International Journal of Students' Research In Technology & Management
ISSN 2321-2543, Vol 5, No 3, September 2017, pp 01-08
https://doi.org/10.18510/ijsrtm.2017.531

FORMULATION OF *IN SITU* GELLING SYSTEM FOR OPHTHALMIC DELIVERY OF ERYTHROMYCIN

ReeshanteniBalasingam*, Abdullah Khan, Rajermani Thinakaran
Undergraduate student, School of Pharmacy, KPJ Healthcare University College,
Lot PT 17010, Kota Seriemas, 71800 Nilai, Negeri Sembilan.
Email:reeshabala@gmail.com

Article History: Received on 15th June 2017, Revised on 2nd July 2017, Published on 7th September 2017

Abstract - Eye is a unique organ which exerts various limitations for the delivery of drug due to its physiology barriers. Therefore, the posterior part of the eyes remains a major concern for formulation scientists to develop ocular drug delivery system which can overcome the barriers of theeye and provide local or systemic effect with immediate or sustained release dosage forms. Conventional ophthalmic dosage forms such as eye drop, ointment and gel provide low bioavailability and less pre-corneal drug residence time due to nasolacrimal drainage of the eyes. The major challenge is to formulate a system to improve the contact time of the drug in eyes. This is achieved by *in situ* gel system where the drugs are incorporatedwith various types of polymers which exhibit solution to gel phase transition. An *in situ* gelling technique provides greater bioavailability by resisting ocular drainage leading to longer residence time. This paper proposes the formulation of *in situ* gels for effective delivery of Erythromycin used to treat conjunctivitis and to evaluate dosage form characteristic such as pH, gelling capacity, gel strength, sterility testing, drug content, *in vitro* diffusion study, antibacterial activity and accelerated stability studies to ensure the safety and stability of the dosage form. Hence an attempt will be made to develop novel *in situ* gelling systems using Erythromycin, antimicrobial agent as a promising alternative to the conventional dosage forms for the effective treatment of various eye infections.

Keywords--*In situ* gel; ophthalmic; conjunctivitis; Erythromycin.

I. INTRODUCTION

The eye is a complex sensory organ design differently from other organs from its anatomy and physiology point of view. Unique anatomical and physiological features of eye make it impermeable to foreign particles.There are various dosage forms for ocular drug delivery but due to strong protective mechanism and barriers exerted by the eyes the ocular drug absorption and penetration especially into the posterior part of the eyes in desired therapeutic concentrations is not achieved successfully.

The cornea of the eye (Figure 1)iscomposed of the epithelium, endothelium, and inner stromawhichactas the main barrier for the ocular absorption of drugs. The outer epithelium layer acts as a barrier for the penetration of hydrophilic drug whilethe inner stroma act as a barrier for the drugs which is hydrophobic.The lipophilic –hydrophilic- lipophilic nature of the tissues contributes to poor corneal penetration and permeability of drugs.Secretion of lachrymal fluids and blinking actionarethe natural mechanisms that prevent eyes from drying and eliminate all foreign substances being introduced into the conjunctival sac.A thusonly small portion of the installed drug will be delivered to the anterior segment of the eyes whereas most of it will be lost because of spillage and drainage through the nasolacrimal duct.

Lisa (2015)stated thatonlyless than 5% intraocular bioavailability is achieved by the common topical ophthalmic dosage forms. Therefore, the major challenge for the formulator is to develop an ophthalmic novel drug delivery system without damaging the natural mechanism and barriers of the eyes at the same time achieving effective ocular drug concentration at the site of action while improving the residence time of the drugs in eyes.

II. LIMITATIONS OF CONVENTIONAL OCULAR DOSAGE FORMS

Commonly the conventional ophthalmic drug delivery system is available in the form of eye drops, ointment, suspension and ocular inserts. Eye drops are mostly being prescribed out of all marketed ocular preparation; in fact, almost 90% of the ophthalmic formulations are available in the form of eye drops (Sampath*etal.*,2012). Eye drops are relatively easy to be introduced into the eyes for various eye diseases. Howeverelimination and rapid spillage of the drug from the precorneal area of the eyes upon installation due to nasolacrimal drainage leads to poor bioavailability and low therapeutic effect of the drug.Repeatedinstallation of high concentration drug will result in several side effects and damage the eye tissues. Frequent blinking of the eyes also drains out the drug at a higher rate.

GouravRajoriaand ArushiGupta(2012) claimed that the topical ophthalmic medication only absorbs approximately 5 to 7 minutes upon installation into the eyes and mostly not more than 2% of the medication is being absorbed and results in low bioavailability. Eye ointments are the next most popular preparations which increasecontact time of the drug in eyes but has some limitations such as greasy preparation and sticking of the eyelids which lead to low patient compliance, occasional irritation, discomfort and blurred vision. Conversely, the advanced ocular delivery system such as ocular inserts provides prolonged action dosage form but not widely accepted by patients because need to be inserted into the eyes, thushave low patient compliance. Other dosage forms, benefits, and drawbacks of conventional ophthalmic dosage forms are summarised in Table 1.

III. *IN SITU* DRUG DELIVERY SYSTEM

A novel drug delivery system with the use of natural or synthetic polymers that undergoes phase transition from solution to gel upon insertion into the cul-de-sac due to the response of the physiochemicalnature of the ophthalmic fluids (GouravRajoria and Arushi Gupta,2012). Gelation is triggered by few parameters such as pH, temperature, solvent exchange and ions which will form achemical or psychical cross linking between the polymeric materials used resulting in the formation of gel. The gel formed must be able to withstand the shear forces in the cul-de-sacandmust be less affected by corneal drainage. The gel forming polymers act as rate controlling polymers which demonstrate prolonged drug release and improve theocular bioavailability of the drug (Mane Kirti and Dhole Shashikant, 2014).There are no limitations reported by any researcher on the *in situ*gels as drug delivery system however, thehigh viscosity of the gel may cause blurred vision compared to the conventional ocular dosage forms. Therefore, the primary objective of the proposed study is to develop an antibacterial *in situ* ophthalmic gel as a less viscous free flowing fluid to overcome this problem.Erythromycin is a wide spectrum antibiotic under macrolide group of antibiotics which is commonly used as alternatives to patients having allergy to penicillin. Erythromycin is used to treat ocular bacterial infections such as trachoma and conjunctivitiscaused by *Staphylococcus aureus, Chlamydia trachomatis and Neisseriagonorrhoeae.* Erythromycin inhibits the cell membrane of the bacteria by reversibly binding to 50s subunit of ribosome without damaging the nuclei acid synthesis (KaulShweta*et al.*,2012).This drug is stable and well established based on the pharmacological studies and available as 0.5% ophthalmic ointment in the market. Thus, the present study was aimed at developing an *in situ* gelling system for the effective delivery of Erythromycin with increased bioavailability through prolonged contact time.

IV. BENEFITS OF *IN SITU* DRUG DELIVERY SYSTEM

Compared to other ocular dosage forms, *in situ* drug delivery system has numerous benefits over the conventional ophthalmic dosage forms such as promotes bioavailability, less affected by nasolacrimal drainage thereby reduces absorption into the eye tissues and prevents thesystemic adverse effect. This novel drug delivery system combines both solution and gel which ease the introduction of formulation into the eyes and increases patient compliance (Figure 2).Furthermore, reduces thefrequency of dosing as the *in situ* gel retains the contact time of drug in the eye and effective therapeutic will be achieved. According toHimanshu Gupta et al.,(2015) the plain eye drop of Sparfloxacineliminated out quickly from the corneal surface of the eye compared to the Sparfloxacin developed as *in situ* gel formulation which showed sustained release of drug for a longer period and enhanced bioavailability (Figure 3).

V. APPROACHES FOR *IN SITU*DELIVERY SYSTEM

In situ gel formulation will be developed as less viscous free flowing liquid when exposing to the stimuli's, solution converts into aviscoelastic gel. Various approaches for achieving *in situ* gelling systemarepHdependent system, ion dependentsystem, and temperature dependentsystem. Formulations based on the different approaches are:

A. pH dependent system

The pH changes trigger the formation of the solution to get such systems are formulated using pH sensitive polymers. When the sterile solutions are exposed to the pH of the eyes it undergoes aphase transition from solution to gel. Example of pH dependent polymers are Carbopol or Carbomer its derivatives. As the external pH increases the hydrogel swells and convert to form gel.

B. Temperature dependent system

Thermal dependent system is a great approach of thegelling system because the gelling is achieved without any great difficulties and easy to control. The mechanism of gelation occurs as the external temperature increases, the polymers undergo desolvation, increases micellar aggregation and increases polymeric network entanglement to form a highly viscous gel. Temperature sensitive polymers are Poloxamer ,Chitosan and Hydroxypropyl Methyl Cellulose (HPMC).

C. Ion dependent system

Phase transitions from solution to gel occur when exposed to the changes by ionic strength. Gelation is triggered when the anionic polymers comes in contact with the cations present in the tear fluid, interaction takesplace, and it converts to form gel.

Gelrite and Sodium Alginate are the examples of ion sensitive polymers.Figure 4 shows the development of *in situ* gel based on the ion dependent system, where the gellan gum (gelrite) undergoes aphase transition from solution to gel when in contact with artificial tear fluid.

Following are the various approaches as reported in the literature.

- Eaga Chandra Mohan *et al.*, (2009) prepared and evaluated *in situ* gel for Ciprofloxacin, an antibacterial agent for the treatment of ocular bacterial infections.
- Such as dacryocystitis, bacterial conjunctivitis, corneal ulceration and blepharitis by using 3 different polymers which are pH-triggered, temperature reversible and ion activated *in situ*gellation. Carbopol 940 in combination with HPMC, Pluronic F-127 (14%) in combination of HPMC (1.5%) and Gellan gum was used as different approaches in thegelling system. Formulation obtained was stable, non irritant, therapeutically effective and provide sustained release of the drug for 6 hours. Thus, the developed system can be a replacement for conventional eye drops.
- SindhuAbraham*et al.*, (2009) prepared and characterized ion-activated *in situ* gel with antibacterial agent, Ofloxacin. Polymers used were sodium alginate in combination with HPC (Hydroxy Propyl Cellulose). *In vitro*drugrelease, studies showed that Alginate or HPC solution alone was poor in retaining the drug compared to the alginate/HPC solution which showed theoptimum result. The formulated *in situ* gel achieved prolong drug release over a period of 8 hours, reduced frequency of drug administration, improved patient compliance and can be served as analternative to the conventional ophthalmic drops, economically and industrially orientated.
- Yuejiang Liu*et al.*, (2010)designed ion-activated *in situ* gelling system for ophthalmic delivery of marine. Gelrite, alginate and gelrite / alginate was used and evaluated for rheological properties. Excellent gel strength was achieved by the mixture of 0.2% Gelrite and 0.6% alginate solutions which provide a better capability to retain drug in both *in vitro* release and *in vivo* pharmacological studies. The tested formulation was found to be non-irritant in the ocular irritancy test. The authors concluded that gelrite/alginate mixture can be used as an *in situ* gelling vehicle to enhance ocular retention.
- Kavitha and Rajas (2011) developed controlled release *in situ* ophthalmic gels of Levofloxacin hemihydrates by using gelrite for the treatment of various ocular bacterial infections. Six different *in situ* gelswere prepared by dispersing gelrite with increasing polymeric concentration. The *in situ* gel was tested for clarity, pH, drug content, sterility test, gelling property, rheological studies, ocular testing and *in vitro* drug release studies. The developed formulation showed sustained drug release for 8 hours,optimumuniformity, and spreadability. The formulation was found to be improved bioavailability and increased pre-corneal drug residence time.
- Abdullah Khan *et al.*, (2013) designed *in situ* gelling system for Gatifloxacin, an antibacterial agent using hydroxypropyl cellulose and sodium alginate as the polymers to increase the pre-corneal resident time andophthalmic bioavailability of the drug. The designed *in situ* gel was evaluated for various physical parameters such as pH, viscosity, drug content, clarity, sterility, and *in vitro* drug release. They observed the formulated gel was transparent, good spreadability, pH range of 6.8 to 7.1 and uniform in consistency.

Result found was increased in the concentration of the polymer sodium alginate, therefore sustained drug release from the formulation for up to 12 hours. Thus the formulation of ophthalmic *in situ* gel for Gatifloxacin improves the bioavailability of the drugs on the precorneal area.

- Bhatia *et al.*, (2013)developed*in situ* gels based on thermo-reversible poloxamer 407 polymeralong with different mucoadhesive polymers such as sodium carboxy methyl cellulose (Na CMC), HPMC K100Lvp, and polyvinyl pyrrolidone (PVP) K30. Cold method was used to formulate the thermo-reversible mucoadhesive gels of Azithromycin. The *in situ* gels were evaluated for ocular irritation, sterility, stability, antimicrobial activity and *in vivo*corneal permeation studies. They found that the *in situ* gel can be safely installed into the eye without any adverse effects; enhance stability and good antibacterial activity compared to the marketed formulation of Azithromycin.
- Rathod and Patel (2013) designed and testedion sensitive *in situ* gelling system for antibacterial agent Norfloxacin, by using Sodium alginate in combination with Hydroxypropyl Methyl Cellulose (HPMC K4M) which acted as a viscosity enhancing agent and gelling agent. The formulated gel was tested for viscosity, gelling capacity, antimicrobial activity, stability testing, *in vitro* drug release, ocular irritation, clarity, pH and drug content. The evaluation result obtained was satisfactory and developed was found to be therapeutically effective, stable, non-irritant, and provided prolong drug release. The authors concluded that the prepared formulation can be a viable alternative to conventional eye drops.
- Reddy and Ahmed (2013) formulated pH based ocular *in situ*gelling systems with Sparfloxacinby utilizing HPMC and carbopol as the gelling agents. The developed gel was examined for drug content, gelling strength, clarity, viscosity, *in vitro* drug release study and *in vivo* using animal models for antibacterial properties. The results obtained were optimum and formulated *in situ* gel can be designed to improve patient compliance and

as substitute to the marketed conventional drug delivery system.

D. Designing In Situ gelling System Of Erythromycin

In this research, *in situ*drug delivery system will developed based of 2 approaches namely ion dependentand temperature dependentsystem using polymers such as Chitosan, Sodium Alginate and Hydroxypropyl Methyl Cellulose (HPMC). Drug and polymers along with the excipients will be characterized for their identity and purity.

The polymeric solution will be prepared by dispersing Chitosan, Sodium Alginate and HPMC into the solvent at various compositions by continuous stirring using amagnetic stirrer to prevent excessive formation of lumps. Erythromycin powder (0.5% w/v) will be dissolved in diluted acetic acid and phosphate buffers 0.1 N NaOH will be used to adjust the pH 6.5.Benzalkonium chloride (0.02% v/v) will be added to the solution as preservative agent. Thus, the drug Erythromycin will be incorporatedwith the various polymeric solutionsand purified water will beadded to make up the final volume to 100ml under constant stirring to obtain uniform solutions. The prepared solution will be filtered using 0.2m filter paper and sterilized in anautoclave at 121°C and 15 psi for 15 minutes (Abdul Malik and Satyananda,2014).

VI. EVALUATION OF *IN* SITU GELLING SYSTEM

The followings are the evaluation parameters for Erythromycin in situ gel formulation:

- Visual appearance and clarity: The prepared gel formulationswill be checked for clarity and appearance by rotating the solution in a glass vial and inverted under the light behind the black and white background to test for its colour, odour and inverted twice to detect any presence of suspended particulate (Abdullah Khan et al.,2013).
- pH measurement: pH of the formulations will be measured using digital pH meter.
- Gelling capacity: Determination of in *vitro* gelation is vital to identify the prepared formulation are ideal to be used as *in situ* gels. Gelling will be determined by placing a drop of the polymeric solution incorporated with thedrug in different ratios into the 1ml freshly prepared artificial tear fluid which is calibrated at 34°C to trigger gelation.The time taken for the solution to convert into gel and formed gel to dissolve will be measured (Abdul Malik and Satyananda, 2014).
- Rheological property: Viscosity is a significant element to determine the sustained release of the drug in the eyes. The Erythromycin solution will be placed in the prepared artificial tear fluid and allowed to form gel. Then, the formed gel will be testfor viscosity by using Brooke field viscometer RVT model (SindhuAbraham et al.,2009).
- Sterility study:Sterility parameter is an important key of evaluation because ocular preparations are intended to be sterile dosage forms. The test for sterility will be carried out aseptically according to British Pharmacopoeia by inoculating 2ml of the sample formulation to fluid thioglycolate medium (20ml) and soyabean casein digest medium (20ml). Both mediums will be incubated for 14 days, fluid thioglycolate medium at 30-35°C and soyabean casein digest medium incubated at 20-25°C to identify the culture of anaerobic and aerobic microbial growth (Abdullah Khan et al.,2013).
- Stability study: Prepared sample will be subjected to stability studies, stored at anaccelerated temperature such as 40°C ± 1.0°C and 75% RH to evaluate the end of storage period for clarity, viscosity, pH,drug content,gelling capacity and *in vitro*drug release (Mahesh NS and Manjula BP, 2012).
- *In vitro* drug release study: *In vitro* drug release of Erythromycin will be determined by diffusion technique using the classical laboratory method with simple modifications of theopen ended glass tube. A cellophane membrane is tied to the open end of the cylinder which resembles as donor compartment. 1ml of the prepared formulation will be placed in the donor compartment over the diffusion cellophane membrane which will be pre soaked in the diffusion medium. The diffusion cellophane membrane act as eye tissues where the diffusion of the drug take place and the entire surface of the membrane will be kept in contact with receptor compartment containing 25ml of artificial tear fluid in 100ml beaker. The medium in the receptor compartment is stirred continuously with amagnetic stirrer and maintained at 37°C to ensure the medium touches the membrane constantly. 1ml of thesample from the receptor compartment will be withdrawn to analyze the drug content using UV Spectrophotometer at 285nm.The liquid withdrawn will be replaced by freshly prepared and warmed artificial tear fluid into the receptor compartment (KaulShweta*et al*., 2012).
- *In vitro* microbiological study: Prepared formulation will be evaluated for amicrobiological study to determine the antibacterial properties of Erythromycin in comparison with the existing marketed formulation against Staphylococcus aureus by using cup plate method. All procedures will be carried out under aseptic condition. 20ml of nutrient agar will be inoculated with 0.2ml of Staphylococcus aureus along with 7µl of artificial tear fluid and allowed to solidify in the petri dish. Then with the help of sterile borer,cups of 4mm diameter will be made on the solidified nutrient agar. The developed formulation (25µl) will be poured into the cups made and incubate for 24 hours to observe the zone of inhibition produced by the developed formulation the

zone of inhibition will be compared with that of marketed formulation under similar conditions(Bhatia *et al.*, 2013).

VII. DISCUSSION

Better understanding of the limitations exerted by the anatomicaland physiologicalbarriersof the eyes brings more advancement in the development of safe and effective ocular drug delivery system. Hence the focus of interest of drug delivery scientistsisto overcome these anatomical and physiological barriers of the eye. *In situ* gels will be a promising approach to enhance bioavailability and sustained release of the drug thereby ensuring theeffective therapeutic outcome. Exploitation of the polymers for sustained release properties contributes to various advantages for *in situ* gelling system which overcome the limitations associated with conventional ocular preparations. The composition and ratios of the polymeric solution is vital to determine the viscosity and gelling strength of the formulation.i*n situ* gels are biodegradable and easy to introduce into the eyes without the need to remove after the drug is completed released from the dosage form thus improves patient compliance. Sustained release of Erythromycin from the *in situ* gel also reduces the frequency of higher concentration of antibiotic dosing which may lead to greater systemic side effects. Besides that, the methodology adopted for the development of novel*in situ* gel is simple and cost effective.

VIII. CONCLUSION

In a nut shell, this study proposes the development of novelas*in situ* gels for effective ocular delivery of Erythromycin through prolonged contact time and enhanced bioavailability.*In situ* gelling system has tremendous advantages over the ocular conventional dosage form. The benefits are less adverse effect, increase patient compliance, not affected by nasolacrimal drainage, increased drug contact time and reduced frequency of dosing, besides that it is easy to apply and also biodegradable. Considering all the benefits, *in situ*gelling system will be a viable drug delivery system for the delivery of therapeutic agents to combat various ocular diseases and serve as an alternative to conventional ophthalmic dosage formsboththerapeuticallyand commercially.

REFERENCES

Abdullah Khan, S.M.d., Noorulla, Mohammed Muqtader, Roshan, S., Sadath Ali. (2013). Development of pH based phase change solutions for ophthalmic drug delivery of Gatifloxacin. *International Journal of Pharmacy*, 3(1), 66-72.

Abdul Malik, P.H., and Satyananda, S. (2014). pH-induced *in situ* gelling system of an anti-infective drug for sustained ocular delivery. *Journal of Applied Pharmaceutical Science*, 4(1), 101-104.

Bhatia HoneyBala, Sachan Ajay, Bhandari Anil. (2013). Studies on thermoreversivemucoadhesive ophthalmic *in situ* gel of Azithromycin.*Journal of Drug Delivery and Therapeutics*, 3(5), 106-109.

Bharath, S., Sindhu,A., Sharon,F., Basavaraj, B.V., Deveswaran, R., Madhavan, V. (2009).Sustained ophthalmic delivery of Ofloxacin from an ion-activated *in situ* gelling system.*Pakistan Journal of Pharmaceuticals Sciences*, 22(2), 175-79.

Eaga Chandra Mohan, Jagan Mohan Kandukuri, VenkateshamAllenki. (2009).Preparation and evaluation of *in-situ* gels for ocular drug delivery. *Journal of Pharmacy Research*, 2(6), 1089-1094.

GouravRajoriaandArushi Gupta. (2012). *In-situ* gelling system: A novel approach for ocular drug delivery.*American journal of pharmtech research*, 2(4), 25-53.

Himanshu Gupta, Aqil Malik,R.K., Khar, Asgar Ali, AseemBhatnagar, Gaurav Mittal. (2015). Physiologically active hydrogel (*in situ* gel) of Sparfloxacin and its evaluation for ocular retention using gamma scintigraphy. *Journal of Pharmacy and Bioallied Science*, 7(3), 195-200.https://doi.org/10.4103/0975-7406.160015

Himanshu Gupta,M.,Aqil, R.K., Khar, Asgar Ali, AseemBhatnagar, Gaurav Mittal, Sanyog Jain. (2009). Development and characterization of 99mtc-Timolol Maleate for evaluating efficacy of *in situ* ocular drug delivery system.*American Association of Pharmaceutical Scientists*, 10(2), 540-546.https://doi.org/10.1208/s12249-009-9238-x

KaulShweta, Kumar Ganesh, KothiyalPreeti. (2012). Development and *in-Vitro* characterization of ocular inserts containing Erythromycin.*International Research Journal of Pharmacy*, 3(8), 247-250.

Kavitha, K., and Rajas, N.J. (2011) Sustained ophthalmic delivery of Levofloxacin hemihydrate from an ion activated *in situ* gelling system. *International Journal of PharmTech*Research, 3(2), 702-706.

Lisa,R.,Schopf, Alexey, M., Popov, Elizabeth,M., Enlow, James, L., Bourassa, Winston, Z., Ong, Pawel Nowak, Hongming Chen. (2015).Topical ocular drug delivery to the back of the eye by mucus-penetrating particles.*Translational Vision Science & Technology*, 4(3), 1-12.

Mane Kirti and DholeShashikant.(2014). *In-situ* gels a novel approach for ocular drug delivery. *World Journal of Pharmacy and Pharmaceutical Sciences*, 3(8), 317-333.

Pallavi, R., Kute, S.B., Gondkar, Saudagar, R.B. (2015). Ophthalmic *in-situ* gel: An overview. *World Journal of Pharmacy and Pharmaceutical Sciences*, 4(4), 549-568.

RamaiyanDhanapal and VijayaRatna, J. (2012).Ocular drug delivery system– a review.*International Journal of Innovative Drug Discovery*, 2 (1), 4-15.

Rathod, Kinjal, B., Patel, Mandev, B. (2013). Formulation and evaluation of an ion activated *in situ* gel for ocular delivery of Norfloxacin.*World Journal of Pharmacy and Pharmaceutical sciences*,2 (6), 5888-5897.

Reddy, J.S., and Ahmed, M.G. (2013). Sustained ocular delivery of Sparfloxacin from pH triggered *in situ* gelling system. *Mahidol University Journal of Pharmaceutical Sciences*, 40(3), 16-25.

Sampath Kumar, K., DebjitBhowmik, P., ShravanPaswan, ShwetaSrivastava. (2012). Recent challenges and advances in ophthalmic drug delivery system. *The Pharma Innovation*, 1(4), 2-15.

Sandeep, C., Atram, Nishan, N., Bobade, Vikrant, P., Wankhade, Dr Shrikant, D., Pande, Dr Kiran, K., Tapar. (2013). Current trends towards an ocular drug delivery system: Review. *International Journal of Pharmacy and Pharmaceutical Science Research*, 3(1), 28-34.

Sindhu Abraham, Sharon Furtado, Bharath, S., Basavaraj, B.V., Deveswaran, R., Madhavan, V. (2009).Sustained ophthalmic delivery of Ofloxacin from an ion-activated *in situ* gelling system.*Pakistan journal of pharmaceuticals sciences*, 22(2), 175-179.

SuryawanshiSarika, S., Kunjwani, H.K., KawadeJayashree, V., AlkunteMohita, A., YadavDattatraya, J. (2012).Novel polymeric *in situ* gels for ophthalmic drug delivery system.*International Journal of Research in Pharmacy and Science*, 2(1), 67-83.

Tinu, T.S., LithaThomas, Anil Kumar, B. (2013). Polymers used in ophthalmic *in situ* gelling system. *International Journal of Pharmaceutical Sciences Review and Research*, 20(1), 176-183.

Yuejiang Liu, Jinpeng Liu, Xiaolin Zhang, Ruodan Zhang, Yongliang Huang, Chunjie Wu. (2012).*In situ* gelling gelrite/alginate formulations as vehicles for ophthalmic drug delivery.*American Association of Pharmaceutical Scientists*, 11(2), 610-620.

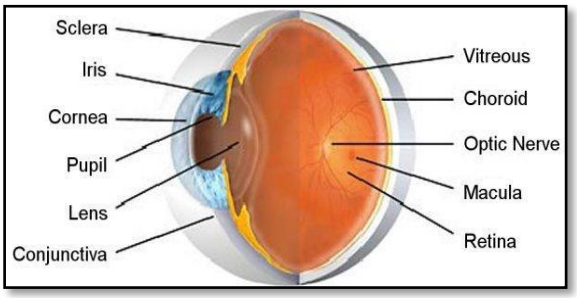

FIGURE 1: Anatomy of human eye. Source from Mane Kirti and Dhole Shashikant(2014).

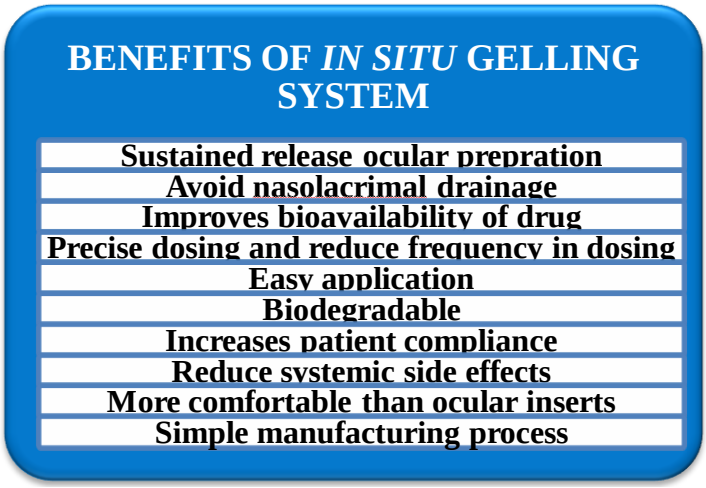

FIGURE 2: Advantages of *in situ* gelling system adapted from Pallavi*et al*., (2015).

International Journal of Students' Research In Technology & Management
ISSN 2321-2543, Vol 5, No 3, September 2017, pp 01-08
https://doi.org/10.18510/ijsrtm.2017.531

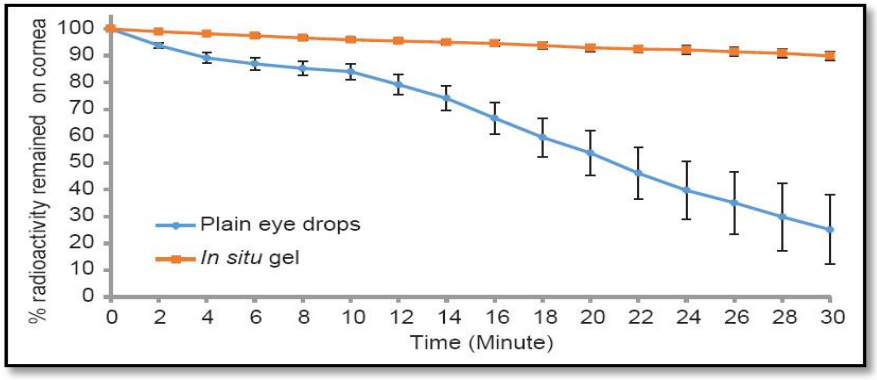

FIGURE 3: Gamma scintigraphy dynamic study shows that plain eye drop formulation designed in *in situ* gel formulation ofSparfloxacin improves rate ofdrug release and prolong contact time of drug at the corneal surface. Adapted from HimanshuGupta et al.,(2015).

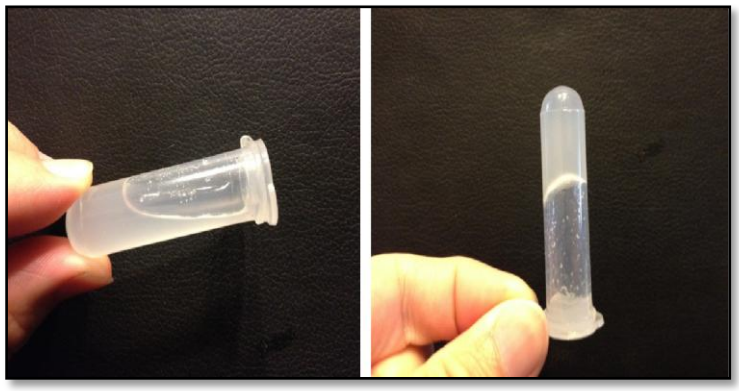

FIGURE 4: Development of *in vitro* hydrogel with *in situ* gels and artificial tear fluid using gellan gum as polymer adapted from Lina Zhu *et al*.,(2015).

TABLE 1: Dosage forms, Benefit and Drawback of ocular conventional dosage forms adapted from Suryawanshi*et al*.,(2012).

DOSAGE FORMS	BENEFITS	DRAWBACKS
Solution	• Easy to administer.	• Short acting. • Rapid nasolacrimal drainage. • Frequent instillation. • Poor pre-corneal penetration. • Loss of drug by drainage.
Ointment	• Prolong drug release. • Enhances drug stability.	• Blurred vision. • Sticking of eyelids. • Discomfort. • Low patient compliance. • Limited drug choice depends on partition coefficient. • Greasy preparation
Suspension	• Great for drug with slow dissolution.	• Loss of drug in solution and suspended solid.
Emulsion	• Prolong drug release from the vehicle.	• Oil entrapment. • Low patient compliance. • Blurred vision.

Gels	• Comfortable than ointments.	• Matted eyelids. • No rate controlling of drug diffuse.
Ocular inserts	• Sophisticated and prolong delivery system. • Less affected by nasolacrimal drainage.	• Low patient compliance. • Discomfort. • Abrasion while application.