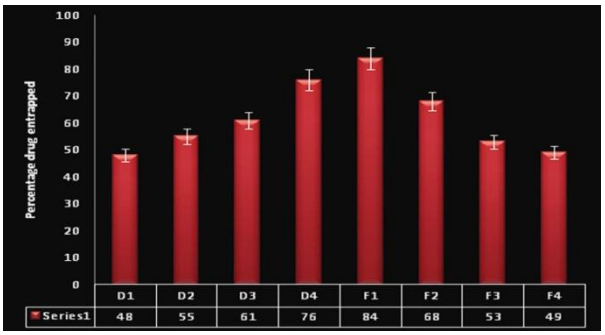

Fig. 3. Drug entrapment efficiency of nanoparticles

In-vitro drug release studies

The data of *in-vitro* release studies as shown in table 3 suggest an initial fast release which may be attributed to the unentrapped drug adsorbed on the surface of the nanoparticles. The release rate was found to be influenced by drug: polymer ratio. Increase of drug release was observed as a function of drug: polymer ratio. Such a finding can be related to the progressive saturation of the polymer ammonium group by drug molecule occurring at higher drug: polymer ratio, which increases the dissolutive nature of drug release In general, all NP formulations showed a prolonged release; no burst effect was observed.

Mechanism of Drug Release

The mechanism of release of Moxifloxacin hydrochloride nanoparticles was studied by treating the release data to zero order, first order, Higuchi and Peppas. It was found that *In-vitro* drug release was best explained by Higuchi's equation, as the plots showed the highest linearity (r^2 = 0.995), followed by first order (r^2 = 0.958) and zero order (r^2= 0.779). Log cumulative percentage of drug release versus log time curves shows high linearity, and it proves that the formulation follows the Korsmeyer-Peppas model and drug release through fickian diffusion.

Table. 3. *In-vitro* drug release studies of all MOXI nanoparticle formulations in Simulated Tear Fluid.

Cumulative drug release								
Time(hrs)	**D1**	**D1**	**D2**	**D3**	**F1**	**F2**	**F3**	**F4**
1	19.17	20.03	20.58	20.87	25.48	22.66	21.54	21.06
2	24.41	26.81	27.63	28.03	38.55	34.85	32.08	31.51
4	36.22	39.99	42.39	43.23	57.58	49.98	45.23	43.97
6	48.18	51.76	52.1	54.34	65.9	62.09	59.75	56.47
8	50.81	54.98	55.74	58.42	74.5	66.34	64.78	60.94
12	56.47	58.76	60.25	62.56	77.75	68.59	66.83	64.71
16	62.81	63.63	66.7	68.38	78.71	72.67	71.53	70.73
18	64.48	68.77	69.09	70.32	80.01	76.42	74.31	72.46
24	67.37	70.51	70.58	72.94	81.56	78.36	74.98	73.65

Microbial studies

The optimized F1 nanoparticulate formulation was tested microbiologically by paper disc diffusion technique. F1 formulation was compared with marketed eye drops. Clear zones of inhibition were obtained. Results revealed prolonged microbial efficacy of developed F1 Moxifloxacin hydrochloride nanoparticles compared with marketed eye drops. The results were shown in the Figure 4.

Sterility test

No turbidity was observed and indicating absence of microbial growth when the formulations were incubated for 14 days at 30ºC- 35ºC in case of fluid thioglycollate medium and at 20ºC - 25ºC in the case of soybean-casein digest medium. The preparations were examined and found to pass the test for sterility.

***In-vivo* studies (Draize Eye Test)**

The results of the ocular irritation studies indicated that optimized F1formulation containing Moxifloxacin hydrochloride nanoparticles were non-irritant. Excellent ocular tolerance was noticed for all the formulation. No ocular damage or abnormal clinical signs to the cornea, iris or Conjunctiva was visible. No signs of redness, watering of the eye and swelling were observed throughout the study with the MOXI nanoparticles.

Stability Studies

The results of stability studies indicate that, the most suitable storage condition for nanoparticles of Moxifloxacin hydrochloride was 4ºC followed by ambient temperature and 37°C±2°C/65% ± 5%RH.

CONCLUSION

In the present study, attempts were made to prepare sustained release of Moxifloxacin hydrochloride ocular nanoparticles using solvent displacement technique using Eudragit RL 100 as release retarding polymer and evaluated parameters like, rheological studies, drug entrapment efficiency, *In-vitro* drug release, microbial studies, sterility testing and *in vivo* studies. Nanoparticles were characterized by particle size, zeta potential and surface morphology. Formulation containing variable such as, different drug: polymer ratios and different solvents ratios (organic phase: aqueous phase) were prepared and treated for different kinetic models of drug release. Stability studies were performed according to ICH guide lines.

Optimized Moxifloxacin hydrochloride Nanoparticles possess

- Good ocular retention property due to unique particle size.
- Particle size, poly dispersity index and zeta potential values were found to be suitable for ocular administration.
- The drug entrapment efficiency increased as the polymer concentration was increased.
- The *in vitro* release studies suggest that release rate was related to drug: polymer ratio. Increase of drug release was observed as a function of drug: polymer ratio.
- Microbial studies suggest that prepared Nanoparticles were effective in the treatment of bacterial infections.
- *In vivo* studies were performed on New Zealand albino rabbits. No ocular damage or abnormal clinical signs to the cornea, iris or Conjunctiva was visible. No signs of redness, watering of the eye and swelling were observed throughout the study.

The results of stability studies indicate that, the most suitable storage condition for nanoparticles of Moxifloxacin hydrochloride was at 4ºC.

REFERENCES

[1] Zhanel, G.G., & Noreddin, A.M. (2001). Pharmacokinetics and pharmacodynamics of the new fluoroquinolones: focus on respiratory infections. *Current Opinion in Pharmacology*, 1(5), 459–63.

[2] Hwang, D.G. (2004). Fluoroquinolone resistance in ophthalmology and the potential role for newer ophthalmic fluoroquinolones. *Survey of Ophthalmology*, 49(Suppl 2), S79–83.

[3] Mah, F.S. (2004). Fourth-generation fluoroquinolones: new topical agents in the war on ocular bacterial infections. *Current Opinion In Ophthalmology*, 15, 316–20.

[4] Van Bambeke, F., Michot, J.M., Van Eldere, J., & Tulkenes, P.M. (2005). Quinolones in 2005: an update. *Clinical Microbiology and Infection*, 11, 256–280.

[5] Mainardes, R.M., Urban, M.C., Cinto, P.O., Khalil, N.M., Chaud, M.V., Evangelista, R.C., & Gremiao MP. (2005). Colloidal carriers for ophthalmic drug delivery. *Curr Drug Targets*, 6(3), 363-71.

[6] P. Srinivas, & G. Mounika (2011). Nanomedicine: The role of newer drug delivery technologies in cancer. *International Journal of Nano Dimension* ,2(1),1-15.

[7] Sanjeeb, S.K., Fahima, D., & Krishnakumar S. (2008). Nanotechnology in ocular drug delivery. *Drug Discovery Today*, 13(3/4), 144-151.

[8] Pignatello, R., Bucolo, C., Spedalieri, G., Maltese, A., & Puglisi G. (2002). Flubriprofen-loaded acrylate polymer nanosuspensions for ophthalmic application. *Biomaterials*, 23, 3247-55.

[9] Pignatello, R., Bucolo, C., Ferrara, P., Maltese, A., Puleo, A., & Puglisi G. (2002). Eudragit RS100 nanosuspensions for the ophthalmic controlled delivery of ibuprofen. *European Journal of Pharmaceutical Sciences*, 16, 53-61.

[10] Kathleen, D., Jo, V., Guy, V.M.,& Annick, L. (2006). Evaluation of ciprofloxacin-loaded Eudragit RS100 or RL100/PLGA nanoparticles. *International Journal of Pharmaceutics*, 314(1), 72–82**.**

[11] Howida, K. I., Iman, S E-L., & Amna, A. M. (2010). Mucoadhesive Nanoparticles as Carrier Systems for Prolonged Ocular Delivery of Gatifloxacin/ Prednisolone Biotherapy. *Molecular Pharmaceutics*, 7(2), 576–585.

[12] Khosro, A., Mohammad, R.S.S., Ali, N., Alireza, J., Mohammad, B-J., et al. (2007). Piroxicam nanoparticles for ocular delivery: physicochemical characterization and implementation in endotoxin-induced uveitis. *Journal of Drug Targeting*, 15(6), 407–416.

[13] Pignatello, R., Ricupero, N., Bucolo, C., Maugeri, F., Maltese, A., & Puglisi, G. (2006). Preparation and characterization of Eudragit retard Nanosuspensions for the ocular delivery of cloricromene. *AAPS Pharm Sci Tech*, 7(1), E27.

[14] Swarnali, D., Preeti, K., Suresh., & Rohitas, D. (2010). Design of Eudragit RL 100 nanoparticles by nanoprecipitation method for ocular drug delivery. *Nanomedicine: Nanotechnology, Biology, and Medicine*, 6(2), 318–323.

[15] Fessi, H., Puisieux, F., Devissaguet, J.P., Ammoury, N., & Benita, S. (1989). Nanocapsule formation by interfacial polymer deposition following solvent displacement. *Int J Pharm*, 55, R1-4.

[16] Zimmer, A., & Kreuter, J., (1995). Microspheres and nanoparticles used in ocular delivery systems. Advanced Drug Delivery, 16, 61–73.

[17] Ubrich, N., Schmidt, C., Bodmeier, R., Hoffman, M & Maincent, P. (2005). Oral evaluation in rabbits of cyclosporine-loaded Eudragit RS or RL nanoparticles. *International Journal of Pharmaceutics*, 288,169–175.

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