ORIGINAL ARTICLE

INTERNATIONAL JOURNAL OF EXPERIMENTAL AND BIOMEDICAL RESEARCH

Published by Pharma Springs Publication Journal Home Page: https://pharmasprings.com/ijebr

Formulation and Evaluation of Nitrofurantoin Microspheres Loaded in Hard Gelatin Capsule

Madhuri Reddy M[*1], Gundala Deepika[2], Meesala Simon[2], Pothireddy Bharat[2], Golam Sofiullah SK[2], Addakula Varalaxmi[2]

[1]Department of Pharmaceutics, St. Mary's Group of Institutions, Deshmukhi (Village), Pochampally (Mandal), Yadadri Bhuvanagiri (Dist)-508284, Telangana, India
[2]St. Mary's Group of Institutions, Deshmukhi (Village), Pochampally (Mandal), Yadadri Bhuvanagiri (Dist)-508284, Telangana, India

Article History:

Received on: 02 Mar 2022
Revised on: 18 Mar 2022
Accepted on: 19 Mar 2022

Keywords:

Nitrofurantoin,
Microspheres,
Hard Gelatin Capsule,
Urinary Tract Infections

ABSTRACT

In side this task a kind attempt has been made to formulate and evaluate Microspheres of the drug Nitrofurantoin in Hard Gelatin Capsule by orifice ionic gelation method to polymer combinations of sodium alginate, carbopol and Sodium carboxy methyl cellulose. The main objective of formulating the Microspheres of Nitrofurantoin in Hard Gelatin Capsule was to enhance the bioavailability, which leads to reducing the frequency of administration in order to be able to improve patient conformance. Different quantities of polymer combinations of sodium alginate, carbopol and Sodium CMC were used to prepare five formulations. Prepared Microspheres of Nitrofurantoin were evaluated for % yeild, carr's index, angle of repose, particle size, drug entrapment efficiency, % moisture loss, stability and swelling properties. The Fourier transform infrared analysis was done to conduct to prove the opportunity of interaction of chemical bonds between drug and polymer. The DSC thermograms studies of Plain drug were performed to verify the presence of impurities in drug. The prepared microspheres were evaluated for particle shape and surface morphology using Scanning Electron Microscopy (SEM) analysis. In vitro dissolution test carried out by using USP type I apparatus at 37 ± 0.5^{o}C in 900 ml of phosphate buffer solution pH 6.8. Formulation F1 and F3 showed a release in a consistent manner. That was expected the release to keep going by still 4 so much hours. Overall a drug release sustained to 12 hrs is achievable. The formulation F1 and F3 showed the best dissolution study it reveals that these formulations have higher dissolution rate. There is scope for the further study and development of Microspheres in Hard Gelatin Capsule by using the combination of these polymers.

*Corresponding Author

Name: Madhuri Reddy M
Phone: +91 8712350836
Email: madhurireddy.62@gmail.com

eISSN: 2583-5254 pISSN:

DOI: https://doi.org/10.26452/ijebr.v1i1.366

Production and Hosted by

Pharmasprings.com

INTRODUCTION

Urinary tract infections are a common condition among women of reproductive age. A urinary tract infection is just an infectious disease in every portion of this same urinary system, which incorporates the vagina (urethra), bladder, and kidneys [1]. A urinary tract infection can be caused by bacteria or a virus that enters the body through the urethra and travels up to the bladder. It can also be caused by bacteria from an infected vagina or rectum enter-

ing through the urethra. The symptoms of a UTI may include: -Painful urination -Fever -Cloudy urine or strong smelling urine Lower abdominal pain [2]. Urinary tract infections are some of the most widely accepted type of infection. They are caused by bacteria entering the urethra and travelling up to the bladder. The infection can also spread to the kidneys, which is called pyelonephritis. Urinary tract infections can be prevented by not holding in your urine, drinking plenty of fluids, wiping from front to back after going to the toilet and washing your hands after going to the toilet [3].

Microspheres in Hard gelatin capsule are a form of drug delivery. They are tiny spheres that can be filled with medicines and then put into a capsule. Microspheres have many advantages over other forms of drug delivery. For example they can be made in different shapes to make them more effective at delivering the medicine to certain parts of the body [4].

They can also be used to release drugs slowly, which makes them more suitable for chronic diseases like diabetes. There are some disadvantages too, such as the fact that they cannot be mixed with liquids so they cannot be taken by mouth, and they need to be swallowed whole without chewing or crushing them [5].

The Microsphere formulation administration cannot be employed for a large number of drugs. Only a small number of drug products are currently available via Microspheres for drug delivery. Nitrofurantoin is selected as a drug for this investigation because it is BCS class Π drug. Its oral dose is 50 to 100 mg. In most of prescription used 50mg or 100 mg conventional tablets once or twice times a day according to severity of disease [6].

Microspheres of nitrofurantoin in Hard Gelatin Capsule were prepared to improve the oral bioavailability, to reduce the frequency of dosing, and to improve the therapeutic value with minimum side effects and improve patient compliance.

MATERIALS AND METHODS

The drug Nitrofurantoin used in the present study was gathered from Cipla Ltd, Mumbai and the polymers Sodium alginate, Carbopol and Sodium CMC [7] used are procured from S.D.Fine Chem. Ltd.

The equipments used in the study are Rotary Vaccum Dryer (Company: SYSTEM ENGITECH PVT. LTD), Double beam UV Spectrophotometer (Company: Shimadzu 1700), Electronic balance (Company: Essae teraoka limited –DS 852 J), pH – meter (Company: Elico), FTIR Spectrophotometer (Company: Perkin Elmer, Germany) and SEM (Company: JOEL JSM-T330A Scanning Microscope).

Methodology

Compatibility Studies

Fourier Transform Infrared Spectroscopy (FTIR)

The Fourier transform infrared analysis was carried of about verify the opportunity of interaction after all chemical bonds between drug and polymer. The FTIR spectrum must've been conducted and using a PerkinElmer 1600 spectrophotometer with either a magnification(resolution) of 2 cm -1. Its scans were performed there in the spectra between 4000 and 400 cm-1 by looking to take an average of 8 needs to scan per sample [8].

Differential Scanning Calorimetry (DSC)

DSC (model 822e, Mettler Toledo, OH, USA) with a Mettler MT50 analytical balance had been used in order to analyzing the thermal behaviour of different samples. Indium (3-5 mg, 99.999% pure, onset 156.6C, heat of fusion of 107.5 J/g) has been used to calibrate the instrument. Samples (3-5 mg) seemed to be prepared by weighing into 100 μl aluminium pans and then hooked. The thermograms seem to have been documented over a temperature range of 10-2000C at such a rate of 100C/min under nitrogen purge gas at 50 mL/min. Mettler Toledo STARe softwear (version 8.10) was being used to analyze data [9].

Preparation of Microspheres

Microspheres seem to have been prepared besides orifice ionic gelation procedure as for polymer combinations of sodium alginate, carbopol and Sodium CMC (carboxymethylcellulose). Nitrofurantoin filled microcapsules have been willing by ionic gelation method. Fleetingly decided to weigh small volumes of polymeric materials and measured quantities of nitrofurantoin seemed to be uniformly distributed in 10 ml distilled water with only a constant stirring at 300 rpm for 30 min [Table 1]. The resultant dispersion has been incorporated drop advisable through with a syringe (17 gauge) through into $CaCl_2$ solution (10 % w/v). And This so formed microspheres seemed to be managed to keep for 30 min just that full reaction and then after, microspheres have been managed to recover by filtration through some kind of sintered glass filter, under vacuum, dried in hot air oven at 60°C for 1 hour [10].

Evaluation of Microspheres

Percentage Yield

The dried microspheres had been decided to weigh and percentage yield of told to prepare microspheres must have [5] been measured by using the

Table 1: Formulation of Microspheres

Formulation no.	Drug quantity	Sodium alginate	Carbopol 934	Sodium CMC	% Yield (X±S.D. n=3)	Drug Release %(X±S.D. n=3)
F1	100mg	200mg	50mg	50mg	73.3±0.835	57.873±
F2	100mg	200mg	75mg	25mg	92.98±0.415	50.243
F3	100mg	200mg	25mg	75mg	90.69±0.578	59.435
F4	100mg	150mg	50mg	100mg	86.786±0.480	44.876
F5	100mg	150mg	100mg	50mg	84.536±0.570	63.675

following formula,

Percentage yield = {The weight of microspheres / (The weight of polymer + drug)}*100

Carr's Index

It really was evaluate by using following equation

Carr's Index = {(Vb –Vt) / Vb}* 100

Where, Vb and Vt are the bulk volume and tapped volume respectively [11].

Angle of Repose

Angle of repose of such microspheres, is indeed the maximum angle possible between area of a pile of [7] microspheres and also the flat(horizontal) plane, seemed to be gained by fixed funnel process to use the equation;

Angle of Repose = Tan^{-1} (h/r)

Where, h is height and d is the diameter of the microsphere pile.

Particle Size Analysis

Particle size of a microspheres was determined by optical microscopy. The eye piece micrometer must've been recalculated [12] with the support of something like a stage micrometer. The particle diameters of more than 50 microspheres have been assessed randomly. The average particle size was determined by using Edmondson's equation.

$D = \Sigma nd / \Sigma n$

Where, n = No. of microspheres checked; D = Mean of the size range.

Drug Entrapment Efficiency

Microspheres seem to be squashed that used a glass mortar by pestle and equivalent to 5 mg of aspirin decided to weigh. The above microspheres had been suspension in 25 ml of phosphate buffer pH 6.8. After 24 h, the solution has been filtered; 1 ml of such filtration has been pipette out too and prepared by diluting to 10 ml and analyzed is for the drug content and use UV Visible1spectrophotometer at 265 nm [13]. The drug entrapment efficiency must have been computed using the following equation:

% Drug entrapment efficiency = (Practical Drug content / Theoretical Drug content) X100

Scanning Electron Microscopy (SEM)

The SEM analysis was carried out using a scanning electron microscope, Prior to examination, samples were mounted on an aluminium stub using a double sided adhesive tape and making it electrically conductive by coating with a thin layer of gold (approximately 20 nm) in vacuum [14]. The scanning electron microscope was operated at an acceleration voltage of 5 kV and resolution of 4000.

Percentage Moisture Loss

The drug loaded microspheres has been tested for percentage moisture decline (loss) that also try sharing a kind clue about hydrophilic nature. The microspheres weighed (W1) initially kept in desiccator containing calcium chloride at 37°C for 24 hours [15]. The final weight (W2) seemed to be stated when it is no additional change in weight of sample seemed to be observed.

Moisture loss = [(W1 – W2)/W1] X 100. All the experimental units were studied in triplicate (n=3).

Determination of Swelling Properties

The dynamic swelling property of microcapsules with in dissolution medium (0.1N HCl) was firm(determined). Microspheres of recognized weight seem to be situated along dissolution remedy for 6 hr and or the swollen microspheres seemed to be compiled by either a centrifuge and also the wet weight of swolled up microspheres was determined first by blotting this same particles as well as the filter paper to consider removing absorbed water on surface and afterwards needs to weigh immediately on such an electronic balance [16]. The percentage of swelling of microspheres in the dissolution media had been determined using equation,

$Sw = [(Wt- Wo)/Wo] \times 100$,

where, Sw= percentage of swelling of microspheres,

Wt = weight of the microspheres after swelling, Wo = initial weight of the microspheres. All the experimental units were studied in triplicate (n=3).

In-vitro Dissolution Study

In vitro dissolution test has been carried out by using USP type I apparatus at 37 $\pm$ 0.5^{o}C in 900 ml of phosphate buffer solution pH 6.8. Microspheres comparable to 20 mg nitrofurantoin must've been attached now at the bottom of a paddle using muslin cloth, and rotated at 100 rpm. A sample of 5 ml has been forced to withdraw at various time intervals such as 30, 60, 120, 180, 240, 300, 360 and 420 min and filter the solution [17]. Assess this same filter the solution sample through UV Spectrophotometer at 265 nm and consider the quantity amount of drug release of drug for each interval to assess cumulative % of drug release but after every time intervals.

Stability Studies

Stability would be described as full scope from which a product remains in under specified limits all through period of storage and use. A drug formulation has been said to be stable if it fulfills the subsequent prerequisites [18]. The Formulation has been split into 3 sets of samples and stored at 4^{o}C in refrigerator, Room Temperature (29^{o}C), 45^{o}C $\pm$ 2^{o}C, 75^{o}C % RH $\pm$ 5 % in humidity control ovens. After 30 days drug components of all samples seemed to be calibrated by the method as it is in entrapment efficiency.

RESULTS AND DISCUSSION

Compatability Studies

DSC of Nitrofurantoin

The DSC thermograms of Plain drug seemed to be begun taking between 30–200°C at such a heating rate of 20°C/min. Pure drug has shown melting point at 272.8°C corresponding to its melting point, and that in the thermograph pattern of formulation no such peak were detected. So that it can be indicated that such drug would be pure [Figure 1].

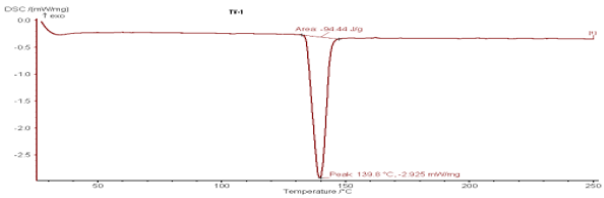

Figure 1: DSC of Nitrofurantoin

FTIR Analysis

The FTIR studies have been performed to drug, polymer mixture (sodium alginate, carbopol and sodium CMC were mixed in equal quantities) and microspheres and resulted in FTIR spectra given peaks corresponding to the functional groups present in each of them. The obtained data proved that each peak representing each functional group is clear and distinct. The peaks corresponding to the O—H stretching in drug showed a peak at 3435.77 cm^{-1}. Interestingly, the peak is shifted to 3420.09 cm^{-1} in microspheres suggesting the formation of hydrogen bonds showing the clear physical interactions between the drug and polymers. The peak at 1651.35 cm^{-1}of the drug representing the C=O functional group has been shifted to 1622.40 cm^{-1} supporting the assumption of hydrogen bonding between the oxygen atom from C=O group in drug with hydrogen atoms of O-H of the polymers and vice versa. No additional peaks were seen in the spectrum of microspheres proving no sign of formation of new chemical compounds indicating that no chemical interaction has occurred [Figure 2, Figure 3 and Figure 4].

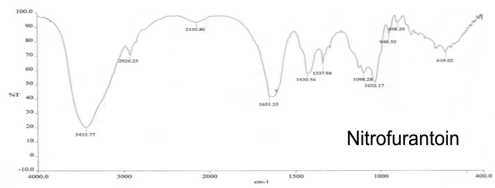

Figure 2: FTIR Spectrum of Nitrofurantoin

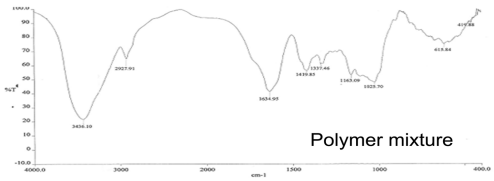

Figure 3: FTIR Spectrum of Polymers

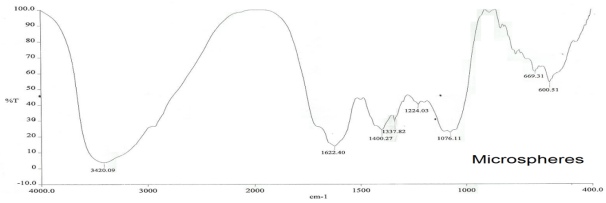

Figure 4: FTIR Spectrum of Microspheres

Physical Parameters

Following the table, five formulations have been prepared and evaluated. Microspheres are subjected to the evaluation of Percentage yield, Particle size, carr's index, Angle of repose, Drug entrapment, moisture loss, mucoadhesion strength, swelling index and *in vitro* drug release and the results was tabulated. The percentage yield of the all the formu-

Table 2: Physical Parameters of Prepared Microspheres

Formulatio no.	Swelling index % (X±S.D. n=3)	Particle size (μm)	Carr's Index	Angle of repose (Θ)	Drug entrapment % (X±S.D. n=3)	Moisture loss % (X±S.D. n=3)
F1	68.21±0.341	660	10.2	22.23	95.278±0.197	5.4±0.9
F2	72.56±0.1504	589	9.6	21.25	95.611±0.256	7.3±0.6
F3	69.47±0.174	620	11.2	24.31	96.691±0.285	4.9±0.8
F4	53.72± 0.473	493	10.8	22.62	94.398±0.730	5.8±1.2
F5	77.96±0.221	560	8.4	24.26	94.848±0.083	9.2±1.0

lations have really been evaluated and formulation F2 showed the highest percentage yield of 92% fol-

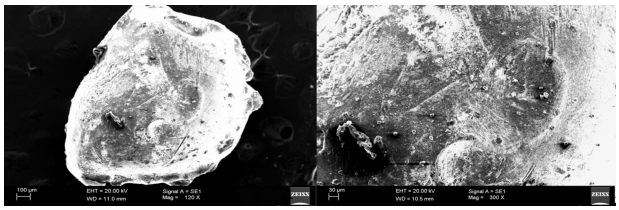

Figure 5: SEM Photographs of Microspheres

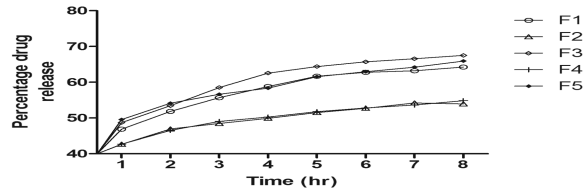

Figure 6: Drug Release from Microspheres

lowed by F3 which is 90% also significantly similar to F2 leading the rest [Table 2].

The particle size of nitrofurantoin filled microspheres has been evaluated by optical microscopy. Together all the batches of microspheres demonstrate uniform size distribution. The typical particle size of microspheres must have been found to be there in the range of 490 to 660 μm. From the results obtained, it was recognized that its particle size of the microspheres significant increase also as the drug: polymer ratio seemed to be elevated. That this might be due to a reduction of electrode surface (interfacial) voltage between the two droplets and the presence of emulsifying agent in the cross linking moderate. Also, as the stirring rate has been significant increase, the particle size of the microspheres had been significantly reduced from. It may be due to formation of small size droplets on higher stirring rate [Table 2].

The swelling values of the formulations containing high carbopol to CMC ratio are high comparing to those with low ratio. This suggests that the carbopol is responsible for water absorption and swelling. Swelling and faster the swelling, higher the drug release. It is clear from F5 having highest swelling index of 77% which has a high carbopol content and as suggested F3 should have the least swelling index surprisingly, F4 has swelled less may be due to the low concentration of sodium alginate. This supports the effect of sodium alginate in swelling [Table 2].

Moisture loss percentage was calculated. All the values are under limits. Formulation F3 showed a lower value compared to all formulations. So we can confirm that formulation is dried properly and the content of carbopol also affects the amount of moisture present in the microspheres as evident from their swelling indices.

SEM Analysis

The prepared microspheres has been evaluated for particle shape and surface methodology using S.E.M. The photographs were given in figures. At random each microsphere is about 700 μm in diameter. It is roughly circle in shape and with a smooth texture [Figure 5]. The drying of microspheres was proper as there are no cracks and folding on the surface.

In vitro Drug Release Studies

The drug release studies had been performed and the percentage was calculated. All formulations showed a good controlled release which is between 53.966±0.597 and 67.510±0.57 representing formulations F2 and F3. Individually the drug release of F1, F2, F3, F4 and F5 is 64.25±0.157, 53.966±0.597, 67.510±0.57, 54.836±0.55 and 65.913±0.211 in 8 hrs respectively [Table 3 & Figure 6]. Formulation F1 and F3 showed a release in a sustained manner. It was expected the release to continue for still 4 more hours. Overall a drug release sustained to 12 hrs is achievable.

Stability Studies

The stability research (studies) of formulations had indeed been carried out and the results were shown in Figure 7. The formulations showed a very good stability at both 4^{o}C then at room temperature. But

Table 3: Percentage Drug Release of Prepared Microspheres

Time in hrs	Percentage drug release (X±S.D. n=3)				
	F1	F2	F3	F4	F5
1	46.89±0.53	42.650±0.28	48.723±0.29	42.696±0.29	49.590±0.16
2	51.84±0.436	46.946±0.37	53.4±0.427	46.546±0.21	54.160±0.619
3	55.69±0.43	48.476±0.27	58.513±0.30	49.056±0.62	56.640±0.485
4	58.82±0.488	49.920±0.11	62.536±0.22	50.29±0.202	58.340±0.512
5	61.66±0.315	51.506±0.25	64.396±0.29	51.80±0.078	61.550±0.29
6	62.73±0.41	52.720±0.22	65.723±0.24	52.820±0.63	62.956±0.66
7	63.23±0.06	54.210±0.67	66.570±0.29	53.660±0.32	64.220±0.12
8	64.25±0.15	53.966±0.59	67.510±0.57	54.836±0.55	65.913±0.21

there was a reduction in drug content when stored at 45^{o}C ± 2^{o}C / 75% RH.

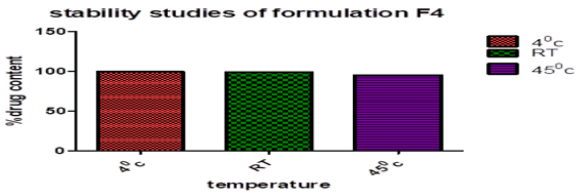

Figure 7: Stability Study: Comparison of % Drug Content of Formulation F2 at 4^{o}C, Room temperature (29^{o}C) and 45^{o}C ± 2^{o}C / 75% RH

CONCLUSION

Inside this current research work, an attempt is made of to provide Microspheres in Hard Gelatin Capsule using polymer combinations of sodium alginate, carbopol and Sodium CMC (carboxymethyl cellulose) with Nitrofurantoin as the formulating drug which is used in Urinary Tract Infections. Performed FTIR studies showed no additional peaks were seen in the spectrum of microspheres proving no sign of formation of new chemical compounds indicating that no chemical interaction has occurred and that there is no incompatibility between drug and polymers. The Microspheres of Nitrofurantoin seemed to be able to prepare by orifice ionic gelation technique as for polymer combos of sodium alginate, carbopol and Sodium CMC (carboxymethyl cellulose). Five formulations have been prepared and evaluated. Microspheres are subjected to the evaluation of Percentage yield, Particle size, carr's index, Angle of repose, Drug entrapment, moisture loss, mucoadhesion strength, swelling index and *in vitro* drug release. The proportion yield of the all the formulations have been evaluated and formulation F2 showed the highest percentage yield of 92% followed by F3 which is 90% also significantly similar to F2 leading the rest. Swelling and faster the swelling, higher the drug release. It is clear from F5 having highest swelling index of 77% which has a high carbopol content and as suggested F3 should have the least swelling index surprisingly, F4 has swelled less may be due to the low concentration of sodium alginate. This supports the effect of sodium alginate in swelling. Formulation F3 showed a lower value compared to all formulations. So we can confirm that formulation is dried properly and the content of carbopol also affects the amount of moisture present in the microspheres as evident from their swelling indices. The formulations showed a good stability at both 4^{o}c and at room temperature. But there was a reduction in drug content when stored at 45^{o}C ± 2^{o}C / 75% RH. Formulation F1 and F3 showed a release in a sustained manner. It was expected the release to continue for still 4 more hours. Overall a drug release sustained to 12 hrs is achievable. For future research combination of these polymers will be helpful in making sustained release Microspheres in Hard Gelatin Capsule with other drugs similar to Nitrofurantoin.

ACKNOWLEDGEMENT

I would like to thank Principal sir (Dr. Kamal Hassan), St. Mary's Group of Institutions, Deshmukhi (Village), Pochampally (Mandal), Yadadri Bhuvanagiri (Dist), Telangana-508284, India.

Funding Support

The authors declare that they have no funding support for this study.

Conflict of Interest

The authors declare that there is no conflict of interest.

REFERENCES

[1] Christiaens TCM, Meyere MD, Verschraegen G, et al. Randomised controlled trial of nitrofurantoin versus placebo in the treatment of

uncomplicated urinary tract infection in adult women. The British Journal of General Practice : The Journal of the Royal College of General Practitioners. 2002;52(482):729–734.

[2] Nicolle LE, Bradley S, Colgan R, et al. Infectious Diseases Society of America Guidelines for the Diagnosis and Treatment of Asymptomatic Bacteriuria in Adults. Clinical Infectious Diseases. 2005;40(5):643–654.

[3] Gupta K, Hooton TM, Roberts PL, et al. Patient-initiated treatment of uncomplicated recurrent urinary tract infections in young women. Annals of Internal Medicine. 2001;135(1):9–16.

[4] Murtaza G, Ahamd M, Akhtar N, et al. A comparative study of various microencapsulation techniques: effect of polymer viscosity on microcapsule characteristics. Pakistan Journal of Pharmaceutical Sciences. 2009;22(3):291–300.

[5] Samanta MK, Tamilvanan S, Babu K, et al. Formulation and evaluation of chlorpromazine hydrochloride loaded self-crosslinked gelatin microcapsules. Indian journal of pharmaceutical sciences. 1997;59(2):68–74.

[6] Shanthi NC, Gupta R, Mahato KA. Traditional and emerging applications of microspheres: A review. International Journal of Pharm Tech Research. 2010;2(1):675–681.

[7] Kumar KR, Ramesh Y, Farheen S, et al. Formulation and evaluation of amlodipine floating micro beads. International Journal of Pharmacometrics and Integrated Biosciences. 2016; 1(4):81–86.

[8] Najmuddin M, Ahmed A, Shelar S, et al. Floating microspheres of ketoprofen: formulation and evaluation. Int J Pharm Pharm Sci. 2010; 2:164–172.

[9] Trivedi P, Verma AML, Garud N. Preparation and characterization of aceclofenac microspheres. Asian Journal of Pharmaceutics (AJP): Free full text articles from Asian J Pharm. 2008; 2:110–115.

[10] Reddy MV, Kumar KS, Ramesh Y, et al. Preparation And Evaluation Of Quetiapine Fumarate Microspheres. Journal of Pharmacy Research. 2011;4(11):41–43.

[11] Chowdary KR, Rao NK, Malathi K. Ethyl cellulose microspheres of glipizide: Characterization, in vitro and in vivo evaluation. Indian Journal of pharmaceutical sciences. 2004;66(4):412–416.

[12] Chowdary KPR, Babu KVVS. Studies on Micro encapsulation by Calcium Alginate. The Eastern Pharmacist. 1989;2:125–126.

[13] Gobinath Y, Deepthi A, Madhavi C, et al. Preparation And Evaluation Of Valacyclovir Microspheres. IJPT. 2015;5(1):8131–8145.

[14] Behera BC, Sahoo SK, Dhal S, et al. Characterization Of Glipizide-Loaded Polymethacrylate Microspheres Prepared By An Emulsion Solvent Evaporation Method. Tropical Journal of Pharmaceutical Research. 2008;7(1):879–885.

[15] Patel B, Modi V, Patel K, et al. Preparation and evaluation of ethyl cellulose microspheres prepared by emulsification-solvent evaporation method. International journal for research in management and pharmacy. 2012;1(1):82–91.

[16] Parameswari A, Gujjula P. Formulation and In-vitro Evaluation of Moxifloxacin Microspheres Using Natural Polysaccharides. Future Journal of Pharmaceuticals and Health Sciences. 2021; 1(1):24–28.

[17] Soni ML, Kumar M, Namdeo KP. Sodium alginate microspheres for extending drug release: formulation and in vitro evaluation. International Journal of Drug Delivery. 2010;2(1):64–68.

[18] Ramesh Y, Sarayu B, Chandana GH, et al. Formulation and Evaluation of Lamivudine Nanosuspension. Journal of Drug Delivery and Therapeutics. 2021;11(4-S):71–77.

Cite this article: Madhuri Reddy M, Gundala Deepika, Meesala Simon, Pothireddy Bharat, Golam Sofiullah SK, Addakula Varalaxmi. **Formulation and Evaluation of Nitrofurantoin Microspheres Loaded in Hard Gelatin Capsule**. Int. J.Exp. Biomed. Res. 2022; 1(1): 23-29.