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Formulation and evaluation of lovastatin loaded nanosponges

Pushpalatha D *, Abdul Waris Khan, Manjunath K and Brunda S

Sree Siddaganga College of Pharmacy, B.H. Road, Tumkur -572102, Karnataka, India.

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Abstract

Nanotechnology mediated drug delivery has been reported to enhance the drug efficacy, bioavailability, reduced toxicity and improve patient compliance by targeting the cells and tissues to elicit the desired pharmacological action. The main aim of the study was to formulate lovastatin loaded nanosponges and to evaluate them. Lovastatin loaded nanosponges were prepared by Emulsion solvent diffusion method using different polymers (Ethyl cellulose, Polyvinyl alcohol, β-cyclodextrin, Pluronic F68, Hydroxy Propyl β- cyclodextrin). The FTIR test is conducted as the preliminary test, by this test there was no interaction between the drug and polymers. Then nanosponges were evaluated for particle size, PDI, zeta potential, SEM, entrapment efficiency and *invitro* drug release. The particle size ranged from 295.5 to 578.8 nm, PDI ranged from 0.189 to 0.465, zeta potential from -17.3 to -35.96 mV and entrapment efficiency was ranged from 78.38 to 95.77 %. The cumulative percentage release from all nanosponges varied from 66.86 to 96.60% after 12 hours depending upon the drug and polymers ratio andF6 formulation showed highest drug release i.e., 96.60%. The release kinetic studies showed that the release first order diffusion controlled and the n value (0.6017) from the Korsmeyer-Peppa's model indicated the release mechanism was non-fickian type.

Keywords: Lovastatin; Nanosponges; FTIR; *in-vitro* drug release

1. Introduction

Nanosponges are made of microscopic particles with few nanometers' wide cavities, in which a large variety of substances can be encapsulated. These particles possess the ability to carry both lipophilic and hydrophilic substances and thereby improving the solubility of poorly water-soluble molecules. The studies conducted in this field proves that the tiny mesh-like structures called nanosponges may revolutionize the treatment of many diseases and early trials suggest this technology is up to five times more effective at delivering drugs for breast cancer than conventional methods [1]. The nanosponge is about the size of a virus with a 'backbone' (a scaffold structure) of naturally degradable polyester. They 'cross link' segments of the polyester to form a spherical shape that has many pockets (or cavities) where drugs can be encapsulated. The polyester is biodegradable, which means that when it breaks down in the body, the drug can be released on a known schedule [2].

Lovastatin, a highly lipophilic drug is frequently used as a blood cholesterol-lowering agent. It is a prodrug and after oral administration, the inactive parent lactone is hydrolyzed to the corresponding hydroxy acid form. Lovastatin belongs to BCS class II, has a naphthalene ring and a lactone ring, where the lactone ring binds to the 3- hydroxy-3-methylglutaryl-coenzym A (HMG-CoA) reductase enzyme and inhibits the formation of cholesterol. Lovastatin shows low oral bioavailability (< 5%) because of least absorption and rapid metabolism in the liver [3,4].

Nanosponges have various advantages which includes (1) Being amphiphilic in nature, nanosponges can carry both hydrophobic and hydrophilic molecules. (2) The superior properties of nanosponges have been attributed to

* Corresponding author: Pushpalatha D
Sree Siddaganga College of Pharmacy, B.H. Road, Tumkur -572102, Karnataka, India.

'tunability', that is the ability to control the structure of particles and control the nature and size of aperture. (3) Nanosponges have the ability to produce predictable/controlled drug release [5]. (4) Nanosponges can be tagged with specific linkers to target diseased cells hence achieving greater efficacy while reducing side-effects, decreasing dose and dosing frequency and in turn increasing patient compliance. (5) Nanosponges can significantly reduce the irritation of drugs without reducing their efficacy. (6) Biodegradable in nature and easy scale up for commercial production [6]. (7) They mix with water and are used as a transport fluid. They can be used to mask unpleasant flavors [7].

Nanosponges have many applications in the field of drug delivery which includes the following (1) Nanosponges are being used for Solubility Enhancement because presence of crosslinking agent and cavities in the nanosponge structure helps interaction with active molecules. The hydrophilic hydroxyl groups on the external surface remain exposed to the environment, while the hydrophobic functionality of the complex hides in the interior cavity of the cyclodextrin the net effect is that a water-soluble complex is formed [8]. (2) In drug delivery due to it 's spherical shape and nanometric in size making them ideal in preparing various dosage forms like topical, parenteral, aerosol, tablets and capsules. It is found that highest solubility and in vitro drug release is observed in inclusion complex [9]. (3) During protein delivery**,** nanosponges helps in maintenance of the native protein structure both during the formulation process and upon the long-term storage. The nanosponges were found to be stable at 300°C and high protein complexation capacity was also observed. (4) Nanosponge formulations were developed as oxygen delivery systems for topical application which were having the ability to store and to release oxygen slowly over time [10].

2. Material and methods

Lovastatin was purchased from Balaji drugs, Bangalore, Ethyl Cellulose and Poly Vinyl Alcohol from Research lab fine chem industries, β- cyclodextrin and Hp-β- cyclodextrin from Gattefose, Hydrabad, Pluronic F68 from HI Media laboratories Pvt ltd, Bengaluru Dichloromethane from SD Fine Chem, Bangalore. All the reagents were analytical grade.

2.1. Determination of λ max of Lovastatin in methanol

Accurately weighed quantity of 10 mg of Lovastatin was taken in 10 ml volumetric flask and it was dissolved in methanol and made up to 10 ml using methanol. From the above stock solution, 10 µg/ml solution was prepared and scanned between 200-400 nm by keeping methanol as blank. The absorption maxima of 237nm for Lovastatin was obtained and used for further studies.

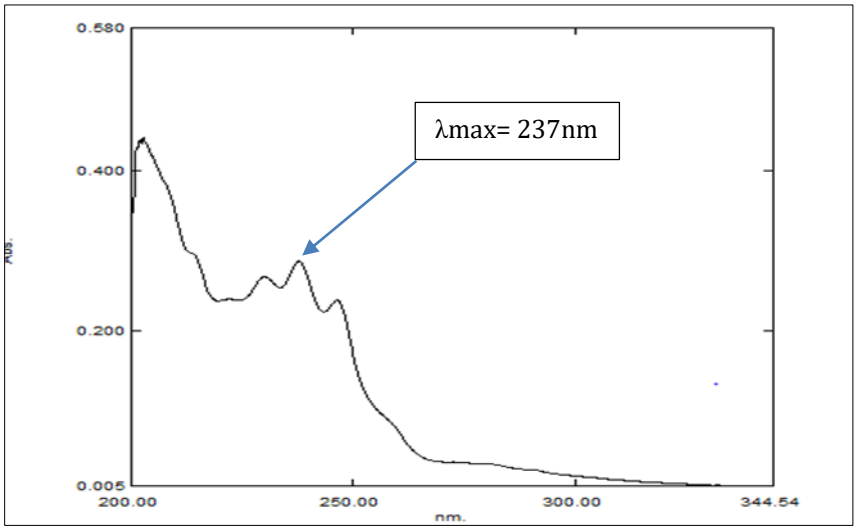

Figure 1 Determination of λ max of Lovastatin in methanol

2.2. Determination of λ max of Lovastatin in phosphate buffer of pH 6.8

Accurately weighed quantity of 10 mg of Lovastatin was taken in 10 ml volumetric flask and it was dissolved in methanol and made up to 10 ml using phosphate buffer of pH 6.8. From the above stock solution, 10µg/ml solution was prepared and scanned between 200-400nm by keeping phosphate buffer as blank. The absorption maxima of 238 nm for Lovastatin was obtained and used for further studies.

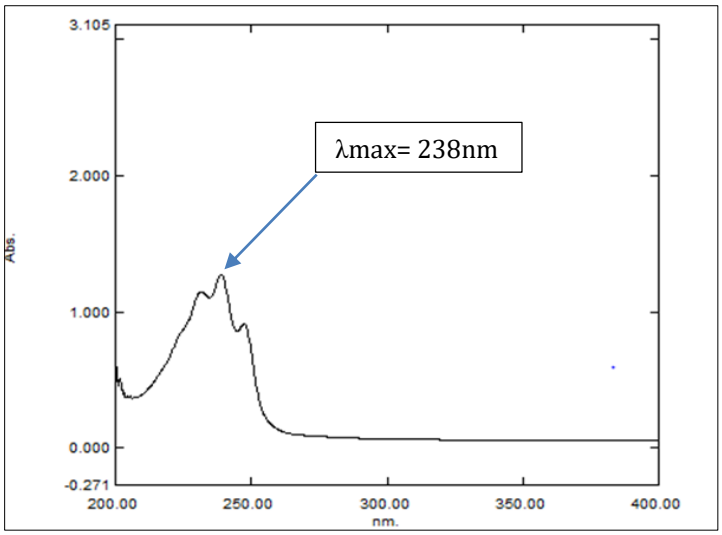

Figure 2 Determination of λ max of Lovastatin in phosphate buffer pH 6.8

2.3. Fourier-transform infrared spectroscopy (FT-IR)

Drug-polymer interactions were studied by FTIR spectroscopy. Pure drug and excipients were subjected to FT-IR studies. Also, physical mixtures were subjected and the spectra recorded by scanning in the wavelength of 400-4000 cm^{-1} in a FT-IR spectrophotometer. The samples analysed by FT-IR include.

- Pure drug (Lovastatin)
- Physical mixture of drug + Ethyl Cellulose + Poly Vinyl Alcohol
- Physical mixture of drug + Ethyl Cellulose + β - Cyclodextrin
- Physical mixture of drug + Ethyl Cellulose+ Pluronic F68
- Physical mixture of drug + Ethyl Cellulose+ Hp - β - Cyclodextrin

2.4. Preparation of calibration curve in methanol

Accurately weighed quantity of 100 mg of Lovastatin was taken in 100 ml volumetric flask and it was dissolved in methanol (Stock Solution I 1000µg/ml). From Stock Solution I, 5ml was taken and transferred to 50 ml volumetric flask and volume was made up to 50 ml methanol (Stock Solution II 100 µg/ml). From Stock solution II, 0.2, 0.4, 0.6, 0.8, 1.0, 1.2, and 1.4 ml was taken and transferred to 10 ml volumetric flasks and volume was made up to 10 ml using methanol. 2, 4, 6, 8, 10,12 and 14 µg/ml solutions respectively. The aliquots were analysed at 237 nm. The plot of concentration v/s absorbance was plotted.

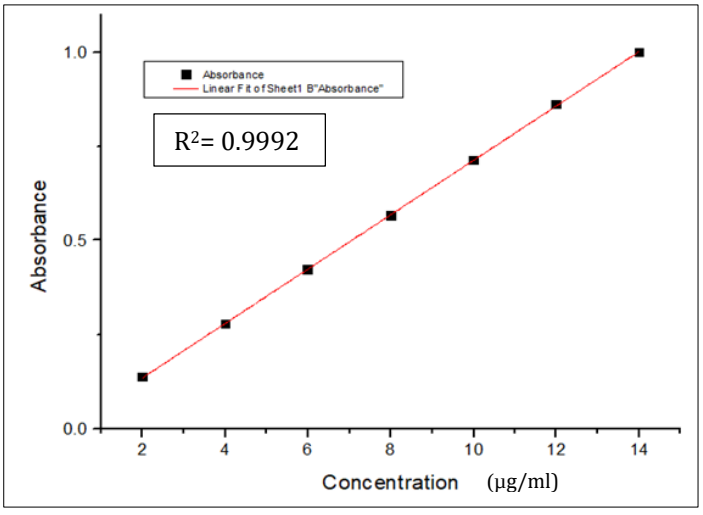

Figure 3 The Standard graph of Lovastatin using Methanol

2.5. Preparation of calibration curve in phosphate buffer pH 6.8

Accurately weighed quantity of 100 mg of Lovastatin was taken in 100 ml volumetric flask and it was dissolved in methanol and volume was made upto 100ml using phosphate buffer 6.8 (Stock Solution I 1000µg/ ml). From Stock Solution I, 5ml was taken and transferred to 50 ml volumetric flask and volume was made up to 50 ml methanol (Stock Solution II 100 µg/ml). From Stock solution II, 0.2, 0.4, 0.6, 0.8, 1.0, 1.2 and 1.4 ml was taken and transferred to 10 ml volumetric flasks and volume was made up to 10 ml using phosphate buffer 6.8. 2, 4, 6, 8, 10, 12 and 14 µg/ml solutions respectively. The aliquots were analysed at 238 nm. The plot of concentration v/s absorbance was plotted.

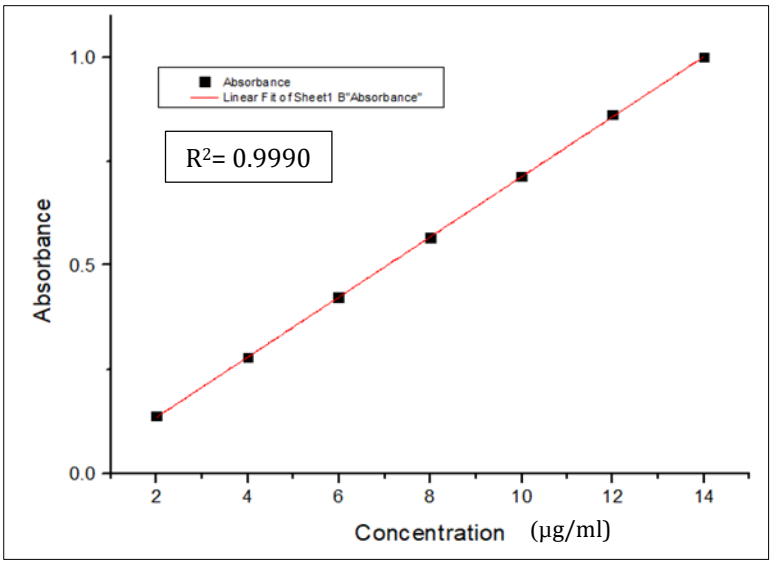

Figure 4 The Standard graph of Lovastatin using phosphate buffer of pH 6.8

2.6. Preparation of Lovastatin loaded Nanosponges using Emulsion Solvent Diffusion method

Nanosponges using different proportions of ethyl cellulose, polyvinyl alcohol, β-cyclodextrin, Pluronic F68 and HP-β cyclodextrin were prepared by Emulsion solvent diffusion method.

Table 1 Composition of different formulation of Lovastatin loaded nanosponges

Formulation Code	Drug (mg)	EC (mg)	PVA (mg)	β - CD (mg)	PL F68 (mg)	HP- β- CD (mg)	Dist. H_2O (ml)
F1	100	100	100	-	-	-	100
F2	100	100	200	-	-	-	100
F3	100	100	300	-	-	-	100
F4	100	100	-	100	-	-	100
F5	100	100	-	200	-	-	100
F6	100	100	-	300	-	-	100
F7	100	100	-	-	100	-	100
F8	100	100	-	-	200	-	100
F9	100	100	-	-	300	-	100
F10	100	100	-	-	-	100	100
F11	100	100	-	-	-	200	100
F12	100	100	-	-	-	300	100

DRUG- Lovastatin; EC = Ethyl Cellulose; PVA= Poly Vinyl Alcohol; β - CD = β - Cyclodextrin;
PL F68 = Pluronic F68 (Poloxamer F68); HP-β -CD = Hydroxy Propyl β- cyclodextrin; Dist. H2O = Distilled Water

Disperse phase consisting of drug (100mg) and requisite quantity of ethyl cellulose dissolved in 10 ml solvent(dichloromethane) was slowly added to a definite amount of polymer in100ml of aqueous continuous phase. The reaction mixture was stirred at 1000 rpm for three hours on a magnetic stirrer. The nanosponges formed were collected by filtration through whatmann filter paper and dried in oven at 50°C for 2 hours. The dried nanosponges were stored in vacuum desiccator to ensure the removal of residual solvent [11].

3. Evaluation of nanosponges

3.1. Particle size analysis

The particle size was determined by dynamic light scattering, using a Malvern system, with vertically polarized light supplied by an argon-ion laser (Cyonics) operated at 40 mW. Experiments were performed at a temperature of 25.0 ± 0.1ºC at a measuring angle of 90º to the incident beam. The technique of laser diffraction is based around the principle that particles passing through a laser beam will scatter light at an angle that is directly related to their size. As the particle size decreases, the observed scattering angle increases logarithmically. The observed scattering intensity is also dependent on particle sizes and diminishes, to a good approximation, in relation to the particle's cross-sectional area. Large particles therefore scatter light at narrow angles with high intensity, whereas small particles scatter at wider angles but with low intensity.

3.2. Zeta potential

Zeta potential analysis was performed to estimate the stability of the Nanosponges. Zeta potential is a measure of effect of electrostatic charges. This is the basic force that causes the repulsion between adjacent particles. Net results are attraction or repulsion depends upon the magnitude of both forces. The thumb rule describes the relation between zeta potential determination responses of the Nanosponges.

3.3. Polydispersity index

In light scattering, the term polydispersity and % polydispersity is derived from the Polydispersity Index, a parameter calculated from a Cumulants analysis of the DLS-measured intensity autocorrelation function. In the Cumulants analysis, a single particle size mode is assumed and a single exponential fit is applied to the auto correlation function and the polydispersity describes the width of the assumed Gaussian distribution. The Polydispersity Index is dimensionless and scaled such that values smaller than 0.05 are rarely seen other than with highly mono disperses standards. Values greater than 0.7 indicate that the sample has a very broad size distribution and is probably not suitable for the dynamic light scattering (DLS) technique. The various size distribution algorithms work with data that falls between these two extremes. Particle size, zeta potential and Polydispersity index were determined by the same instrument *i.e. Malvern zeta sizer* [12,13].

3.4. Scanning electron microscopy

For the evaluation of the surface morphology of nanosponges, the sample was analyzed in a scanning electron microscope after preparing the sample by lightly sprinkling on a double adhesive tape stuck to an aluminum stub. The stubs were then coated with platinum. The stub containing the coated sample was placed in a scanning electron microscope. The samples were then randomly scanned and photomicrographs were taken at the acceleration voltage of 20 kV. From the resulting image, average particle size was determined [14].

3.5. Drug Content

An accurately weighed amount of 20 mg of lovastatin nanosponges were added to 20 ml methanol and placed in a thermo-shaker operated at 100 rpm at 25ºC for 45 minutes, followed by vertexing for 10 minutes. The solution was filtered through a 45 µm membrane filter, and the drug was determined spectrophotometrically at λmax 237nm, on the basis of the previously constructed standard curve. The drug content of the formulated nanosponges was calculated on the basis of the following equation [15].

$$\%\ Drug\ content = \frac{Practical\ amount\ of\ the\ drug\ obtained}{\text{Theroretical amount of drug added}}\ X\ 100$$

3.6. Percentage Drug entrapment efficiency (%DEE)

50 mg from the prepared drug loaded nanosponges by emulsion solvent diffusion method using suitable polymer were suspended in 50 ml of methanol and were subjected for ultracentrifugation for 40 minutes. The percentage of

incorporated Lovastatin was determined spectrophotometrically at 237nm. After centrifugation of the aqueous suspension, amount of free drug was detected in the supernatant and the amount of incorporated drug was determined as a result of the initial drug minus the free drug. The drug entrapment efficiency (EE) of lovastatin nanosponges was determined using the formula: [16].

$$\% \text{ of drug entrapment } = \frac{\text{Total drug content} - \text{ Drug weight in aqueous phase}}{\text{Total drug content}} \text{x100}$$

3.7. *In vitro* Drug Release Study

In vitro drug release studies were carried out in *Franz* diffusion cell. 2 ml of Nanosponges dispersion was used for diffusion study. Nanoponges containing drug were placed in donor compartment while the receiver compartment consists of 22 ml of diffusion medium Phosphate buffer pH 6.8 maintained at 37 °C temperature in Franz diffusion cell. The rpm of the magnetic bead was maintained at 50 rpm. 2 ml of the sample was withdrawn at predetermined intervals. The samples were analysed for the drug content by UV spectrophotometer at 238 nm. Equal volume of the diffusion medium was replaced in the vessel after each withdrawal to maintain sink condition. From the data obtained the percentage drug release was calculated and plotted against function of time to study the pattern of drug release [17].

3.8. Kinetic Modelling of Drug Dissolution Profiles:

The results of in vitro release profile obtained for all the formulations were plotted in modes of data treatment as follows:

- Zero order kinetic model – Cumulative % drug released versus T.
- First order kinetic model – Log cumulative percent drug remaining versus T.
- Higuchi's model – Cumulative percent drug released versus square root of T.
- Korsmeyer equation/Peppa's model–Log cumulative percent drug released versus log T [18].

4. Results and discussion

4.1. Drugs-polymer interaction study by FT-IR spectrophotometer

An FT-IR spectroscopy study has been carried out separately to check the compatibility between the drug (Lovastatin) and the polymers (EC, PVA, β – CD, PL- F68 and HP-β -CD) used for the preparation of Nano sponges. The FT-IR was performed for drug and physical mixture of drug and polymers. The spectra obtained from FT-IR spectroscopy study at wave number from 4000 to 400 cm^{-1} are shown below.

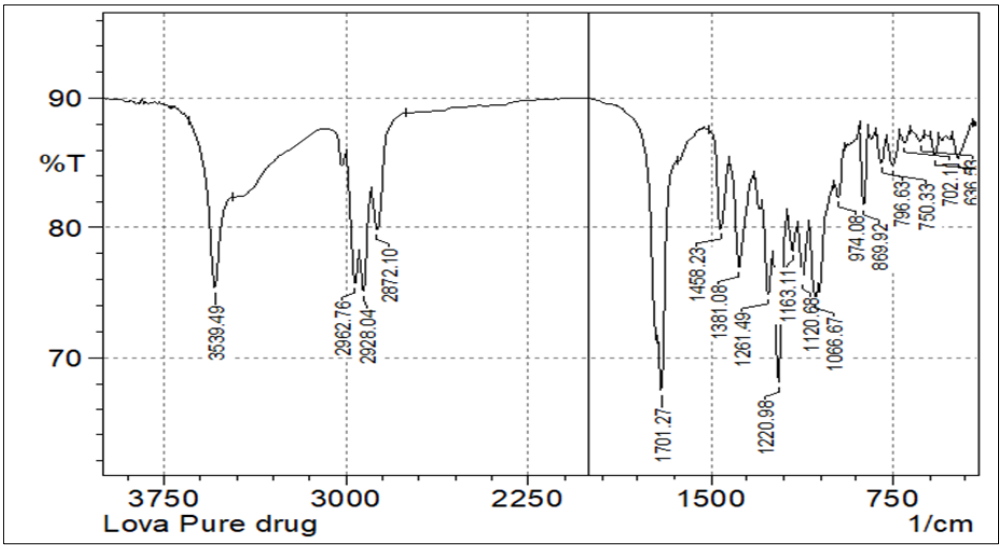

Figure 5 The FTIR spectrum of pure Lovastatin

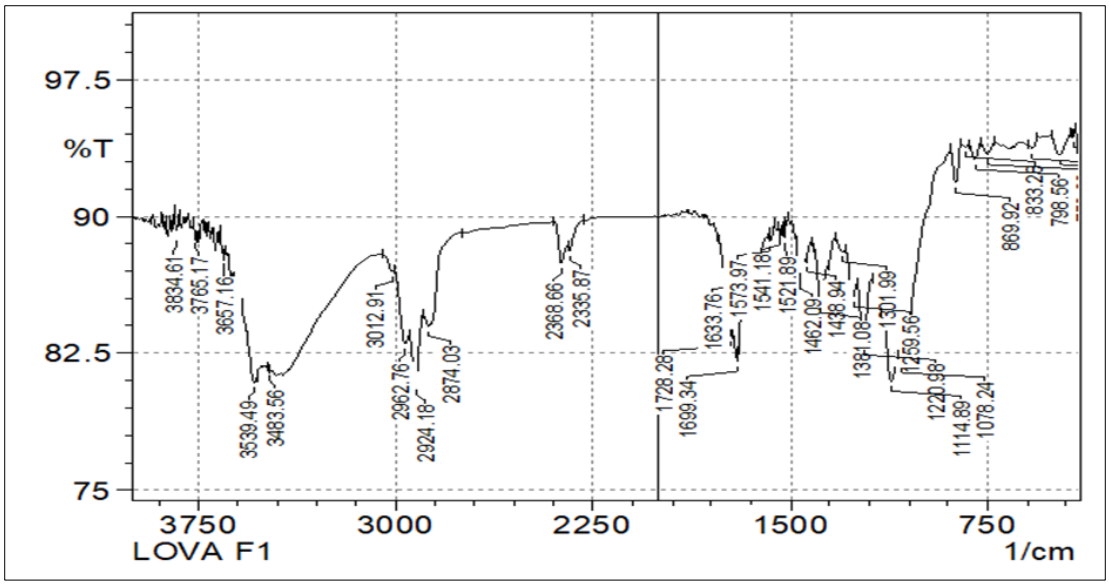

Figure 6 The FTIR spectrum of physical mixture of Lovastatin, EC and PVA

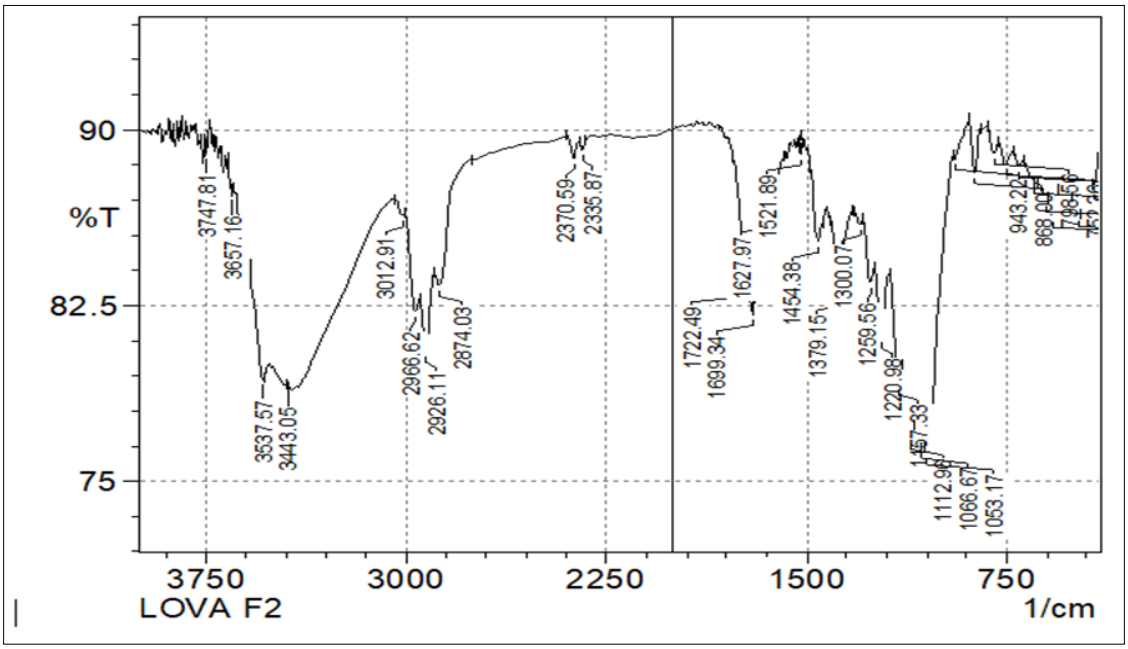

Figure 7 The FTIR spectrum of physical mixture of Lovastatin, EC and β – CD

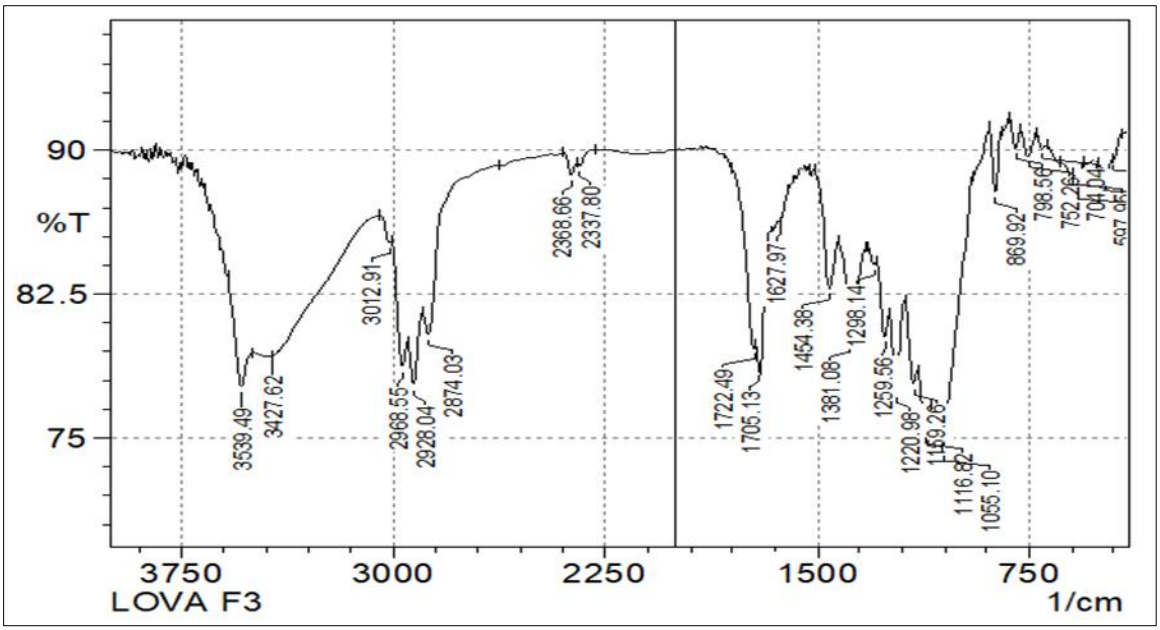

Figure 8 The FTIR spectrum of physical mixture of Lovastatin, EC and Pluronic F68

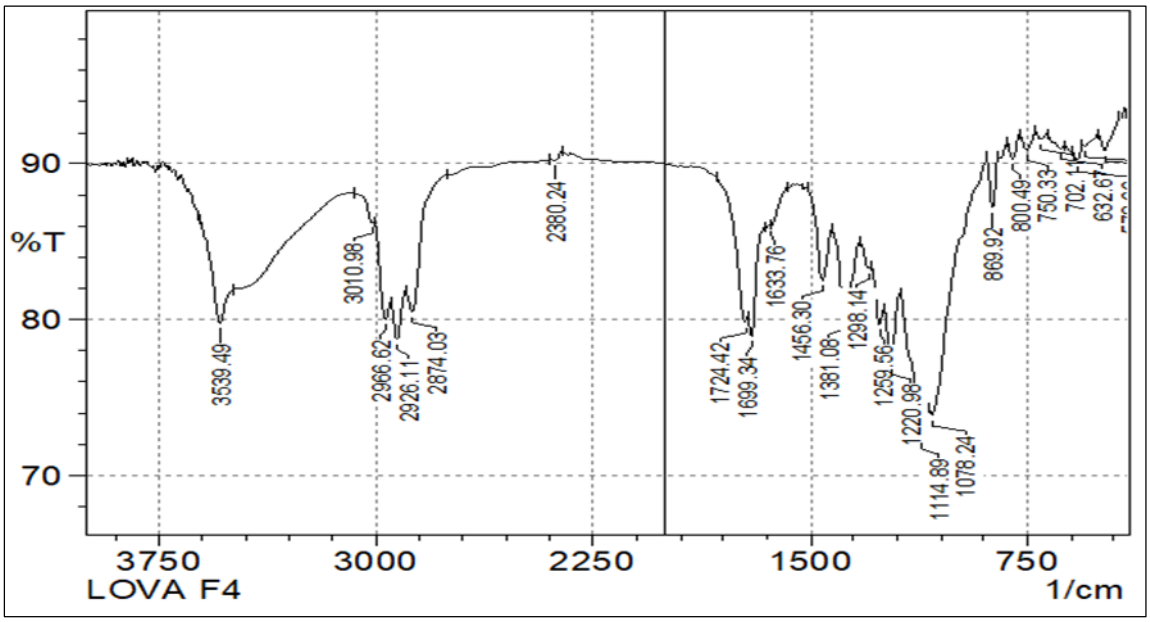

Figure 9 The FTIR spectrum of physical mixture of Lovastatin, EC and HP-β - CD

4.2. FTIR Interpretation

Perusal to the above FTIR spectra, the characteristic peaks of Lovastatin of pure spectrum was retained in the FTIR spectra of physical mixture of drug with Ethyl Cellulose, PVA, β – CD, PL-F68 and HP-β -CD. Therefore, there was no drug polymer interaction is found. Hence, these polymers were used for the preparation of Nano sponges.

Table 2 Interpretation of FTIR spectra of above figures

Sr. NO	Name of the Compound	Wave number (cm^{-1})	Functional group
1	Lovastatin	1066.67	C-O Stretching
		1220.98 -1261.49	C-O-C Stretching
		1381.08 -1458.23	C-H Bending
		2872.10 -2928.04	C-H Stretching
		3539.49	O-H Stretching
2	Lovastatin: EC: PVA (1:1:1)	1078.24	C-O Stretching
		1220.98 -1259.56	C-O-C Stretching
		1381.08 -1462.09	C-H Bending
		2874.03-2924.18	C-H Stretching
		3539.49	O-H Stretching
3	Lovastatin: EC: β- CD (1:1:1)	1066.67	C-O Stretching
		1220.98 - 1259.56	C-O-C Stretching
		1379.15 - 1454.38	C-H Bending
		2874.03 - 2926.11	C-H Stretching
		3537.57	O-H Stretching
4	Lovastatin: EC: PL- F68 (1:1:1)	1055.10	C-O Stretching
		1220.98 - 1259.56	C-O-C Stretching
		1381.08 - 1454.38	C-H Bending
		2874.03 - 2928.04	C-H Stretching
		3539.49	O-H Stretching
5	Lovastatin: EC: HP-β- CD (1:1:1)	1078.24	C-O Stretching
		1220.98 - 1259.56	C-O-C Stretching
		1381.08 - 1456.30	C-H Bending
		2874.03 - 2926.11	C-H Stretching
		3539.49	O-H Stretching

4.3. Characterization of Nanosponges

Lovastatin loaded nanosponges were prepared by Emulsion solvent diffusion method. The Nanosponges were evaluated for particle size, zeta potential and polydispersity index and the results were reported as follows.

4.4. Particle size, Zeta potential and PDI

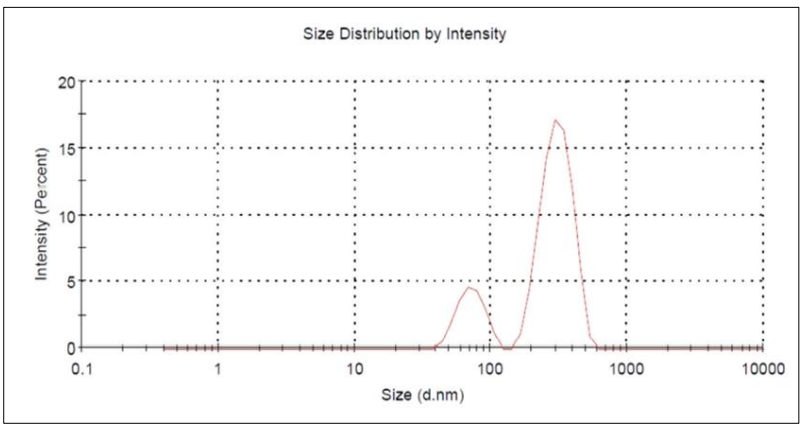

Figure 10 Size Distribution Profile of optimized formulation F6

The particle size ranged from 295.5 to 578.8 d. nm, PDI ranged from0.189 to 0.465 and zeta potential from -17.3 to -35.96 mV.

Table 3 The particle size, PDI and zeta potential of Lovastatin loaded nanosponges prepared with PVA, β – Cyclodextrin, Pluronic F68 and HP-β-cyclodextrin

Formulation Code	Particle size (d. nm)	PDI	Zeta potential (mV)
F1	326.5	0.384	-17.30
F2	295.5	0.286	-19.40
F3	422.7	0.349	-20.40
F4	532.3	0.465	-18.70
F5	433.9	0.189	-22.60
F6	496.6	0.426	-35.96
F7	561.2	0.398	-15.54
F8	578.8	0.250	-25.62
F9	429.8	0.435	-23.70
F10	523.7	0.487	-37.40
F11	428.2	0.312	-26.80
F12	543.5	0.367	-27.30

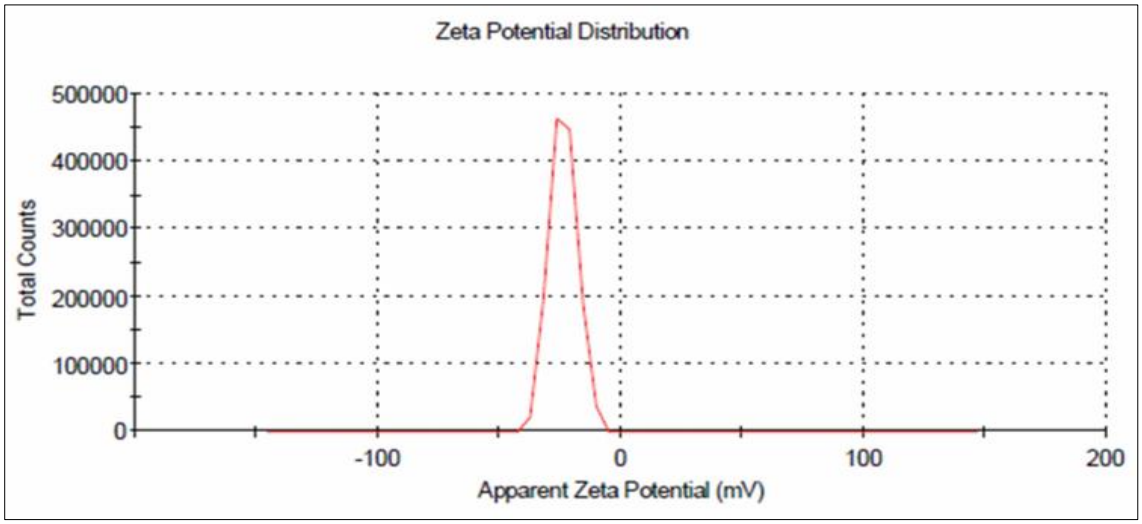

Figure 11 Zeta potential profile of optimized formulation F6

4.5. Scanning Electron Microscopy

SEM analysis of the formulated Lovastatin nanosponges were performed to evaluate the surface morphology of nanosponges. The SEM images of optimized formulation F6 is shown in below.

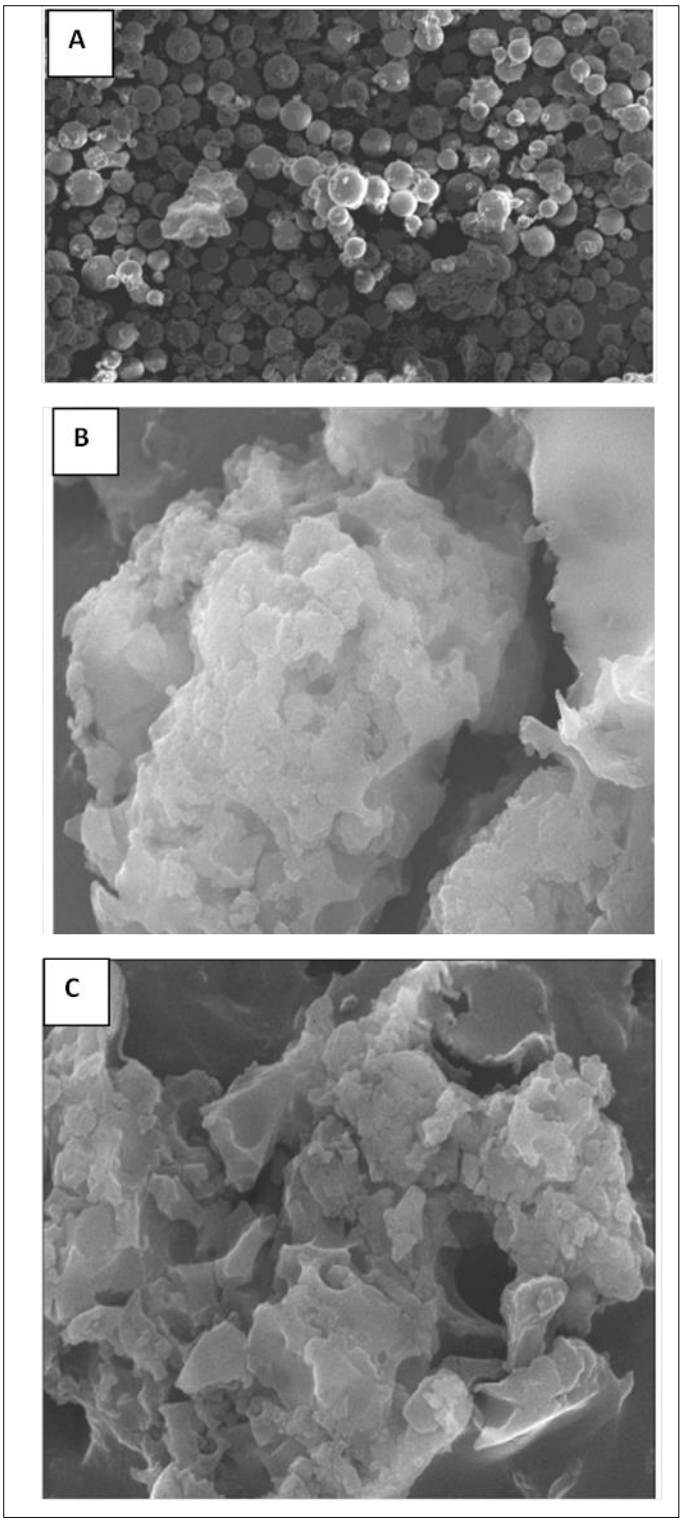

Figure 12 SEM images of optimized formulation F6 (A) 100X (B) 10,000X (C) 20,000X

4.6. Drug content and Entrapment efficiency

The drug content of formulations was carried out by extraction with methanol as mentioned in the methodology section. Formulations (20 mg) were extracted Lovastatin using 20 ml of methanol. The drug content results were ranged between 79.47 to 96.82% and drug entrapment efficiency results were ranged between 78.38 to 95.77%.

Table 4 Data of drug content and entrapment efficiency of Lovastatin loaded nanosponges prepared with EC, PVA, β – Cyclodextrin, Pluronic F68 and HP-β-cyclodextrin

Formulation Code	Drug Content %	Entrapment efficiency (%)
F1	84.53	80.12
F2	88.32	78.38
F3	79.47	80.77
F4	92.25	89.35
F5	91.34	87.45
F6	96.82	94.23
F7	87.04	90.16
F8	92.15	95.77
F9	89.21	86.32
F10	90.36	88.98
F11	92.54	83.12
F12	93.31	89.46

4.7. Release studies

The drug releases from the Nanosponges were studied by *Franz* diffusion method. The *in vitro* release profiles of Lovastatin from Lovastatin nanosponges are shown in Table No.5. The cumulative percentage release of Lovastatin from different Lovastatin nanosponges varied from 72.16 to 96.60% depending upon the drug polymer ratio.

Table 5 Table showing percentage drug released from different formulations (F1-F12) during 12 hours

Time (Hours)	Formulations											
	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12
0.5	12.0	12.1	12.5	12.8	9.5	14.4	11.9	12.0	11.0	13.7	15.6	13.0
1	19.5	17.7	18.3	18.3	17.7	21.6	15.3	12.2	11.7	22.1	24.4	22.9
2	36.1	39.1	36.1	32.5	33.1	37.4	27.1	18.7	15.0	29.7	32.5	33.0
3	45.6	45.0	42.0	42.0	40.8	55.3	44.3	27.1	18.7	35.4	37.4	39.2
4	50.1	49.2	43.2	43.8	41.9	60.4	49.3	29.1	23.4	44.0	42.8	47.9
5	61.2	61.5	57.8	52.6	46.3	64.1	57.5	50.1	30.3	50.3	50.9	54.4
6	61.7	62.0	61.6	58.1	54.9	72.3	64.5	59.0	45.5	55.0	56.4	64.9
8	67.3	68.2	64.6	62.9	61.3	78.4	68.6	63.9	57.6	61.1	75.6	76.2
10	74.1	75.0	70.3	65.0	74.7	85.5	72.4	69.7	64.2	66.1	79.1	87.1
12	80.7	81.0	78.0	72.8	86.1	96.6	78.5	74.8	66.8	68.4	82.9	92.2

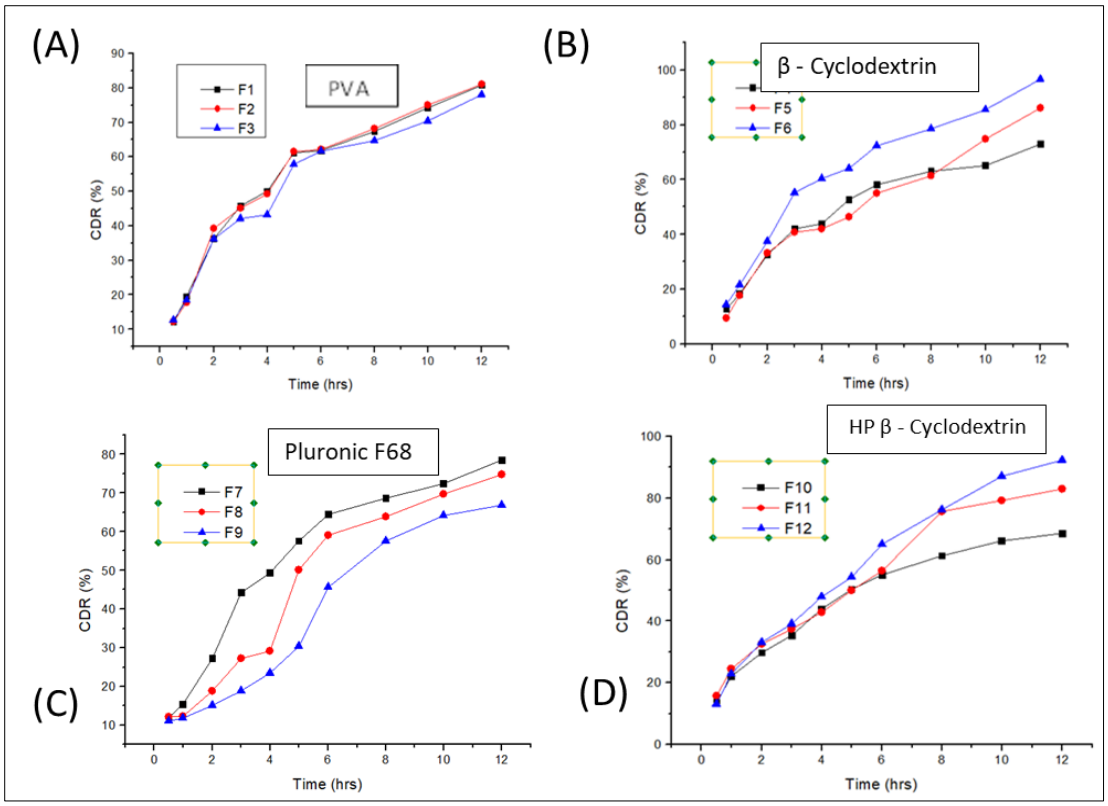

Figure 13 The comparison of percentage cumulative drug release profile of Lovastatin loaded Nanosponges. (A) F1-F3 (B) F4-F6 (C) F7-F9 (d) F10-F12

4.8. Release kinetics

Data obtained from *In vitro* release studies were fitted to various kinetic equations such as zero order, first order, Higuchi model and Korsmeyer- Peppa's model. A model processing of the *In vitro* release for F6 were shown in Table No.6 and 7. For remaining formulation, a similar procedure was followed.

Table 6 The regression values of kinetic models of different formulations

Formulation Code	Regression Factor			Korsmeyer-Peppa's	
	Zero order	First order	Higuchi model	R^2	n value
F1	0.8498	0.9736	0.967	0.9706	0.6202
F2	0.8416	0.9702	0.9587	0.9584	0.6282
F3	0.8695	0.9715	0.9675	0.9715	0.6014
F4	0.841	0.8988	0.9358	0.9684	0.594
F5	0.8632	0.9639	0.968	0.967	0.663
F6	0.8855	0.9846	0.9740	0.9727	0.6017
F7	0.7598	0.8658	0.9013	0.9466	0.6915
F8	0.9015	0.9514	0.9245	0.9179	0.6572
F9	0.8763	0.8889	0.8389	0.8076	0.5985
F10	0.5712	0.6713	0.7823	0.8896	0.4279
F11	0.6701	0.7928	0.8473	0.936	0.4261
F12	0.8095	0.9026	0.9463	0.9748	0.5493

Table 7 Processing of release data of formulation F6 into different kinetic models

Time (Hours)	Log time	SQRT	%CDR	Log %CDR	%CRR	Log % CRR
0.5	-0.3010	0.7071	14.40	1.1583	85.60	1.9324
1	0 .000	1.000	21.68	1.3360	78.32	1.8938
2	0.3010	1.4142	37.40	1.5728	62.60	1.7965
3	0.4771	1.7320	55.30	1.7427	44.70	1.6503
4	0.6020	2.0000	60.41	1.7811	39.59	1.5975
5	0.6989	2.2360	64.13	1.8070	35.87	1.5547
6	0.7781	2.4494	72.34	1.8593	27.66	1.4418
8	0.9030	2.8284	78.45	1.8945	21.55	1.3334
10	1.0000	3.1622	85.53	1.9321	14.47	1.1604
12	1.0791	3.4641	96.60	1.9849	3.40	0.5314

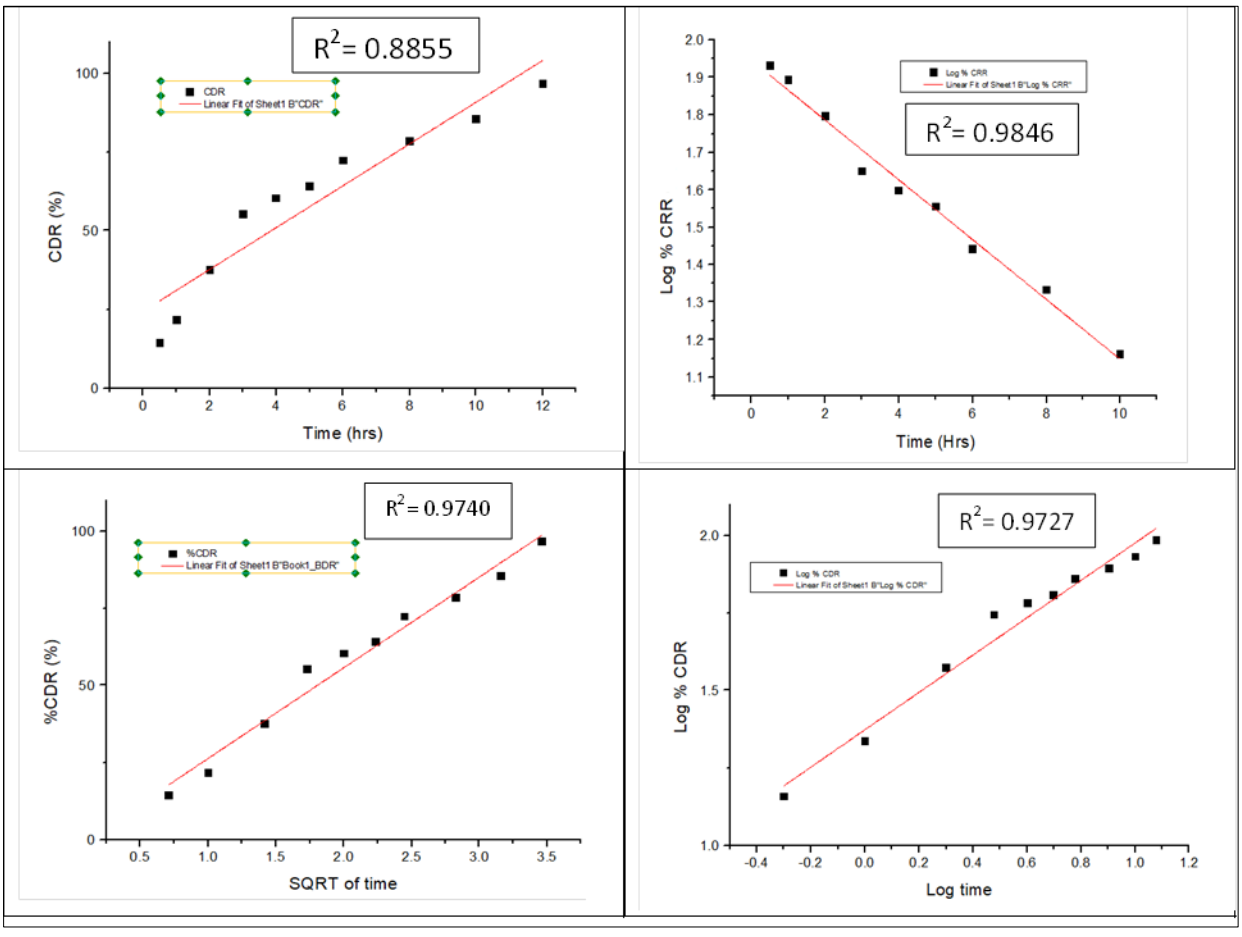

Figure 14 The Zero order, First order, Higuchi, Peppa's model kinetics plot of optimized formulation F6

5. Conclusion

In the present study, an attempt was made to formulate Nanosponge delivery system for lipophilic drug Lovastatin using Ethyl Cellulose, Polyvinyl alcohol, β- cyclodextrin, Pluronic F68 and Hydroxy Propyl β- cyclodextrin as polymers, which

are meant to be used for better anti-hyperlipidaemic action. FT-IR studies were carried out to find out the possible interaction between the selected drug and polymers. FT-IR studies revealed that there was no interaction between the selected drug and polymers. Lovastatin loaded nanosponges were prepared by Emulsion solvent diffusion method. The method was able to produce Nanosponges of acceptable range and stability. All the formulations showed very high entrapment efficiencies. Nanosponges were formulated by taking 100 to 300mg of polymers. Among the all batches F6 was optimized after considering their particle size, zeta potential, SEM and *in vitro* drug release profile.

Particle size, SEM, PDI and zeta potential of all the Nanosponge formulations were in the acceptable and suitable range. Average entrapment efficiency most of Lovastatin Nanosponges was found to be greater than 80 % whereas the optimized formulations F6 was shown 94.23 % entrapment.

Release kinetics studies showed that Lovastatin release from the nano-sponges follows Non-Fickian diffusion. Based on the observations, it can be concluded that the formulated nanosponge delivery system of Lovastatin using widely accepted and physiologically safe polymers was capable of exhibiting controlled release properties for a period of 12 hours. They are thus may reduce frequency of dosing, thereby minimizing the occurrence of side effects, improve bioavailability and increase the effectiveness of the drug.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors have declared that, there is no conflict of interest exist in this research article.

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