INTERNATIONAL RESEARCH JOURNAL OF PHARMACY
www.irjponline.com
ISSN 2230 – 8407

Research Article

COMPARISON OF DRUG RELEASE: MICROPARTICLES VS NANOPARTICLES

Sharad Visht *, Nishat Anjum, Aanchal Saini
Smt. Tarawati Institute of Bio-Medical & Allied Sciences, Roorkee, India
*Corresponding Author Email: sharadvisht@gmail.com

Article Received on: 08/04/18 Approved for publication: 29/04/18

DOI: 10.7897/2230-8407.09460

ABSTRACT

AIM: The purpose of this research was to study and compare the drug release from microparticles vs nanoparticles as drug delivery systems.
METHODS: The microparticles and nanoparticles were prepared using single phase emulsification method followed by heat stabilization method. The glycyrrhetinic acid ammonium was used as drug, bovine serum albumin as polymer and carbopol 934P as mucoadhesive agent. Microparticles and nanoparticles were evaluated and the kinetics of drug release were studied using BIT software. The *in-vivo* drug release were studied and the *in-vitro* – *in-vivo* correlation was established.
RESULTS: The line equation was found to be y = 0.0012x + 0.0003 for glycyrrhetinic acid ammonium and the FTIR showed no drug excipient interaction. The product yield was calculated and particle size, drug entrapment, drug loading, swelling index, mucoadhesion testing by *in-vitro* wash-off test and percentage cumulative drug release were determined for microparticles and nanoparticles. The kinetics of drug release was studied using BIT software which showed that the drug release follows Korsmeyer-Peppas equation model as best fit for microparticles or nanoparticles which indicate the drug is released by anomalous transport mechanism.
DISCUSSION AND CONCLUSION: It was concluded that nanoparticles maintains the plasma drug concentration better than microparticles on the basis of *in-vivo* drug release.

KEYWORDS: Microparticles, nanoparticles, glycyrrhetinic acid, emulsion, drug release

INTRODUCTION

Microparticles and nanoparticles are classified under particulate drug delivery systems which are used for various purposes like targeted drug delivery, prolong drug release, improvement of bioavailability, reduce dose size, minimise or eliminate side effects etc.[1-4] Microparticles are solid, spherical particles with size range between 1 to 1000 µm, made from different polymers (natural, synthetic, semisynthetic). The coupling of mucoadhesive characteristics and microparticles results in mucoadhesive microsphere. The microparticles consisting of either a mucoadhesive polymer or having an outer coating of mucoadhesive polymer ease its adherence to any mucosal tissue. Nanoparticles are solid, spherical particles with size range between 1 to 200 nm.[5,6] Nanoparticles have several advantages like their structural stability, narrow size distribution and the possibility of their functionalization for targeted drug delivery. The purpose of current study was to develop and evaluate the microparticles and nanoparticles, so as to compare their drug release *in-vitro* and *in-vivo* from drug delivery system.[7-10] Glycyrrhetinic acid (Figure. 1) is a pentacyclic triterpenoid, derivative of the beta-amyrin type obtained from the hydrolysis of glycyrrhizic acid (obtained from liquorice). It has pharmacological actions like anti-inflammatory, antibacterial, antineoplastic, ulcer healing, antiviral, antiprotozoal, expectorant (antitussive) and antifungal. It metabolises in the liver and by intestinal bacterial, excreted by faeces and in urine.[10-16]

MATERIAL AND METHODS

The drug was procured form Rankem Pvt. Ltd. The chemical used were procured from SD Fine chemicals.

Characterization of drug

The drug was evaluated for physical characteristics, organoleptic properties, melting point, loss on drying (LOD), pH, ultraviolet-visible spectrophotometry analysis (UV), Fourier transform infrared spectroscopy (FTIR) and high performance liquid chromatography (HPLC).[11]

Physical characterization

The physical state of drug was determined.[11]

Organoleptic properties

The organoleptic properties like colour, odour and taste of drug were determined.[11]

Melting Point

The melting point of drug was determined by capillary melting technique using pre-calibrated melting point apparatus by L-ascorbic acid AR and sodium carbonate AR. The small quantity of drug was introduced into a capillary tube sealed at one end and was further placed in the digital melting apparatus to determine average melting point. [11]

Loss on Drying

The accurately weighed 10 g drug was placed in hot air oven, pre-heated at 105 °C for 1 h and weighted at each hour until two constant readings were obtained.[11,17,18]

Determination of λ_{max} and Preparation of Calibration Curve of Glycyrrhetinic Acid Ammonium by Ultraviolet Visible Spectrophotometric Analysis

The stock solution (1 mg/ml) of drug was prepared in pH 7.4 phosphate buffer and further dilutions (10-100 µg/mL) were prepared. The 0.1N HCl was used for base correction. The λ_{max} of drug was determined and calibration curve was prepared using ultra-violet visible spectrophotometer (Shimadzu 1700S).[11]

Fourier Transform Infrared Spectroscopy and drug excipient interaction

The Fourier transform infrared spectroscopy was performed using Fourier transform infrared spectrophotometer (FTIR 8400S, CE, Software Irresolution) to characterize various types of bonds and group present in the sample by preparing the thin disc formed by compression of perfectly dried sample and potassium bromide (KBr) at 105 °C for 1 h in the proportion of 1:10 using KBr press at pressure 15,000 psi.[11]

Retention Time and Calibration Curve by High Performance Liquid Chromatography

The reverse phase C_{18} Column (125 mm X 4 mm, 5 µ) was used in isocratic HPLC system that was monitored at 252 nm at ambient temperature. The washing of column was performed using methanol and water in ratio of 1:1 for 10 min at 0.5 mL/min flow rate and then with 100% methanol for 30 min at 0.5 mL/min flow rate with open purge valve. Then phosphoric acid and acetonitrile in ratio of 1:3 v/v at pH 2.5 was used as mobile phase, filtered through 0.2 µm membrane filter bath. Sonicator was employed for degassing the mobile phase. The total injection volume used was 20 µL and flow rate of mobile phase was 0.5 mL/min. The Stock solution (1 mg/ml) of drug was prepared in ethanol and dilutions (10-100 µg/mL) were prepared further. All dilutions were filtered through a 0.2 µm membrane filter, before injecting it into the chromatographic system. Degassing was done by placing all samples in bath sonicator.[11]

Experiment design and preparation of particulates

The mucoadhesive particulates were prepared using composition given in Table 1 by single phase emulsification technique followed by heat stabilization method. Temperature was set at 50 °C for removal of water.

Preparation of microparticles

Microparticles were prepared by single phase emulsification method followed by heat stabilization method. Accurately weighed amount of drug and carbopol was dissolved in distilled water. Then bovine serum albumin was added and mixing was done for 10 minutes. The mixture was poured in 120 ml liquid liquid paraffin preheated at 50ºC and shear was applied (1000 rpm) for 10 hours. The developed microsphere were washed using acetone four times and separated using centrifuge and dried at room temperature.

Preparation of nanoparticles

The method used to prepare microparticles was slightly modified to prepare nanoparticles like change in phase ratio, concentration of drug-polymer solution and rotation as given in Table 1.[19]

Evaluation of particulates

The yield of particulates were calculated and various evaluation parameters including scanning electron microscopy, particle size analysis, drug entrapment efficiency, drug loading efficiency, swelling index, percentage mucoadhesion, percentage drug release of all prepared batches were performed. The drug release kinetics and stability study were performed. The pharmacokinetic study was carried out and *in-vivo in-vitro* correlation was established.

Scanning Electron Microscopy and Particle Size Analysis

The surface morphology was determined using Scanning Electron Microscopy (CARL ZEISS AG-EVO®40 Series) using Thermo Ultra Dry SDD EDS detector at 20 kV. The particulates were spread over two side adhesive carbon tape stuck on brass stub. It was placed in a glass chamber to coat with gold under an argon atmosphere using a high-vacuum evaporator (Polaron SEM coating system) to make a conductive surface of particulates. The study was performed at accelerated voltage of 30 KV and chamber pressure of 0.6 mmHg. The particle size was also analysed.[5,20,21]

Drug content

The accurately weighed 100 mg of particulates were placed on 100 ml volumetric and the pH 7.4 phosphate buffer was added to qs 100 ml. The mixture was stirred for 6 hours on agitator and after 24 hours centrifuge. The absorbance was measured to calculate concentration of drug.[5]

Encapsulation Efficiency and Drug Loading

The encapsulation efficiency and loading efficiency were determined by dissolving prepared particulates individually in phosphate buffer solution (pH 7.4) and absorbance at 252 nm was measured using UV spectrophotometer (Shimadzu 1700S) to analyse drug content. The encapsulation efficiency (Eq. 1) and percent drug loading (Eq. 2) was calculated using below mentioned formula:[5,22]

Entrapment efficiency (%) = Calculated drug concentration X 100 / Theoretical drug concentration …Eq 1

Drug loading (%) = Calculated drug concentration X 100 /Total weight of microparticles ….Eq.2

Swelling Index

The accurately weighed (500 mg) particulates were placed in a glass vial containing pH 7.4 phosphate buffer 10 mL at 37 ± 0.5 °C in incubator and was stirred occasionally. The particulates were periodically removed by blot using filter paper and the change in weight of particulates was measured till equilibration. The weight was recorded after a period of 3 h in triplicate and the swelling ratio (SR) was calculated using formula (Eq. 3).[5]

$$\text{Swelling index (\%)} = W_1\text{-}W_2 \text{ X } 100 / W_1 \quad \text{....Eq 3}$$

Where,

W_1 = Weight of microparticles after swelling

W_2 = Initial weight of microparticles

Mucoadhesion

The falling liquid film method using freshly excised rat stomach mucosa (2 x 1 cm) was used to evaluate in-vitro mucoadhesion

property of prepared particulates. The particulates were mounted onto the glass slide and rinsed it with 2 mL pH 7.4 phosphate buffer solution. Amount of hydrated particulates were dispersed individually onto the tissue specimen was weighed. Glass slide was incubated for 15 min in desiccators at 90% relative humidity for proper polymer -membrane interaction. The slide was then kept at 45 º angle relative to the horizontal plane and mucosa was rinsed with pH 7.8 phosphate buffer at a rate of 10 ± 2 mL/min and maintained at 37 ºC for 10 h. The amount of microparticles retained on the tissue surface was collected after 10 h and residual amount of medium was separated by centrifugation followed by drying at 50 ºC. The mucoadhesion strength of the microparticles was calculated using as following equation (Eq. 4):[5]

Mucoadhesion (%) = Weight of sample – Weight of detached particles X 100 / Weight of sample ….Eq 4

***In-vitro* Drug Release and Drug Release Kinetics**

The particulates were examined using USP type I apparatus (Electrolab, TDT-08L, Mumbai, India) for *in-vitro* drug release using dissolution medium (pH 7.4 phosphate buffer solution, 900 mL) maintained at 37 ± 0.5 °C temperature. The particulates equivalent to 100 mg of drug were wrapped in Whatman filter paper and placed in the basket of dissolution apparatus and was rotated at 100 rpm. Aliquots were withdrawn at 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12 h with replacement of same amount of medium to the dissolution vessel in order to maintain the sink conditions. The study was conducted in triplicate. The samples were analysed by a UV spectrophotometer (UV-1700, Shimadzu) at 252 nm after suitable dilution. The drug release kinetics was determined using BIT-Software (Version 1.12).[5, 23]

***In-vivo* pharmacokinetic study**

The experimental protocol was approved by Institutional Animal Ethics Committee (711/02/a/CPCSEA), India. All Wistar albino male rats (200 g weighed) were housed in individual poly propylene cages at 24 °C ± 2 °C under 12 h light/dark cycle as standard conditions in animal House at M.I.E.T., Meerut. The feed was *ad-libitum* with standard pellet diet with free access to water.

The particulates were examined for *in-vivo* pharmacokinetic study in Wistar albino rats. After one day fasting of 12 Wistar albino rats, the glycyrrhetinic acid ammonium (100 mg/kg) and particulates, equivalent to 100 mg drug were administered to rats. The Wistar albino rats were fixed on dissection board. Blood samples were withdrawn at 60, 120 and 180, min after drug administration. With the help of insulin syringe the 0.5 mL blood was withdrawn from lateral tail vein. Blood was placed into tubes containing 1 mL, 500 U/mL heparin solution (prevent blood coagulation). The blood sample was centrifuged for 10 min at 1500 rpm to separate plasma. The Shimadzu HPLC system with a 20 µL sample loop, C-18 reversed phase column (VP-ODS, 250 X 4.6 mm, 5 mm) was used to determine the plasma drug concentration. The mobile phase was acetonitrile/phosphoric acid (3:1, pH=2.5). The flow rate of mobile phase was maintained 0.6 mL/min using LC-10AD pump. A variable wavelength photodiode-array detector (SPD-10A) set at 252 nm wavelength with Class VP software was used to analyse the data.[5]

***In-vitro*-*in-vivo* correlation**

The *in-vitro* and *in-vivo* drug release profile of particulates were compared to establish *in-vitro* - *in-vivo* correlation. The linear regression equation was determined for point-to-point correlation that could be classified as level "A" correlation according to the FDA definition.[5,24,25,26,27]

Stability study

The particulates were studied for stability at 25 ± 2 °C/60 ± 5% RH, 37 ± 2 °C/65 ± 5% RH, 45 ± 2 °C/75 ± 5% RH for 6 months in screw capped amber coloured glass bottles and evaluated for colour change and percent drug content after 1, 3 and 6 months. The initial drug content was considered as 100%.[5]

RESULT AND DISCUSSION

The glycyrrhetinic acid ammonium was crystalline, white and odourless with characteristic taste. The melting point was 293 ± 0.12 °C. The loss on drying was 0.1 ± 0.01%. The line of equation for drug was Y = 0.001X - 0.000 at 252 nm in phosphate buffer saline (pH = 7.4) using UV-Visible Spectrophotometric Analysis and R^2 value was 0.999 as shown in Table 2 and Figure. 2.

The Fourier Transform Infrared Spectroscopy showed the presence of =C-H Bending (991.34), C-O Stretch (1112.65), -C-H Bending (1354.79), C=C Stretch (1506.3, 1558.38), C=C Stretch (1616.24), C=O Stretch (1731.96), C=O Stretch (1770.53), O-H stretch, H-bonded (3425.34, 3444.63), H-N stretch (3235.34, 3414.64), C-N stretch (1112.65, 1354.79) in glycyrrhetinic acid, BSA, Carbopol 934P, Microsphere as shown in Figure. 3.

The retention time was 7.3 minutes as shown in Figure. 4 and calibration curve by HPLC showed the line equation Q = 0 + 48. 6996 * A in phosphoric acid and acetonitrile in ratio of 1:3 v/v at pH 2.5 mobile phase mobile phase at 0.5 mL/min Flow rate.

The production yield, bulk density, true density, angle of repose, Hausner's ratio, compressibility/ Carr's index were determined for particulates and results were shown in Table No. 3.

The Scanning Electron Microscopy (SEM) showed the rough surface of microparticles with irregular structure and smooth surface of nanoparticles with high aggregation. The results of particle size were tabulated in table 4. The encapsulation efficiency and drug loading were found to be 44.86±0.23%, 36.85±0.27 and 52.74±0.73%, 42.74±0.12% for microparticles and nanoparticles respectively. The Swelling Index was found to be 81.73±0.12 for microparticles and 92.63±0.53 for nanoparticles.

The in-vitro cumulative % drug release was found to be 88.45±0.12 and 97.16±0.11 for microparticles and nanoparticles respectively as shown in Table 4. Nanoparticles showed the higher drug release due to smaller particle size that takes less time for diffusion of solvent and drug release as shown in Figure. 5.

The drug release kinetics showed the Korsmeyer-Peppas Equation as best fit model as shown in Table 5 and mechanism of drug release was found to be anomalous transport.

***IN-VIVO* PHARMACOKINETIC STUDY**

The *in-vivo* plasma drug concentration showed lower drug concentration by nanoparticles than microparticles that may be due to movement of nanoparticles into lymphatic system and data and Figure is shown in Table 6 and Figure 6.

***In-vitro – in-vivo* correlation**

The *in-vitro – in-vivo* data of microparticles showed in table 7 was plotted as in Figure 7, the r^2 value was 0.995 while the *in-vitro – in-vivo* data of nanoparticles showed in table 8 was plotted as in Figure 8, the r^2 value was 0.946.

Table 1: Composition of particulates

S.No.	Ingredients	Amount	
		Microparticles	Nanoparticles
1	Glycyrrhetinic acid ammonium (mg)	100	100
2	Bovine serum albumin (mg)	100	100
3	Carbopol 934P (mg)	25	25
4	Span (ml)	0.1	0.1
5	Water (ml)	5	15
6	Liquid paraffin (ml)	120	120
7	RPM	3000	10000
8	Time (h)	10	10
9	Temperature (raised linearly)	50	50

Table 2: Calibration data of glycyrrhetinic acid ammonium in pH = 7.4 phosphate buffer saline at 252 nm by ultraviolet-visible spectrophotometry

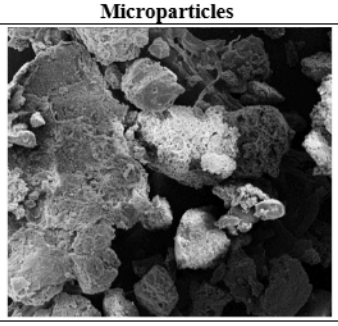
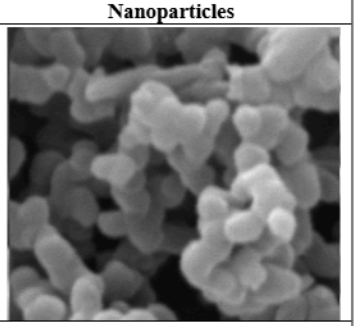
S.No.	Concentration (µg/ml)	Absorbance
1	10	0.013
2	20	0.025
3	30	0.038
4	40	0.053
5	50	0.065
6	60	0.079
7	70	0.09
8	80	0.105
9	90	0.117
10	100	0.129

Table 3: Bulk characterization of particulates

Parameters	Microparticles	Nanoparticles
Yield (%)	97.95±0.34	95.79±0.61
Bulk Density (g/ml)	0.712± 0.04	0.597±0.42
True density (g/ml)	0.843 ±0.05	0.684±0.74
Angle of Repose (°)	17.41±0.3	16.63±0.2
Hausner's Ratio	1.12±0.01	0.98±0.63
Compressibility/ Carr's index	12.1±0.02	11.31±0.36

n=3

Table 4: Evaluation parameter of particulates

	Microparticles	Nanoparticles
Scanning electron microscopy		
Particle size analysis	3.5±1.46 µm	248.95±1.32 nm
Entrapment efficiency (%)	44.86±0.23	36.85±0.27
Drug loading efficiency (%)	52.74±0.73	42.74±0.12
Swelling index (%)	81.73±0.12	92.63±0.53
% Mucoadhesion testing by in vitro wash-off test (10 h)	86.34±0.63	93.43±0.25

	Time (h)	Cumulative % drug release	
***In-vitro* drug release of particulates**	1	11.59±0.41	19.67±0.19
	2	23.71±0.61	27.44±0.24
	3	31.27±0.11	35.39±0.49
	4	37.77±0.26	42.69±0.26
	5	45.28±0.54	48.11±0.20
	6	48.69±0.16	53.58±0.47
	7	56.17±0.12	60.27±0.20
	8	61.55±0.11	66.75±0.66
	9	68.23±0.34	71.59±0.43
	10	72.61±0.22	77.16±0.11
	11	79.37±0.17	85.24±0.14
	12	88.45±0.12	97.16±0.11
n=3			

Table 5: Drug release kinetics of particulates

	Microparticles	Nanoparticles
Best Fit Model		
R^2	0.9820	0.9896
K	3.0067	3.5237
Parameters for Korsmeyer-Peppas Equation		
N	0.7657	0.6305
K	3.0067	3.5237
Mechanism of release	Anomalous Transport	Anomalous Transport

Table 6: The *in-vivo* drug release study of particulates

	Cumulative % drug release	
Time (Hours)	**Microparticles**	**Nanoparticles**
1	0.15±0.13	0.09±0.21
2	0.2±0.26	0.16±0.14
3	0.24±0.11	0.19±0.23

Table 7: The *in-vitro – in-vivo* correlation data for microparticles

	Cumulative % drug release	
Time (Hours)	**Microparticles (*In-vitro*)**	**Microparticles (*In-vivo*)**
1	11.59±0.41	0.15±0.13
2	23.71±0.61	0.2±0.26
3	31.27±0.11	0.24±0.11

Table 8: The *in-vitro – in-vivo* correlation data for nanoparticles

	Cumulative % drug release	
Time (Hours)	**Nanoparticles**	**Nanoparticles**
1	19.67±0.19	0.09±0.21
2	27.44±0.24	0.16±0.14
3	35.39±0.49	0.19±0.23

Table 9: Stability data of particulates

Conditions	Time (Months)	Drug content (%)	
		Microparticles	**Nanoparticles**
25 ± 2 °C/60 ± 5% RH	**1**	99.75±0.22	99.89±0.75
37 ± 2 °C/65 ± 5% RH		99.94±0.53	99.79±0.26
45 ± 2 °C/75 ± 5% RH		99.86±0.63	99.87±0.11
25 ± 2 °C/60 ± 5% RH	**3**	98.97±0.64	98.85±0.53
37 ± 2 °C/65 ± 5% RH		98.78±0.86	98.47±0.77
45 ± 2 °C/75 ± 5% RH		98.47±0.39	98.56±0.24
25 ± 2 °C/60 ± 5% RH	**6**	98.67±0.24	98.86±0.73
37 ± 2 °C/65 ± 5% RH		97.75±0.74	97.43±0.27
45 ± 2 °C/75 ± 5% RH		97.15±0.26	97.32±0.44

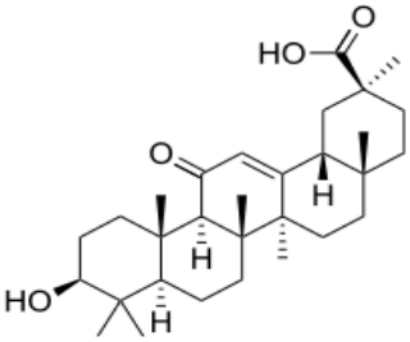


Figure 1: Structure of glycyrrhetinic acid

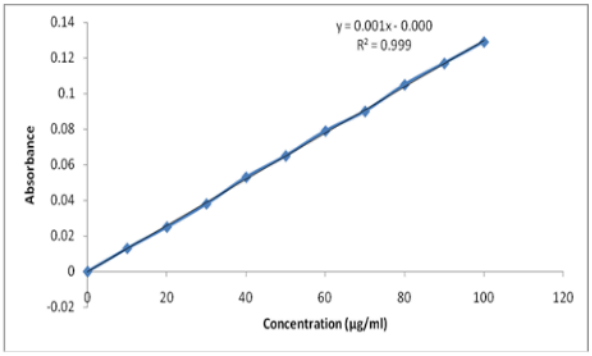


Figure 2: Calibration curve of glycyrrhetinic acid ammonium in in phosphate buffer saline (pH = 7.4) at 252 nm by ultraviolet visible spectrophotometry

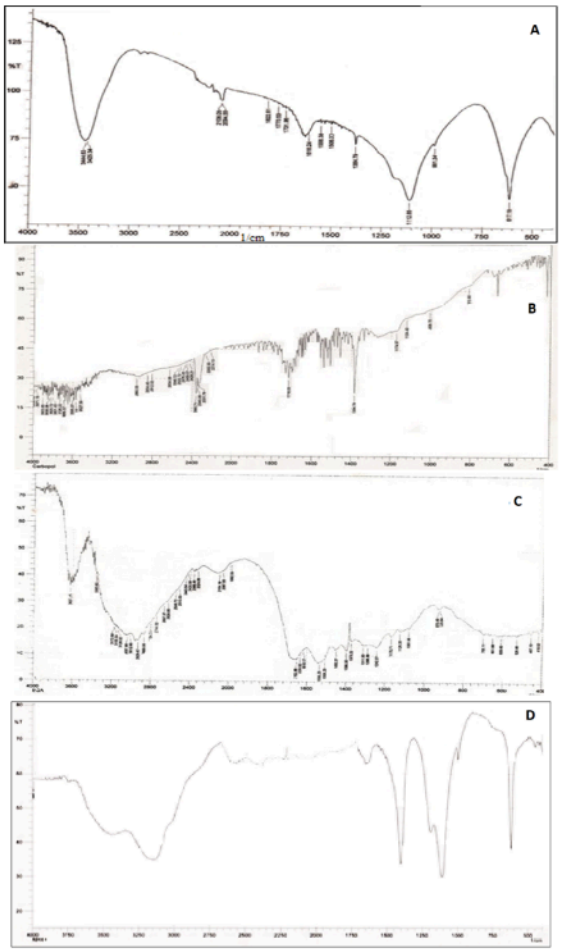


Figure 3: Fourier Transform Infrared Spectroscopy of glycyrrhetinic acid ammonium (A), carbopol 934P (B), bovine serum albumin (C), microspheres (D)

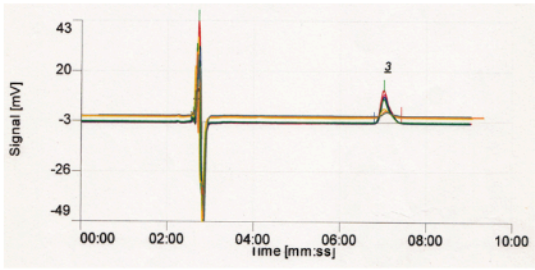


Figure 4: Retention time of glycyrrhetinic acid ammonium by high performance liquid chromatography

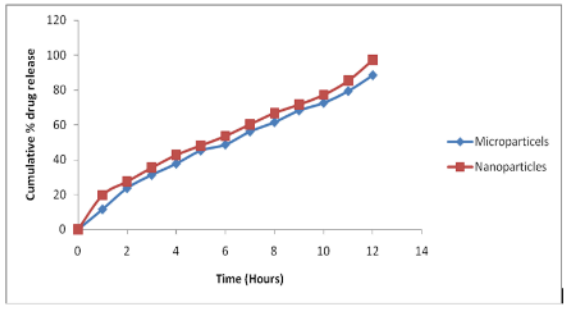


Figure 5: *In-vitro* drug release of particulates

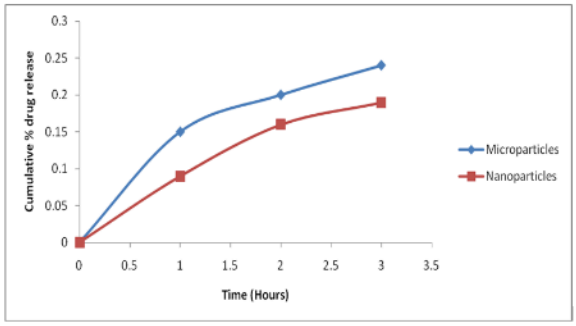


Figure 6: *In-vivo* drug release study of particulates

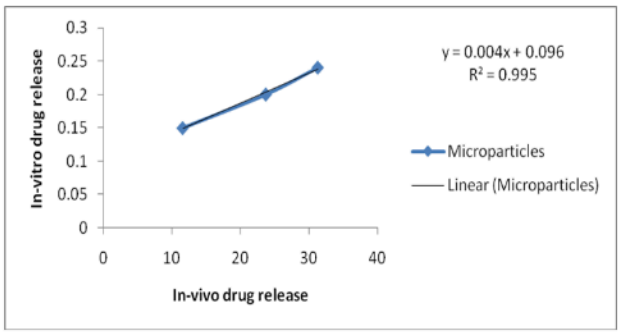


Figure 7. ***In-vitro – in-vivo* correlation for microparticles**

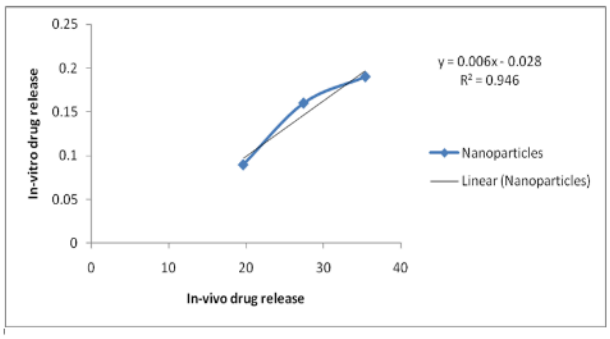


Figure 8: *In-vitro – in-vivo* correlation for nanoparticles

Stability study

The stability study showed the maximum release drug content at 45 ± 2 °C/75 ± 5% RH at 6 months was 97.15±0.26 for microparticles and 97.32±0.44 for nanoparticles as shown in Table 9. It was concluded that the degradation of drug was affected by temperature, %RH and duration of storage.

CONCLUSION

The preparation of nanoparticles is a tedious process and has more issues in drug entrapment, loading, stability, especially problem of aggregation. The *in-vitro* dissolution showed a rapid and maximum drug release with nanoparticles then microparticles due to its small size. The kinetics of drug release showed the erosion and diffusion were mechanism of drug release (Anomalous transport). The nanoparticles have better response in maintenance of plasma drug concentration when used *in-vivo*. It was concluded

that the degradation of drug was affected by temperature, %RH and duration of storage.

REFERENCES

1. Burgess DJ, Hickey AJ. Microsphere Technology and Applications. Encyclopedia of pharmaceutical technology, 3rd Edition, Vol-1 Editor-James Swarbrick. PharmaceuTech, Inc. Pinehurst, North Carolinia, USA. Informa Healthcare USA, Inc. New York London. 2328-2337.
2. Rodzinski A, Guduru R, Liang P, Hadjikhani A, Stewart T, Stimphil E, Runowicz C, Cote R, Altman N, Datar R, Khizroev S. Targeted and controlled anticancer drug delivery and release with magnetoelectric nanoparticles. Scientific Reports (6); 2016:1-14.
3. Karra N, Benita S. The Ligand Nanoparticle Conjugation Approach for Targeted Cancer Therapy. Current Drug Metabolism. 2012; 13(1): 22-41.
4. Jóhannesson G, Stefánsson E, Loftsson T. Microspheres and Nanotechnology for Drug Delivery. Devlopment in Ophthalmology. 2016; 55: 93-103.
5. Wang S, Zhong TMZ, Chen M, Wang Y. Nanotechnologies for Curcumin: An Ancient Puzzler Meets Modern Solutions. Journal of Nanomaterials. 2011; 1-8.
6. Visht S, Kulkarni GT. Glycyrrhetinic acid ammonium loaded microspheres using *Colocasia esculenta* and *Bombax ceiba* Mucilages: *In-vitro* and *in-vivo* characterization. Current Drug Therapy. 2016; 11(2): 101-104.
7. Visht S, Kulkarni GT. Studies on the preparation and *in-vitro-in-vivo* evaluation of mucoadhesive microspheres of glycyrrhetinic acid isolated from liquorice. Bangladesh Pharmaceutical Journal. 2015; 18:30-37.
8. Arya RKK, Singh R, Juyal V. Mucoadhesive microspheres of famotidine: Preparation characterization and *in-vitro* evaluation. International Journal of Engineering Science and Technology. 2010; 8(6): 1575-1580.
9. Sriharitha, Preethi J, Swaroop H. A Review on Nanoparticles in Targeted Drug Delivery System. Research & Reviews: Journal of Material Science. 2016; 4(4): 1-6.
10. Seetharaman S, Balya H, Kuppusamy G. Preparation and Evaluation of Cefixime Nanoparticles Prepared Using Fenugreek Seed Mucilage and Chitosan as Natural Polymers. International Journal of Pharmaceutical and Clinical Research. 2016; 8(3): 179-188.
11. Couvreur P. Nanoparticles in drug delivery: Past, present and future. Advanced Drug Delivery Review. 2013; 65(1): 21–23.
12. Sanna V, Sechi M. Nanoparticle therapeutics for prostate cancer treatment. Nanomedicine: Nanotechnology, Biology, and Medicine. 2012; 73(1): 27-32.
13. Visht S, Kulkarni GT. A comparison between different methods for extraction of glycyrrhetinic acid from liquorice stolons. International Journal of Pharma Professional's Research. 2012; 3(2): 622-626.
14. Cao D, Jiang J, You L, Jia Z, Tsukamotp T, Cai H, Wang S, Hou Z, Suo Y, Cao X. The protective effects of 18-*β*-glycyrrhetinic acid on *Helicobacter pylori* infected gastric mucosa in Mongolian gerbils. BioMedical Research International. 2016; 1-8.
15. Chamoli A, Ahmad M, Hasan M, Panda BP. Simultaneous determination of 18-α-glycyrrhetinic acid and 18-β-glycyrrhetinic acid in *Glycyrrhiza glabra* root by reversed phase high performance liquid chromatography. Drug Development and Therapeutics. 2016; 7 (1): 59-62.
16. De A, Datta S, Mukherjee A. Quantitative analysis of glycyrrhizic acid from a polyherbal preparation using liquid chromatographic technique. Journal of Advanced Pharmaceutical Technology and Reswarch. 2012; 3 (4): 210-215.
17. Ghader JA, Vahid N, Ehsan A, Mostafa M, Hadi K. Antiulcer properties of *Glycyrrhiza glabra* L. extract on experimental models of gastric ulcer in mice. Iranian Journal of Pharmaceutical Research. 2015; 14 (4): 1163-1170.
18. Korhalkar A, Deshpande M, Lele P, Modak M. Antimicrobial activity of Yashtimadhu (*Glycyrrhiza glabra*L.) - A Review. International. Journal of Current Microbiology and Applied Sciences. 2014; 3 (1): 329-336.
19. Mohamed JM, Bharathidasan P, Mohamed RM. Preformulation and development of curcumin magnetic nanosuspension using magnetite (Fe_3O_4) and methyl cellulose. International Journal of Pharma and Bio Sciences. 2012; 3(4): 419-432.
20. Ahmad T, Singh SB, Pandey S. Phytochemical Screening and Physicochemical Parameters of Crude Drugs: A Brief Review. International Journal of Pharma Research & Review. 2013; 2(12): 53-60.
21. Sari TP, Mann B, Sharma R, Kumar R, Vikrant, Minaxi. Process Optimization for the Production of Nanoencapsulated Curcumin and Analysis for Physicochemical Characteristics and Antioxidant Mechanism. International Journal of Biotechnology and Bioengineering Research. 2013; 4(6): 581-586.
22. Steffi PF, Srinivasan M. Preparation, Characterization and Stabilization of Curcumin Nanosuspension. International Journal of PharmTech Research. 2014; 6(2): 842-849.
23. Jun JY, Nguyen HH, Paik SYR, Chun HSb, Kang BC, Sanghoon K. Preparation of size-controlled bovine serum albumin (BSA) nanoparticles by a modified desolvation method. Food Chemistry. 2011; 127 (4): 1892–1898.
24. Buzanello RADS, Souza MFD, Oliveira DAD, Bona E, Leimann FV, Filho LC, Araújo PHHD, Ferreira SRS, Gonçalves OH. Preparation of curcumin-loaded nanoparticles and determination of the antioxidant potential of curcumin after encapsulation. Polímeros. 2016; 26(3): http://dx.doi.org/10.1590/0104-1428.2246
25. Ravichandran R. Studies on Dissolution Behavior of Nanoparticulate Curcumin Formulation. Advances in Nanoparticles. 2013; 2: 51-59.
26. Song X, Bai X, Liu S, Dong L, Deng H, Wang C. A novel microspheres formulation of puerarin: pharmacokinetics study and *in-vivo* pharmacodynamics evaluations. Evidence-Based Complementary and Alternative Medicine. 2016; 20 (16): 1-8.
27. Xie X, Lin W, Xing C, Yang Y, Chi Q, Zhang H, Li Y, Li Z, Yang Y, Yang Z, Li M. *In-vitro* and *in-vivo* evaluations of PLGA microspheres containing nalmefene. PLOSONE. 2015; 10 (5): 1-19.

Cite this article as:

Sharad Visht *et al*. Comparison of drug release: Microparticles vs Nanoparticles. Int. Res. J. Pharm. 2018;9(4):52-58 http://dx.doi.org/10.7897/2230-8407.09460

Source of support: Nil, Conflict of interest: None Declared

Disclaimer: IRJP is solely owned by Moksha Publishing House - A non-profit publishing house, dedicated to publish quality research, while every effort has been taken to verify the accuracy of the content published in our Journal. IRJP cannot accept any responsibility or liability for the site content and articles published. The views expressed in articles by our contributing authors are not necessarily those of IRJP editor or editorial board members