Research Article

Microsuspension of an Antibiotic, Design Statistical Analysis and Optimization

Rajappa Margret Chandira[1,*], Palanisamy Pethappachetty[1], Gudanagaram Ramamoorthy Vijayasankar[1], Nallaiya Tamilarasan[2]

[1]Department of Pharmaceutics, Vinayaka Mission's College of Pharmacy, Vinayaka Mission's Research Foundation (Deemed to be University), Salem, Tamil Nadu, INDIA.
[2]Vinayaka Mission's College of Pharmacy, Vinayaka Mission's Research Foundation (Deemed to be University), Salem, Tamil Nadu, INDIA.

Submission Date: 11-05-2022; Revision Date: 24-06-2022; Accepted Date: 19-07-20222.

ABSTRACT

An attempt has been made in this study for formulation and evaluation of ofloxacin Microsuspension by adding excipients in formulations. It can be given by any route due to its rapid disintegration rate. The performance of biological systems has improved. Suspensions are more chemically stable than solutions. It can be used for drugs that are poorly water-soluble and administered via any method. The physicochemical characterization for a pure drug such as organoleptic properties, spectral analysis UV spectroscopic studies, ATR-FTIR and DSC were investigated and confirmed. Various formulations of ofloxacin micro-suspension were formulated by using SLS, PVP and Urea in different concentrations by the micro-precipitation method. The prepared micro-suspension has a smooth surface morphology and is spherical at 200nm. The Microsuspension were evaluated for physical characterization, pH, drug loading, sedimentation volume, viscosity, particle size, *in vitro* drug release and the stability studies carried out for the optimized formulation.

Keywords: Ofloxacin, Microsuspension, Micro-Precipitaion method, Enhance absorption, Bioavailability.

Correspondence:
Prof. Dr. Rajappa Margret Chandira
Department of Pharmaceutics, Vinayaka Mission's College of Pharmacy, Vinayaka Mission's Research Foundation (Deemed to be University), Salem, Tamil Nadu, INDIA.

Email: mchandira172@gmail.com

INTRODUCTION

Microsuspension

It's a colloidal dispersion of drug particles that are submicron in size. A micro suspension is a biphasic, colloidally dispersed system made up of pure drug particles dispersed in an aqueous vehicle with a particle size of less than 1mm and stabilized with surfactants and polymers, and manufactured using appropriate procedures such as bottom-up and down approaches for drug delivery applications via oral, topical, parenteral, ophthalmic and pulmonary routes. The micro-suspension has been reported to enhance absorption and bioavailability. Antimicrobial medications are taken orally to have a systemic effect, however, this might result in side effects such as hypersensitivity, gastrointestinal discomfort, and bacterial resistance. This kind of administration also does not assure an acceptable concentration at the action site since the active component is not retained locally for a long enough amount of time. To improve the drug's dissolving velocity and saturation solubility. Biological performance has improved. A coarse dispersion of finely subdivided insoluble solid drug floating in a suitable liquid (typically aqueous) medium can be defined. It is a biphasic preparation that is flocculated or deflocculated and consists of one or more solid particles. It comprises one or more active chemicals suspended in a vehicle that is appropriate for them. Wide mouth bottles should be used to store them. It can be used for drugs that are poorly water-soluble and administered via any method. Due to the high dissolution rate, biological performance has improved. Chemically, suspensions are more stable than solutions.[1-4]

SCAN QR CODE TO VIEW ONLINE

www.ajbls.com

DOI: 10.5530/ajbls.2022.11.49

MATERIALS

Ofloxacin was received as a gifted sample from Goodman Pharmaceuticals, Pondicherry and Sodium Lauryl Sulfate, Polyvinyl Pyrrolidone, Urea and Ethanol were purchased from VMCP in Salem, Tamilnadu, India. The studies of other chemicals and reagents were in analytical grade.

METHODS

Physicochemical Characterization and Drug Identification[5]

Physicochemical characterization of the drug provides the information to identify the nature of the drug substance.

Spectroscopic Studies (UV spectral analysis)[6]

A Shimadzu spectrophotometer was used to gather ultraviolet and visible spectra (UV–Vis) in the 200–400 nm range, in 0.1 N Hcl was created for this research.

Preparation of Stock Solution[7]

Dissolving 50 mg of Ofloxacin in 50 ml of 0.1 N Hcl produced a stock solution of Ofloxacin (1000 g/ml). The dilutions ranged from 3 to 15 g/ml. Using a Shimadzu-1700 Pharmaspec UV- visible spectrophotometer, the solution was kept in the wavelength range of 200-400 nm to determine the maximum absorbance of Ofloxacin. The result is shown in Figure 1.

ATR-FTIR Spectra Analysis[8]

FTIR Spectroscopy with Perkin Elmer RX1 was used to test the compatibility of Ofloxacin with the carrier's urea, PVP mixture of urea was utilised to make microsuspension. To evaluate the changes in the chemical composition of the drug after combining it with excipients, spectral analysis of Ofloxacin, urea, and PVP was performed. In the frequency range 4000-400cm^{-1}, JASCO FT/IR 4100, MD, and the USA conducted an FTIR compatibility investigation. The result is shown in Figures 2, 3, and 4.

UV Spectral Analysis

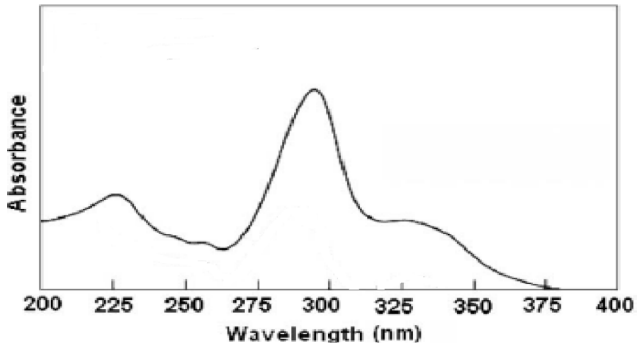

Figure 1: Maximum absorbance of ofloxacin.

ATR – FTIR (Drug interaction studies)

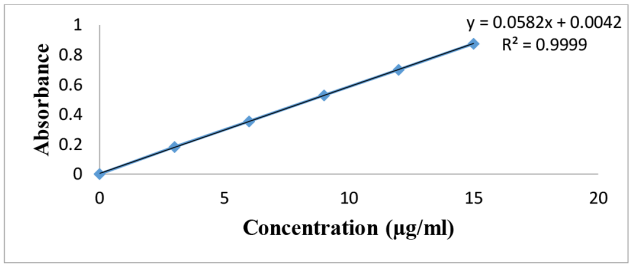

Figure 2: UV absorbance for ofloxacin using 0.1N Hcl.

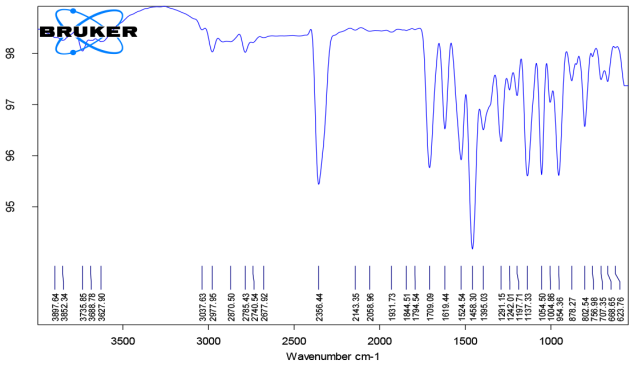

Figure 3: ATR-FTIR spectrum of Ofloxacin.

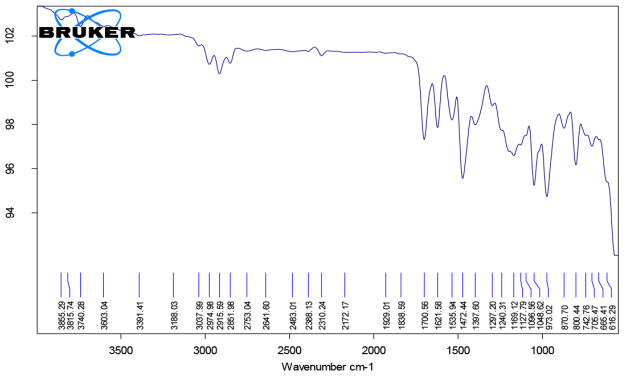

Figure 4: ATR-FTIR Spectroscopy of Ofloxacin Microsuspension Formulation.

Differential Scanning Calorimetry (DSC)[9]

A curve of pure Ofloxacin, PVP, urea, and physical mixtures was measured using a thermal analysis device with a liquid nitrogen sub-ambient accessory. A weighed 10 mg of sample was deposited in an aluminium pan and completely sealed before being introduced into the calorimeter thermocouples. All materials were weighed (8-10 mg) and heated at a scanning rate of 10°C/min

Differential Scanning Calorimetry (DSC)

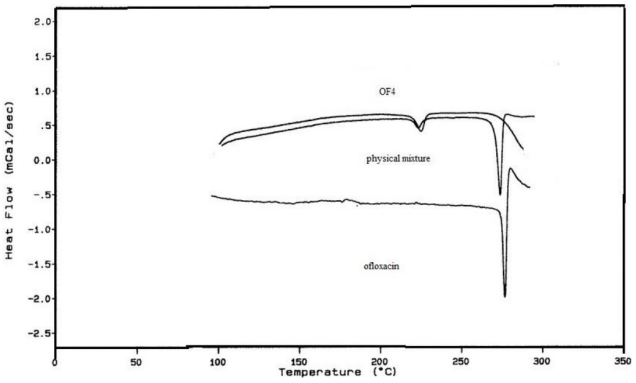

Figure 5: Differential scanning calorimetry (DSC) ofloxacin, Physical mixture and OF4.

Table 1: Preparation of ofloxacin Loaded Microsuspension.

Formulation	OF1	OF2	OF3	OF4	OF5	OF6
Ofloxacin	50mg	50mg	50mg	50mg	50mg	50mg
SLS	--	25mg	--	25mg	--	25mg
PVP	50mg	50mg	100mg	100mg	--	--
UREA	100mg	150mg	100mg	150mg	100mg	150mg
ETHANOL	10ml	10ml	10ml	10ml	10ml	10ml
WATER	10ml	10ml	10ml	10ml	10ml	10ml

and under dry nitrogen flow (100 ml/min) between 50 -300°C. The result is shown in Figure 5.

Formulation Development

Preparation of ofloxacin micro-suspension by micro-precipitation[10]

The micro-suspension was made by using the precipitation method. The drug's organic component, Ofloxacin, was dissolved in 5 mL of methanol. At room temperature, the organic phase was gently infused drop by drop with a syringe into 10ml of 0.1N Hcl aqueous phase containing carrier urea, PVP, and surfactants SLS at the speed of 500-700rpm. Increase the speed of the magnetic stirrers until all of the drug solutions has been added to the surfactant solution and the methanol has evaporated completely. The formulation shown in the Table 1.

Evaluation studies for Microsuspension

Scanning electron microscope (SEM)[11]

The surface morphology of the material was examined using a scanning electron microscope (SEM), Model JSM 84 0A, JEOI, Japan. The samples are properly dried in a vacuum desicator before mounting on brass specimen studies using double-sided adhesive tape. A gold-palladium alloy with a temperature of 120°C on the sample sputter coating apparatus, calves were coated in Argon with a flame voltage of roughly 20mA. (Model E5 100 Polaron U.K). Sputtering was conducted for around 5 min to get a uniform coating on the sample and allow it for elevated the SEM pictures. The SEM was operated at a modest 15KV accelerating voltage and 80mA load current. The condenser optics focal length was fixed between 4.4 and 5.1. The diameter of the optical system aperture is 240 microns with a working distance of 39mm. The result is shown in Figure 6.

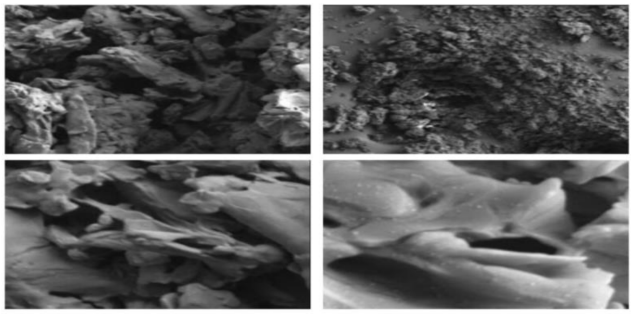

Figure 6: The surface morphology of prepared micro-suspension.

Table 2: Percentage yield and Entrapment efficiency.

Formulation code	Percentage yield (%)	Entrapment Efficiency (%)
OF1	84.86	84.37
OF2	89.67	86.77
OF3	90.00	87.3
OF4	94.61	90.2
OF5	86.33	87.13
OF6	92.13	88.67

Determination of Percentage Yield and entrapment efficiency[12]

A precise measurement of 10 ml of suspension (20 mg/ml) was taken in a 100 ml volumetric flask. 0.1 N Hcl was added to make up the required volume in different ratios and the entrapment efficiency was calculated. After drying, the samples were weighed and the yield was determined as a percentage. The result is shown in Table 2.

$$\text{Percentage yield} = \left(\frac{\text{Practical yield}}{\text{Theoritical yield}} \right) \times 100$$

$$\text{Entrapment efficiency} = \left(\frac{\text{Practical drug content}}{\text{Theoritical drug content}} \right) \times 100$$

Viscosity measurement[13]

The viscosity of the sample was evaluated at 25°C by using a Brookfield Synchrolectic viscometer, model

Table 3: Evaluation of ofloxacin Microsuspension.

Parameters	Formulation Batches Code		
	OF3	OF4	OF6
Viscosity (cps)	250	297	280
Ph	4.18	4.45	4.27
Sedimentation Volume (F)	0.90	0.97	0.96
Color	Pale yellow	Pale yellow	Pale yellow
Taste	Less Bitter	Less Bitter	Less Bitter
Drug loading	40.46	41.95	41.47

LVF (Brookfield Laboratories, Massachusetts), spinning at 30 revolutions per minute (Spindle 4). The result is shown in Table 3.

Determination of PH[14]

A digital pH metre was used to determine the pH of the prepared suspensions, and the findings were recorded. The result is shown in Table 3.

Sedimentation volume[15]

Volume of sedimentation F is the proportion of the sediment equilibrium volume (Vu) to the entire volume of suspension (Vo). The result shown in Table 3.

$$F = Vu / Vo$$

Where Vu denotes the sediment volume.
The total volume of suspension is referred to as Vo.
The sedimentation volume F is usually less than or equal to one.

Drug Loading[16]

The drug concentration was determined using a spectrophotometric assay at 294 nm and a blank of 0.1 N Hcl (pH1.2). The result is shown in Table 3.

Particle size analysis[17]

Particle size analysis of ofloxacin micro suspension is characterized by using the instrument Micronanotrac A150. All the prepared ofloxacin micro-suspension formulations were analysed for particle sizes. The mean particle size (PS) for ofloxacin suspension was measured. The result is shown in Table 4.

In-vitro Drug Release Study[18]

The dissolution equipment was used to perform the *in-vitro* drug release study for the prepared micro-suspension (paddle type). The dissolution medium 900 ml of 0.1 N Hcl, was placed in a bowl at a temperature of 37°C and 50 rpm. A 5 mL of suspension was poured into each bowl and the study was carried out for 60 min. Every 10 min, a 5 mL sample was taken from a bowl and the dissolution medium was replaced with an equal amount of new dissolution media. After withdrawal, samples were filtered, diluted properly, and spectrophotometrically analyzed at 294 nm with 0.1 N HCl as a blank for Ofloxacin. The cumulative percentage of drug release was calculated. The results show in Table 5 and Figure 7.

Table 4: Particle size analysis of ofloxacin Microsuspension.

Sl.No	Formulation	Particle size (nm)
1.	OF3	360.00
2.	OF4	284.30
3.	OF6	297.10

Table 5: *In vitro* drug release profile of Ofloxacin Microsuspension.

Sl. No	Time (mins)	Percentage of drug release (%)		
		OF3	OF4	OF6
1	0	0	0	0
2	5	7.02	8.14	8.06
3	10	15.11	17.35	16.55
4	15	23.35	25.89	23.8
5	20	30.05	33.11	30.15
6	25	37.28	41.03	38.18
7	30	45.89	49.72	45.27
8	35	53.92	58.93	53.42
9	40	60.05	66.05	62.33
10	45	67.83	73.23	70.28
11	50	75.44	80.19	77.93
12	55	83.51	87.58	85.81
13	60	90.11	94.17	93.07

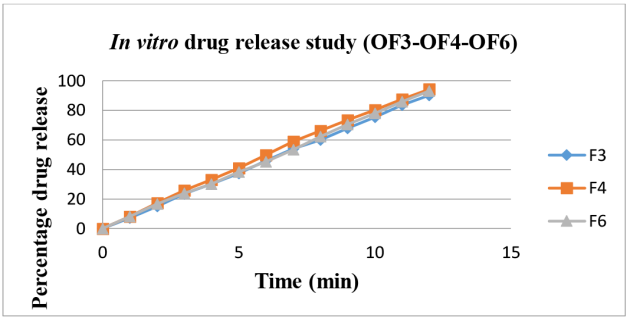

Figure 7: *In vitro* Drug profile of Ofloxacin Microsuspension (OF3-OF4-OF6).

Stability Studies[19]

As per ICH guidelines the short-term stability studies were carried out for the optimized formulation were kept at Accelerated temperature at 40°C±2°C/75%±5%RH

Table 6: Stability Studies of Optimized Ofloxacin Microsuspension(OF4) formulation at refrigerated temperature (4°C) and Accelerated temperature (40°C) for three months.

Sl. No	Parameters	Initial volume	For 1 month		For 2 months		For 3 months	
			Accelerated condition (40±2°C / 75±5% RH)	Refrigeration condition (4°C)	Accelerated condition (40±2°C / 75±5% RH)	Refrigeration condition (4°C)	Accelerated condition (40±2°C / 75±5% RH)	Refrigeration condition (4°C)
1.	Viscosity (cps)	297	296	297	295	295	294	295
2.	Ph	4.45	4.48	4.48	4.51	4.51	4.55	4.55
3.	Sedimentation Volume (F)	0.97	0.97	0.97	0.97	0.97	0.97	0.97
4.	Color	Pale yellow	Pale yellow	Pale yellow	Pale yellow	Pale yellow	Pale yellow	Pale yellow
5.	Taste	Less Bitter	Less Bitter	Less Bitter	Less Bitter	Less Bitter	Less Bitter	Less Bitter
6.	Drug loading	41.5	41.84	41.90	41.56	41.68	41.09	41.21

and Refrigerated temperature at 4°C±2°C/75%±5%RH for three months. The result is shown in Table 6.

RESULTS AND DISCUSSION

Organoleptic Properties

The organoleptic characteristics of the drug sample were investigated and the results of the drug Ofloxacin are white to pale yellow colour and the melting point is 250-257°C degrees Celsius. As a result, the observed values are by IP.

Solubility Study

During solubility studies using the shaking flask method, excess amounts of the drug were separately added to distilled water, ethanol, and 0.1N Hcl. A UV spectrophotometric approach was used to determine the solubility level at 294 nm. In ethanol, water, and 0.1N Hcl, the antibiotic Ofloxacin was slightly soluble.

Evaluation of ofloxacin Microsuspension

Scanning Electron Microscopy (SEM)

The surface morphology of the micro-suspension was evaluated by SEM examination of the formulated oflaxacin micro-suspension. Optimized OF4 Formulation SEM pictures given in the OF4 Formulation were investigated for SEM imaging to acquire the morphological image of the suspension. But the Figure below text shows that the globules in Micro-Suspension are homogeneously generated with no global size breakdown.

Physical characterization of ofloxacin Microsuspension

Evaluation studies were carried out for the prepared optimized ofloxacin micro-suspension of viscosity, pH, sedimentation volume, colour, taste and drug loading

DISCUSSION[20-21]

Organoleptic Properties

The organoleptic characteristics of the drug sample were investigated and the results of the drug Ofloxacin are white to pale yellow colour and the melting point is 250-257°C degrees Celsius. As a result, the observed values are by IP.

Solubility Study

During solubility studies using the shaking flask method, excess amounts of the drug were separately added to distilled water, ethanol, and 0.1N Hcl. A UV spectrophotometric approach was used to determine the solubility level at 294 nm. In ethanol, water, and 0.1N Hcl, the antibiotic Ofloxacin was slightly soluble.

UV Spectral Analysis

In UV spectral analysis, the maximum wavelength of the drug Ofloxacin in 0.1N HCl is 294 nm. In the concentration range of 3-15 g/ml, Ofloxacin absorbance in 0.1N Hcl was found to be linear.

It was determined that the substance passed the preliminary identification test and It also determined that the drug had a maximum wavelength of 294 nm after scanning it in 0.1N HCl. The result shows that the drug obeys Beer-Lamberts law in the concentration range of 3, 6, 9, 12 and 15g/ml.

ATR – FTIR (Drug interaction studies)

The drug interaction experiments were analysed using ATR-FTIR, and these excipients were mixed in varied ratios with ofloxacin depending on the functional category. The peaks in the spectra of ofloxacin Microsuspension OF4 formulation are compared to the peaks in the spectrum of ofloxacin. This indicates that the drug is compatible with the other ingredients in the formulation.

Differential Scanning Calorimetry (DSC)

In ofloxacin was combined with several polymers. The combination of a drug with polymers increases the likelihood of masking an interaction. The pure drug, OF4, and physical combinations of polymers and drug were examined using DSC thermograms. Ofloxacin DSC thermogram exhibits a prominent endothermic peak at 50–300°C, which corresponds to its melting point.

Scanning Electron Microscopy (SEM)

The surface morphology of the micro-suspension was evaluated by SEM examination of the formulated oflaxacin micro-suspension. Optimized OF4 Formulation SEM pictures are given in the OF4 Formulation were investigated for SEM imaging to acquire the morphological image of suspension. But the Figure below text shows that the globules in Micro-Suspension are homogeneously generated with no global size breakdown.

Determination of Percentage Yield and Entrapment Efficiency

After drying, ofloxacin-loaded micro-suspension was weighed. The yield was determined as a percentage. The drug-loaded micro-suspension prepared were evaluated for percent yield (OF1-84-86% - OF6-92.13%). The entrapment efficiency of the micro-suspension formulations comprising varied ratios of the polymer ranges from 84.37 to 88.67 percent, respectively.

Physical Characterization of Ofloxacin Microsuspension

The Microsuspension were evaluated for physical characterization (pH, drug loading, sedimentation volume, viscosity, particle size and *in vitro* drug release study).

The pH range for the prepared OF3, OF4 and OF6 microsuspension formulation is 4.18, 4.45 and 4.27, the viscosity range is 250cps, 297cps and 280cps, the sedimentation volume is 0.90, 0.97 and 0.96F, the drug loading range is 40.46, 41.95 and 41.47, the particle size range is 360.00nm, 284.30nm and 297.10nm are within the pharmacopeial limits.

Particle Size Analysis

Particle size analysis was generated from micronanostrac A150. The particle size was consistent in the range of 200-300 nm with a particle size distribution of less than 284.30 indicating a good result.

In-vitro Drug Release Study

In-vitro drug releases for the prepared ofloxacin micro-suspension the amount of drug release was measured at various time intervals by using a paddle type. From this study, the OF4 formulation considers an optimized formulation because it releases 94.17% of the drug at a time interval of 60 min.

Stability Studies

Stability studies were conducted for optimized formulation (OF4) at Accelerated temperature at 40°C±2°C/75%±5%RH and Refrigerated temperature at 4°C±2°C/75%±5%RH for three months. Mild variations were noticed in Viscosity, pH, Sedimentation volume, Color, Taste, and Drug loading. As a result, was revealed to be the formulation (OF4) and all of the reports are within the specification ranges in refrigerated stability studies.

SUMMARY AND CONCLUSION

The present study was undertaken to formulate and evaluate micro-suspension of an antibiotic, ofloxacin. Preformulation studies were carried out initially and based on that, different batches were formulated with different concentrations of surfactants and carriers. As a result of these studies, it is possible to conclude that the Ofloxacin-loaded Microsuspension formulations, particularly the OF4 formulation, demonstrated improved release behaviour, which would aid in reducing dose frequency and providing an effective modified route of administration.

ACKNOWLEDGEMENT

The authors are thankful to Dr. B.Jaykar, Professor and Registrar, Vinayaka Mission's Research Foundation (Deemed to be University) and Vinayaka Mission's College of Pharmacy, Salem, Tamil Nadu for extending their support and facilities for this research.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

ABBREVIATIONS

ICH: International conference on harmonization; **IP:** Indian Pharmacopeia; **Mins:** Minutes; **OF:** Ofloxacin; **PVP:** Polyvinyl Pyrrolidone; **SLS:** Sodium Lauryl Sulphate; **UV:** Ultra Violet.

REFERENCES

1. Kolluru LP, Atre P, Rizvi SAA. Characterization and applications of colloidal systems as versatile drug delivery carriers for parenteral formulations. Pharmaceuticals (Basel). 2021;14(2):108. doi: 10.3390/ph14020108, PMID 33573103.
2. Gunasekaran T, Haile T, Nigusse T, Dhanaraju MD. Nanotechnology: An effective tool for enhancing bioavailability and bioactivity of phytomedicine. Asian Pac J Trop Biomed. 2014;4(Suppl 1):S1-7. doi: 10.12980/APJTB.4.2014C980, PMID 25183064.
3. Ammar HO, Ghorab MM, Mahmoud AA, Noshi SH. Formulation of risperidone in floating microparticles to alleviate its extrapyramidal side effects. Future J Pharm Sci. 2016;2(2):43-59. doi: 10.1016/j.fjps.2016.08.001.
4. Gupta D, Bhatia D, Dave V, Sutariya V, Varghese Gupta S. Salts of therapeutic agents: Chemical, physicochemical, and biological considerations. Molecules. 2018;23(7):1719. doi: 10.3390/molecules23071719, PMID 30011904.
5. Wakankar A, Chen Y, Gokarn Y, Jacobson FS. Analytical methods for physicochemical characterization of antibody drug conjugates. In MAbs 2011. Taylor and Francis.
6. Hotta S, Rughooputh SDDV, Heeger AJ, Wudl F. Spectroscopic studies of soluble poly (3-alkylthienylenes). Macromolecules. 1987;20(1):212-5. doi: 10.1021/ma00167a038.
7. Erhirhie EO, Ekene NE, Ajaghaku DL. Guidelines on dosage calculation and stock solution preparation in experimental animals' studies. J Nat Sci Res. 2014;4(18):100-6.
8. Durak T, Depciuch J. Effect of plant sample preparation and measuring methods on ATR-FTIR spectra results. Environ Exp Bot. 2020;169:103915. doi: 10.1016/j.envexpbot.2019.103915.
9. Menczel JD, Judovits L, Prime RB, Bair HE, Reading M, Swier S. Differential scanning calorimetry (DSC). Thermal analysis of polymers: Fundamentals and applications. 2009;7:239.
10. Seto Y, Morizane C, Ueno K, Sato H, Onoue S. Supersaturable self-emulsifying drug delivery system of Krill oil with improved oral absorption and hypotriglyceridemic function. J Agric Food Chem. 2018;66(21):5352-8. doi: 10.1021/acs.jafc.8b00693, PMID 29754485.
11. Wells OC, Broers AN, Bremer CG. Method for examining solid specimens with improved resolution in the scanning electron microscope (SEM). Appl Phys Lett. 1973;23(6):353-5. doi: 10.1063/1.1654916.
12. Krishna SR, Ramu A, Vidyadhara S. Study of Influence of Formulation and process variables on entrapment efficiency and particle size of Floating microballoons of clopidogrel bisulphate by DoE. Res J Pharm Technol. 2020;13(9):4373-80. doi: 10.5958/0974-360X.2020.00773.8.
13. Cannon MR, Fenske MR. Viscosity measurement. Ind Eng Chem Anal Ed. 1938;10(6):297-301. doi: 10.1021/ac50122a002.
14. Kalra YP. Determination of pH of soils by different methods: Collaborative study. J AOAC Int. 1995;78(2):310-24. doi: 10.1093/jaoac/78.2.310.
15. Freundlich H, Jones AD. Sedimentation volume, dilatancy, thixotropic and plastic properties of concentrated suspensions. J Phys Chem. 1936;40(9):1217-36. doi: 10.1021/j150378a012.
16. Shen S, Wu Y, Liu Y, Wu D. High drug-loading nanomedicines: Progress, current status, and prospects. Int J Nanomedicine. 2017;12:4085-109. doi: 10.2147/IJN.S132780, PMID 28615938.
17. Anderson DG, Vandeberg JT. Coatings. Anal Chem. 1983;55(5):1-18. doi: 10.1021/ac00256a001.
18. Keawchaoon L, Yoksan R. Preparation, characterization and *in vitro* release study of carvacrol-loaded chitosan nanoparticles. Colloids Surf B Biointerfaces. 2011;84(1):163-71. doi: 10.1016/j.colsurfb.2010.12.031, PMID 21296562.
19. Boyanton Jr BL, Blick KE. Stability studies of twenty-four analytes in human plasma and serum. Clin Chem. 2002;48(12):2242-7. doi: 10.1093/clinchem/48.12.2242, PMID 12446483.
20. Doye PA, Mena TA, Das NI. Formulation and bio-availability parameters of pharmaceutical suspension. Int J Curr Pharm Sci. 2017;9(3):8-14. doi: 10.22159/ijcpr.2017.v9i3.18892.
21. Müller RH, Jacobs C. Buparvaquone mucoadhesive nanosuspension: Preparation, optimisation and long-term stability. Int J Pharm. 2002;237(1-2):151-61. doi: 10.1016/s0378-5173(02)00040-6, PMID 11955813.

Cite this article: Chandira RM, Pethappachetty P, Vijayasankar GR, Tamilarasan N. Microsuspension of an Antibiotic, Design Statistical Analysis and Optimization. Asian J Biol Life Sci. 2022;11(2):367-73.