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EMERGING PARENTERAL DRUG DELIVERY TECHNOLOGIES FOR CONTROLLED AND SUSTAINED THERAPEUTIC DELIVERY.

Dr. Prashant S. Misal[1], Dr. Amol A. Joshi[2], Miss. Nutan M. Dudhal[3], Mr. Ashishkumar R. Jadhav[4], Mrs. Priyanka B. Hajare[5], Dr. Wajid N. Chaus[6], Dr. Sukumar M. Lande[7]

Professor, Shri Ganpati Institutes of Pharmaceutical Sciences & Research, Tembhurni[1].
Principal, ASPM's K. T. Patil College of Pharmacy, Dharashiv[2]
Assistant Professor, Shikshan Prasarak Mandals College of Pharmacy, Akluj[3].
Assistant Professor, Vitthal Pratishthan College of Pharmacy, Madha[4].
Assistant Professor, B. R. Harne College of Pharmacy Karav, Vangani (W) Mumbai[5].
Principal, Dayanand Institute of Pharmacy, Latur, Maharashtra.
Associate Professor, ASPM's K. T. Patil College of Pharmacy, Dharashiv[7*].

*** Corresponding Author:**
Dr. Sukumar M. Lande,
Associate Professor, ASPM's K. T. Patil College of Pharmacy, Dharashiv.
Email: sukumar1lande@gmail.com

ABSTRACT:
Chemotherapy induced nausea vomiting is one of the most prevalent side effects caused during the treatment with anticancer drugs. This is overcome by administration of antiemetics particularly 5-hydroxytryptamine (5-HT3) receptor antagonists, like ondansetron hydrochloride and palonosetron hydrochloride. These drugs need to be administered at the start of the chemotherapy on day 1 and then frequently administered till a period of 5 to 6 days intravenously or orally. Conventional oral and parenteral routes suffer from various drawbacks and frequent administration leads to patient incompliance. Controlled release parenteral have been emerging as parenteral drug delivery having various advantages over conventional parenteral such as delivery for a prolonged time period giving uniform drug levels, lowering peak and trough levels and this side effects, reduction in repeated dosing, delivery of drug at a specific site or localized, reduction in overall dose and finally achieving improved patient compliance and comfort.
Keywords: Parenteral, Ondansetron, Chemotherapy, Palonosetron etc.

INTRODUCTION:

Dosage forms are administered by various modes of administration such as the oral, nasal, pulmonary or transdermal route. The need to treat new and current disease new therapeutic agents and new routes of administration are constantly being developed. Out of many different routes of administration Parenterals form a major class of dosage forms and route of administration. These are sterile products that are administered directly into the blood circulation and hence termed as parenteral means (*para enteron*– beside the intestine) bypassing the alimentary canal. They show many advantages like: fast onset of action with increased bioavailability as they go directly in the blood circulation bypassing the barriers of alimentary canal, localised delivery by administering at

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a particular site, administration in non- cooperative condition of patient. Parenterals are majorly classified as small volume having volume upto 100ml and large volume with volumes greater than 100ml. Small volume parenterals are administered by various routes as Intravenous (IV), Intramuscular (IM), Intradermal (ID), Subcutaneous (SC), Intrathecal (IT), Epidural, Intra-arterial, Intra-articular, Intracardiac and Intraocular.

Formulation of subcutaneous controlled release injection of Ondansetron Hydrochloride

Ondansetron hydrochloride is a selective inhibitor of 5- hydroxytryptamine widely used in CINV as well as in post-surgical nausea vomiting, administered either orally or by IV. Ondansetron Hydrochloride is a first-generation antiemetic. Drug shows bioavailability of 60

% and short half-life of 3–6 h. The dosing schedule for adults is 8 mg before start of the chemotherapy followed by frequent administration as infusion or tablet twelve hourly per day continued over a period of 5 days. Dose not exceeding 32 mg (0.32 mg/kg) per day. The peak plasma concentration is achieved after 1.5 to 2 h of administration which is about 0.03–0.04µg/ml (Rolia, et al. 1995). Frequent administration of the drug leads to the side effects and decreased patient compliance. Commercially the drug is available as formulations of Ondansetron in the form of conventional tablets and intravenous injections. Novel drug delivery systems that have been explored to overcome drawbacks or conventional ondansetron dosage forms are sustained release tablets, nasal mucoadhesive systems, microspheres, transdermal patches (Sekar, et al, 2013. Hassan N, et al. 2009)

Thus, there would be a rationale to develop a controlled release subcutaneous injection of ondansetron hydrochloride by incorporating in an *insitu* gel forming base, achieving prolonged release, achieving uniform plasma profiles, decreasing frequency of dosing and overall compliance of the treatment in chemotherapy induced nausea vomiting. A formulation able to prolong therapeutically effective ondansetron concentrations could be an alternative option for control of both acute and delayed CINV in both MEC and HEC settings.

Formulation of subcutaneous controlled release injection of Ondansetron Hydrochloride:

Preparation of calibration standards:

Spiked plasma was prepared by taking 0.25ml plasma, 0.25 ml stock solution of drug and 0.50 ml of Methanol. Appropriate quantities of this stock solution were added into EDTA tube to get the spiked plasma within the range of 10-50 µg/ml followed by centrifuging the tubes to get the supernatant separated and evaporated to dryness. The dried residue was diluted to 10ml with mobile phase to obtain the solution, 20µl of which was injected into the column for analysis.

FORMULATION OF IN-SITU GEL FORMING INJECTABLE:

Batch no	**Factors (%Concentration)**		
	Poloxamer 407 A	**HPMC K100M B**	**PEG400 C**

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F1	18	1.5	2
F2	20	1.5	2
F3	18	3.5	2
F4	20	3.5	2
F5	18	2.5	1.5

Formulation batches (F1 to F5) were prepared using cold method of manufacturing. The polymer poloxamer 407 (18% - 21 %) under continuous stirring was added in water at 4°C and the prepared solutions were kept in refrigerator at 4°C (2-8^{0}C) with occasional stirring for 24 h so as to form a clear solution. This was then followed by addition of citric acid 1% and Sodium citrate 0.5% followed by addition of drug (2%) under continuous stirring and copolymer HPMC K100M (1.5 %- 3.5%), and PEG 400 (1.5%-2.5%) along with tonicity adjusting agent NaCl 0.9% under continuous stirring to form a clear viscous solution. (Julian et al, 1987, O. Inal et al, 2013). The final formulation prepared were filled under aseptic conditions in amber coloured glass ampoules of 2ml capacity and were sterilized by steam sterilization by autoclaving at 121^{0}C at 15 psi for 20 min. They were evaluated for gelation temperature and gel strength as responses for the optimization design.

Determination of Gelation temperature:

An aliquot (2 ml) of the formulations at 4□C, were added to test tubes containing simulated phosphate buffer pH 7.4 volume 1ml, that were kept in a water bath. The water bath temperature was increased with increments of 1^{0}C / min and allowed to equilibrate for 5 min after each setting. Upon tilting the test tube through 90□C the temperature at which the meniscus showed no movement, was noted as the gelation temperature. This method used was modification of Miller and Doravan technique.

Determination of Gel-Strength:

The formulations about 20 ml were added in the 25 ml beakers of Surimi test using Texture Analyzer (Texture Pro CT V1.4) and subjected to heating from 25^{0}C till it formed the gel. The probe (TA 3/100) of the analyser was allowed to traverse the gel up to 1 cm at a speed of 1mm/s. Gel strength was noted from the load reading in g/cm.

Appearance & pH:

Appearance and clarity of the optimized formulation was checked visually at 4^{0}C, room temperature 25^{0}C and after formation of gel at 37^{0}C (Nasir, et al. 2013). The pH was determined using digital pH meter at room temperature taking adequate volume.

Insitu gel formation at physiological temperature:

2 ml of optimized formulation at 4^{0}C was added to test tubes containing 1ml Simulated phosphate buffer pH 7.4, kept in water bath at 37 ^{0}C under stirring and observed for gel formation.

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Gel-Strength:

The Optimized formulation about 20 ml was added in the 25 ml beaker of the Surimi test Texture Analyzer (Texture Pro CT V1.4) and subjected to heating at 37^0C to form a gel. The probe of the analyser was allowed to traverse the gel up to 1 cm at a speed of 1mm/s. Gel strength was noted from the load reading in g/cm.

Drug content estimation:

The *in situ* formed gel equivalent to 10 mg (0.25 ml) was taken and shaken with methanol and filtered to get the residue that was further diluted using methanol to get a stock solution of (100µg/ml) that was further diluted up to 10 ml (40 µg/ml), which was analyzed using HPLC and drug content determined from the calibration curve equation.

Sterility Testing:

The optimized formulation was subjected to sterility testing as per the IP for bacteria and fungi following the procedure stated in IP along with the positive and negative controls.

***In-vitro* Drug Release Studies:**

2ml of the optimized formulation was added into the 1ml of simulated body fluid (pH7.4) which was preheated at 37˚C. These release studies were conducted using membrane less dissolution method i.e orbital shaking incubator at 30 rpm. After predetermined time intervals at 1,24, 48, 72, 96, 120,144 h, samples were withdrawn, suitably diluted and analysed to calculate percentage cumulative drug release (% CDR) spectrophotometrically at 308 nm.

Accelerated Stability study:

The optimized formulation as per the International Conference on Harmonization (ICH) guidelines were subjected to accelerated stability studies, by placing sufficient amount of formulation within the final packaging at refrigerator i.e. at (5^0C ± 3^0C) 2-8 ^{0}C ± 3^0C till 12 months and 25^0C ± 2^0C /60% RH ± 5% RH, till 6 months and evaluated for 1,3,6 and 12 months and at 1,3 and 6 months respectively. They were evaluated at for any possible changes in appearance, pH, clarity, gelation temperature, *in vitro* drug release to work out the conditions for storage (ICH guidelines).

RESULTS AND DISCUSSION:

Melting point determination:

The melting point of Ondansetron Hydrochloride found to be 180-185^{0}C.This confirmed identity and purity of the drug.

Infrared Spectroscopy:

The FTIR spectrum of the Ondansetron Hydrochloride shows characteristic absorption bands of the drug and confirms identity of the drug as shown in Figure and table.

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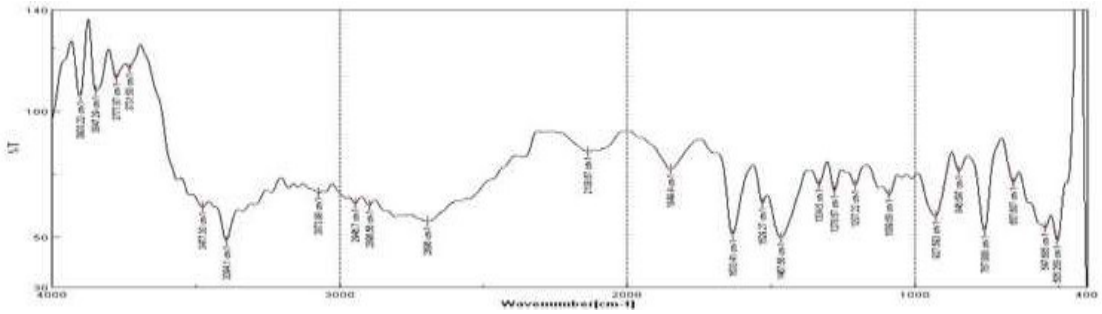


Figure : FTIR spectrum of Ondansetron hydrochloride drug

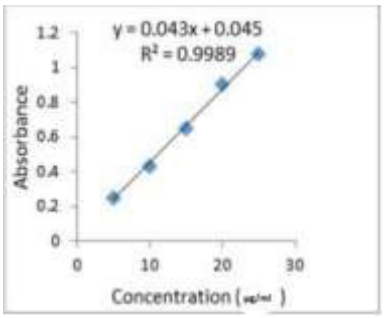
Table : Interpretation of the peaks obtained in the IR spectra along with their corresponding functional groups

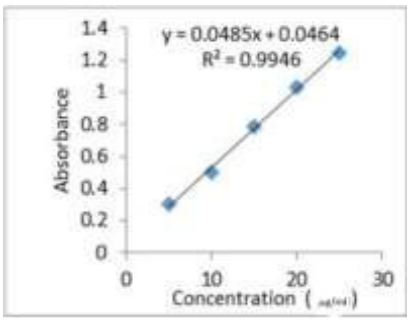
Sr.No.	Functional Groups	Observed Frequency (cm^{-1})
1.	N-H stretching	3415 cm^{-1}
2.	C-N stretching	980.12cm^{-1}
3.	C=O stretching	1720.11 cm^{-1}
4.	CH3 stretching	1350cm^{-1}
5.	C=C stretching	1480cm^{-1}

UV Spectroscopy:

Determination of wavelength of absorption maxima (λmax.) in methanol and Simulated body fluid pH 7.2 and calibration :

Wavelength of maximum absorbance (λ_{max}) of Ondansetron hydrochloride was found to be 302nm. Beer's lambert law was found to be obeyed in the concentration range of 5-25 µg/ml and calibration curves were obtained as shown in the Figure 5.2.3a and b along with regression coefficient and equation in the figure .





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(a) **(b)**

Figure : Calibration curve of Ondansetron HCl in (a) Methanol and (b) SBF pH 7.2

Optimized batch:

The criteria for selection of optimized formulation was gelation at body temperature and maximum gel strength, that would form a stable, viscous gel which would maintain its stability and not erode till a prolonged period.

Characterization of optimized Formulation:

Based on the studies the optimized batch prepared was evaluated for parenteral and other properties to determine the desired characteristics.

Appearance & pH:

Parenteral solutions need to be clear and free of particulate matter. Also, they should be processed under aseptic conditions and to be sterilized to maintain the sterility. Optimized batch was clear and colourless. This is attributed to solubility of all the formulation ingredients and their compatibility. Also, the method of preparation used and terminal sterilization by autoclaving is appropriate method for the formulation ingredients. pH of optimized batch was found to be 4-5. Both these characteristics are ideal for administration of the formulation as a subcutaneous injection. (Venkatesh, e t al. 2007).

Gel-Strength:

Optimized batch showed gel strength as 17.69.0g/cm ±0.2. The ability of the *insitu* formed gel to tolerate the shear forces in the body for a prolonged time period is signified by the gel strength. The gel formed should have a firmness, adhesiveness and should maintain its stability throughout the desired time. The strength depends on the polymer types, the viscosity imparted and other excipients. Poloxamer 407 gels inside and the copolymer HPMC which is hydrophilic swells and forms a viscous gel in the body fluid. Poloxamer 407 alone does not form a gel that has a sufficient strength to be stable for a longer period. Addition of HPMC K100M imparts the strength as the insitu gelling takes place. In aqueous media HPMC gets hydrated and swells leading to gelling and formation of matrix. This entanglement also increases due to the HPMC polymer having methyl cellulose and as well the hydroxyl group which is interacts with PEO and PPO of poloxamer forming a complex and increasing gel strength (Nasir, et al. 2013). Also, HPMC interacts with the network of poloxamer micelles that may lead to formation of high resistant *in situ* gel to erosion. Also, the spherical micelles formed spontaneously with the PPO-rich hydrophobic moieties have the ability to accommodate drugs via solubilization that leads to drug entrapment in the formed gel matrix. There is stabilizing effect due to PEG that straightens the texture properties by increasing viscosity, compressibility adhesiveness and hardness.

Viscosity:

It is desirable that the sol form should be less viscous in order to administer easily without

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force that would be painful. The viscosity of the optimized formulations in sol form was found to be 2600 cP and upon gelling the viscosity obtained was increased to 3200 cP. This viscosity of the sol form is ideal to administer into the subcutaneous tissue at low temperature with good syringeability. The change in viscosity implies the conversion of sol into formation of a viscous gel mass. The viscosity is imparted by the poloxamer 407 and the copolymer present which suggests the formation of thermally induced gel structure of poloxamer. The formulation remained liquid up to certain temperature and an increase in the viscosity with increase in temperature confirms the formation of gel (Parmar, et al. 2012).

Syringeability:

It is the ability of the formulation to pass easily through needle. The needle selected through which the solution passed easily in the time limit of 10 seconds was 24 gauge. This is ideal for administration by subcutaneous route with less pain and irritation. An injection should be easy to administer into the tissue without force.

Drug content estimation:

The drug content was found to be 98.00 %±1.5% indicating insignificant loss of drug during the formulation. Thus, the formulation ingredients, method of preparation and sterilization conditions are ideal for the drug and also ensures uniform mixing of the drug.

Sterility Testing:

As shown in the table 5.2.8 the test sample shows no growth for bacteria and fungi as there is no turbidity after 14 days.

Observations for microbiological growth for sterility testing

Sample	**Bacterial Growth 30°-35°C/alternate fluidthioglycolate medium/*Clostridium sporogenes***		**Fungal Growth 20°-25°c/ Soyabean casein digest medium /*Candida albicans.***	
	Observation	**Inference**	**Observation**	**Inference**
Positive control	Turbid	Turbid	Turbid	Turbid
Negative control	Clear	Clear	Clear	Clear
Test sample	Clear	Clear	Clear	Clear

Hence concluding that formulation is sterile. Parenteral formulations are single dose and sterile. Sterility can be imparted by aseptic processing of formulations and sterilization of formulation

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by different methods. The sterility of the optimized formulation is the result of aseptic processing and terminal sterilization by moist heat i.e. autoclaving.

In-vitro Drug Release Studies:

One of the important tools to determine the release kinetics is by performing the dissolution studies. Since the formulation involved the conversion of sol to gel at a specific temperature the studies were conducted using orbital shaking method that involved formation of gel immediately when 2ml of the solution was added to the medium maintained at 37^0C. The medium used was simulated phosphate buffer pH 7.2 mimicking the conditions of the body fluid. The optimized batch showed a mean release of more than 90-98 % as shown in the figure at a prolonged period over 5- 6 days or 120-144 h and thus total release of ondansetron from the gel was achieved in 6 days.

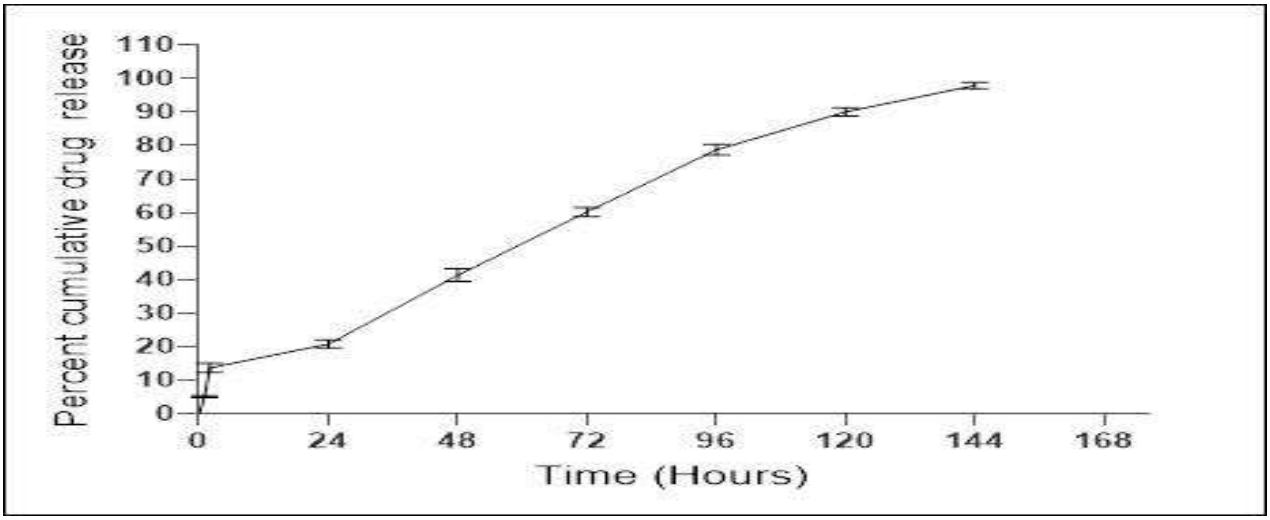

Figure : Plot of percent cumulative Invitro Drug release of ondansetron Hcl vs Time

Each point represents the mean ± SD; n = 3.

CONCLUSION:

The desired characteristics of an injection with respect to parenteral prerequisites like the appearance, sterility, viscosity, syringeability, physical aspects of insitu gelling like the gelation temperature of 37 ^{o}C and maximum gel strength so as to form a stable prolonged *insitu* gel to be stable entrapping the drug, chemical stability with respect to the drug content was achieved. The formulation was optimized using DOE studies with biocompatible excipients comprising of thermosensitive *insitu* gelling polymer, Poloxamer along with copolymers, HPMC K 100M and polyethylene glycol and prepared aseptically by simple method of mixing. The formulation showed a prolonged release of more than 98% upto 144 h on evaluation by i*nvitro* method.

Thus controlled release subcutaneous ondansetron injection in an thermosensitive *insitu*

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gelling parenteral drug delivery system to be administered once at the start of chemotherapy to be effective throughout the treatment cycle could be an alternative to the conventional formulations, administered for acute and delayed CINV, owing to its ability to Control drug release over the length of treatment, reduced dosing frequency and increased patient compliance experiencing long term treatment formulated involving less complicated fabrication and easy administration.

We also concluded that the temperature triggered *insitu* gel forming base proves to be a good option to formulate a stable injection using biocompatible polymers and copolymers like Poloxamer and HPMC and can be explored for other drug candidate for achieving controlled release by subcutaneous route.

REFERENCES

1. Abashzadeh S., Dinarvand R.,Sharifzadeh M.,Hassanzadeh G, Amini M, Atyabi F. Formulation and evaluation of an in-situ gel forming system for controlled delivery of triptorelin acetate, European J. of pharmaceutical sciences 2011, 4(4), 514-521.
2. Akash MS, Rehman K, Sun H, Chen S. Assessment of release kinetics, stability and polymer interaction of poloxamer 407-based thermosensitive gel of interleukin-1 receptor antagonist. Pharm Dev Technol 2014;19(3): 278-284.
3. Athare AV, Rohamare P, Bansode A, Mahale N. and Chaudhari, S. Formulation and evaluation of eletriptan hydrobromide thermoreversible nasal in situ gel. Int. J. Pharma. Res. Dev 2012; 4:267-275
4. Azita HH. Talasaz,1 Ali A. Ghahremankhani,1 Shadi H. Moghadam,1 Mazda R. Malekshahi,1 Fatemeh Atyabi,1 Rassoul Dinarvand. In Situ Gel Forming Systems of Poloxamer 407 and Hydroxypropyl Cellulose or Hydroxypropyl Methyl Cellulose Mixtures for Controlled Delivery of Vancomycin. J. of Applied Polymer Science 2008; Vol. 109(4), 2369–2374
5. Baloglu E, Karavana SY, Senyigit ZA, Guneri T. Rheological and mechanical properties of poloxamer mixtures as a mucoadhesive gel base. Pharm Dev Technol 2011; 16(6):627-36.
6. Chaudhary B, Verma S .Preparation and Evaluation of Novel In Situ Gels Containing Acyclovir for the Treatment of Oral Herpes Simplex Virus Infections. The Scientific World Journal, vol. 2014, Article ID 280928, 7 pages, 2014.
7. Chen J, Zhou R, Li L, Li B, Zhang X, Su J.Mechanical, Rheological and Release Behaviors of a Poloxamer 407/ Poloxamer 188/Carbopol 940 Thermosensitive Composite Hydrogel. Molecules 2013; 18(10):12415-12425.
8. Cho E, Gwak H, Chun I. Formulation and evaluation of ondansetron nasal delivery systems. Int J Pharm 2008; 12;349(1-2):101-7.
9. Choi H, Lee M, Kim M, Kim C. Effect of additives on the physicochemical properties of liquid suppository bases. Int J Pharm 1999; 190(1):13-9. doi: 10.1016/s0378-5173(99)00225-2. PMID: 10528092.

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10. Costa P, Manuel J, Lobo S. Modeling and comparison of dissolution profiles. European J. of pharmaceutical sciences 2001;13(2):123-133.
11. Dangi Amish A, Sheth Zankhana P, Janki Joshi, Formulation and Evaluation of Transdermal Ondansetron Hydrochloride Matrix Patch: *In Vitro* Skin Permeation and Irritation Study, IJPRAS 2012; 1(2):26-37.
12. De A, Chakraborty S, Mukherjee A, Chattopadhyay J, & Kumar M. Optimization and Biopharmaceutical Evaluation of a Formulated Patch of Ondansetron for Transdermal Delivery. Research & Reviews: Journal of Pharmacy and Pharmaceutical Sciences 2013;2*: 85*- 94.
13. De A, Chakraborty S, Mukherjee A, & Chattopadhyay J. Formulation and Development of In Situ Gelling System for Nasal Administration for Ondansetron Hydrochloride by Using Pluronic F-127. Research & Reviews: Journal of Pharmacy and Pharmaceutical Sciences 2013;2*: 52-62.*
14. Garala K, Joshi P, Shah M, Patel J, Formulation and evaluation of periodontal in situ gel, Int J Pharm Investig 2013; 3(1):29–41.
15. Indian Pharmacopoeia. The Controller of Publications, New Delhi; Ministry of Health and Family welfare. India . 7th ed. 2014.
16. International conference on harmonization of technical requirements for registration of pharmaceuticals for human use. Stability testing of new drug substances and products Q1A R2 August 2003 CPMP/ICH/2736/99
17. Jadhav P, Jadhav N, Hosmani AH, Patil S.Development and evalution of in-situ thermoresponsive nasal gel system for Nardostachys jatamansi, Der Pharmacia Lettre 2013; 5(2):113-125.
18. Jabarian L E, Rouini MR, Atyabi F, et al. *In vitro* and *in vivo* evaluation of an in situ gel forming system for the delivery of PEGylated octreotide. European J of Pharm Sci. 2013; 48: 87–96.
19. Jun L, Bochu W, Yazhou W. Thermo-sensitive polymers for controlled release drug delivery system. International Journal of Pharmacology 2006; 2(5):513-519
20. Julian C. Gilbert, Julie L. Richardson, Martyn C. Davies, Karen J. Palin. The Effect Of Solutes And Polymers On The Gelation Properties Of Pluronic F-L 27 Solutions For Controlled Drug Delivery. J. of Controlled Release 1987;113- 118
21. Kang F, Singh J. *In vitro* release of insulin and biocompatibility of In-situ forming gel systems. Int J Pharm 2005; 304(1–2): 83-90.
22. Kalsi PS. Spectroscopy of organic compounds. New age international publishers. 5th ed: 60- 159
23. Karthikeyan M. Effect of Different Viscosity Grades of HPMC on Drug Release Profile, Journal of Pharmacy Research 2008;1(1): 23-28.
24. Kulkarni A, Khan S, Dehghan MH. Evaluation of poloxamer-based in situ gelling of articain as drug delivery system for anesthetizing periodontal pocketsan *in vitro* study. J. Dent. Res 2012; 3:201-208.

Acta Biomed 2026; Vol. 97, N. 1: ISSN: 0392-4203 | eISSN: 2531-6745

25. Kwon KW., et al., Effects of alcohol addition on gelation in aqueous solution of poly(ethyleneoxide)-poly(propylene oxide)-poly(ethylene oxide) triblock copolymer. Polym. J 2001; 33:404.
26. Nasir F, Iqbal Z, Khan A, et al., Development and evaluation of pluronic- and methylcellulose- based thermoreversible drug delivery system for insulin, Drug Dev Ind Pharm 2014; 40(11):1503-1508.
27. Nikam K, Pawar M, Jadhav S, Bairagi V. Novel trends in parenteral drug delivery system, Review. International Journal of pharmacy and technology 2013; 5(2):2549-2577.
28. O. Inal and E. Algin Yapar, Effect of Mechanical Properties on the Release of Meloxicam from Poloxamer Gel Bases. Indian J Pharm Sci 2013; 75(6): 700–706.
29. Pachpute D, Patil D, Chaudhari P. Formulation development and evaluation of in situ-gel of levodopa. Int j pharm sci 2014; 4(5): 449-453.
30. Panchal D., Patel U. and Bhimani B, et al. Nasal in-situ gel: a novel drug delivery system. Int.
31. Prashanth P,Shah S,Arvind G,Konda N. Formulation & characterization of In situ implant of Octreotide Acetate.Int J of pharm.2013;3(3):565-573.
32. Patel HR, Patel RP, Patel MM. Poloxamers: A pharmaceutical excipients with therapeutic behaviors, Int.J. PharmTech Res 2009; 1(2):299-303.
33. Raymond C Rowe, Paul J Sheskey, Marian E Quinn; Handbook of Pharmaceutical Excipients; Pharmaceutical Press and the American Pharmacists Association; 6th edition; 2009.
34. Rita J., Pradip, K., Manish, L. and Rayasa.R. Thermoreversible mucoadhesive gel for nasal delivery of Sumatriptan. AAPS Pharm. Sci. Tech. 2006. 7, E1-E7
35. Ranga S, A review on design of experiments (DOE) Review article. Int J of pharm and chem sci. 2014; 3(1): 26-22.