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Research Article

Development of Teneligliptin Polymeric Nanocarriers for Antidiabetic Therapy: Formulation and Evaluation.

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Abstract

The present study focuses on the formulation and evaluation of Teneligliptin-loaded nanoparticles by using the nanoprecipitation method to enhance the solubility of teneligliptin and therapeutic efficacy in the management of Type 2 Diabetes Mellitus. The nanoparticle prepared by using ethyl cellulose and polyvinyl alcohol was employed as polymer and stabilizer, respectively, to prepare nine different batches F1 to F9 were prepared. The nanoparticles were characterized for total drug content, entrapment efficiency, particle size, zeta potential, surface morphology, FT-IR, DSC and XRD study. Drug content among the formulations ranged from 90.94 % to 99.06 %, and entrapment efficiency varied between 93.95 % and 99.17 %. Particle size analysis revealed a range of 194.80 nm to 268.50 nm, while zeta potential values spanned from −11.25 mV to −26.90 mV, indicating good colloidal stability. In vitro drug release studies conducted over 60 minutes showed cumulative release ranging from 44.18 % to 76.74 %. Batch F7 shows excellent results optimal characteristics, including the highest drug content (99.06 %), entrapment efficiency (99.17 %), and favourable particle size distribution. In vitro drug release studies revealed that F7 exhibited the maximum cumulative drug release (76.74 % at 60 minutes), following Korsmeyer–Peppas kinetics indicative of anomalous (non-Fickian) diffusion. These findings suggest that Teneligliptin nanoparticles, particularly formulation F7, offer a promising approach for improved drug delivery and bioavailability in diabetic therapy.

Key words: teneligliptin; diabetes mellitus; nanoparticles; nanoprecipitation; drug release kinetics

1. Introduction

Diabetes is a metabolic disorder characterized by high levels of glucose in the blood, resulting from either inadequate insulin secretion or the body's inability to use insulin effectively. The primary forms of diabetes mellitus include Type 1 Diabetes Mellitus (T1DM), commonly called insulin-dependent diabetes; Type 2 Diabetes Mellitus (T2DM), also known as non-insulin-dependent diabetes; and Gestational Diabetes Mellitus (GDM), which arises during pregnancy [1].

Type 1 diabetes mellitus, often referred to as insulin-dependent diabetes, typically affects children and young adults under 30 years of age, although it can also appear later in life. This form of diabetes arises when the insulin-producing beta cells in the pancreas, specifically within the islets of Langerhans, are destroyed, usually due to an autoimmune reaction or unidentified factors. Because the body can no longer produce insulin, individuals with type 1 diabetes must rely on insulin therapy as their primary treatment [2].

In recent times, type 2 diabetes mellitus has increasingly been diagnosed in overweight children, even though it has typically been seen in adults above 30 years of age. Known as non-insulin-dependent diabetes mellitus (NIDDM), this condition develops when the body becomes resistant to insulin and there is a comparatively reduced production of insulin [3].

Gestational diabetes mellitus (GDM) refers to a form of glucose intolerance that first appears during pregnancy. It is more frequently seen in women who are overweight or have a genetic predisposition to diabetes. Proper treatment

to control blood sugar levels is crucial to reduce the likelihood of complications in the baby [4].

Diabetes affects multiple organ systems in the body and, if not properly controlled, can lead to serious health issues over time. These health problems are typically divided into two categories: microvascular and macrovascular complications. Microvascular complications arise from damage to small blood vessels and include conditions like nerve damage (neuropathy), kidney damage (nephropathy), and eye damage (retinopathy) [5]. Macrovascular complications include conditions like heart disease, stroke, and peripheral vascular disease. In cases of peripheral vascular disease, injuries or bruises may heal slowly, which can lead to the development of gangrene and, in severe situations, may necessitate amputation [6].

1.1 Background and Molecular Basis of Triple Helix Formation

Nanoparticles (NPs) are tiny solid carriers used in drug delivery systems, generally ranging in size from 10 to 1000 nm. These carriers may be either biodegradable or non-biodegradable, and the drug can be incorporated by dissolving, encapsulating, entrapping, or binding it within the nanoparticles structure. The term "nanoparticles" includes two main types: nanospheres and nano capsules. In nano capsules, the drug resides in a central oily or aqueous core enclosed by a membrane, while in nanospheres, the drug is evenly dispersed throughout the particle matrix. Nanotechnology presents innovative opportunities in healthcare, particularly in areas where conventional therapies are limited [7].

The main goals in designing nanoparticles for drug delivery include controlling their size, modifying their surface properties, and optimizing the release pattern of the active drug. These strategies help ensure targeted delivery, precise dosing, and sustained therapeutic effect at the intended site of action [8].

Teneligliptin is an oral antidiabetic drug used in managing type 2 diabetes mellitus. It belongs to the class of DPP-4 (Dipeptidyl Peptidase-4) inhibitors. These medications work by boosting the effects of incretin hormones, which promote insulin secretion following meals and decrease glucose generation in the liver. This combined mechanism aids in regulating blood sugar levels effectively.[9] The main aim of the present study was the preparation of nanoparticles using polymers like Ethyl Cellulose at different concentrations by Nanoprecipitation method.

2. Materials and Methods:

2.1. Materials:

Teneligliptin was purchased from Toronto Research Chemicals Mumbai, and all other polymers like Polyvinyl Alcohol (PVA), Ethyl Cellulose, Methanol, Dichloromethane (DCM), and Distilled Water were purchased from Rajesh Chemical Mumbai.

2.2. Method:

Utilizing a variety of polymers, the nanoprecipitation technique was employed to create Teneligliptin drug nanoparticles. Teneligliptin drug nanoparticles were prepared using the nanoprecipitation technique with a variety of polymers. Initially, an aqueous solution was prepared by weighing the required amount of Polyvinyl Alcohol (PVA) into a dry beaker. A measured quantity of distilled water was gradually added to the beaker containing PVA, and the mixture was stirred using a magnetic stirrer at 1800 rpm for approximately 6 hours until the PVA was completely dissolved. Separately, an organic solution was prepared by accurately weighing 20 mg of Teneligliptin and transferring it into a dry beaker. To this, 10 ml of methanol was added to dissolve the drug, followed by the gradual addition of 10 ml of dichloromethane (DCM). The required amount of ethyl cellulose was then weighed and added to the same beaker containing the Teneligliptin, methanol, and DCM mixture. This organic phase was then slowly injected into the prepared aqueous phase under continuous stirring at 1800 rpm for about 5 hours to allow nanoparticle formation via the nanoprecipitation process. The resulting suspension was kept in a refrigerator overnight to facilitate the settling of particles. The formed nanoparticles were then filtered using Whatman filter paper, collected, and dried. The method of Preparation is shown in Figure 1.

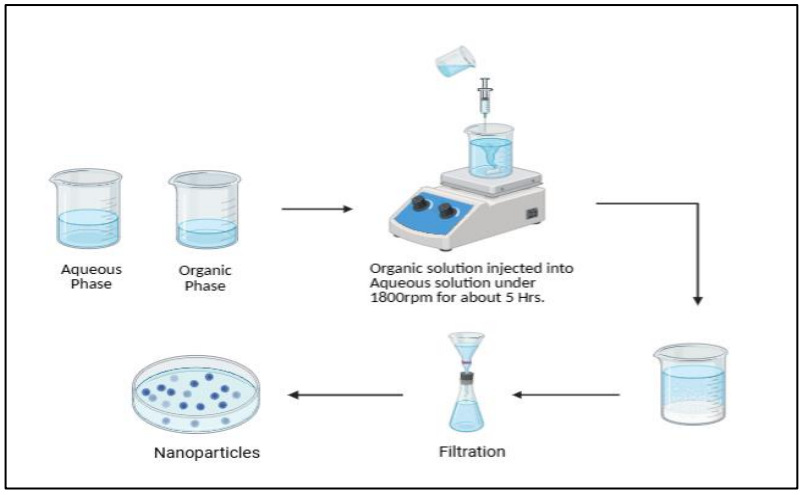

Figure 1: Preparation of Nanoparticles by Nanoprecipitation Method.

2.3 Characterization of Optimized Teneligliptin Nanoparticles:

2.3.1. Total Drug Content (TDC)

An amount of polymeric nanoparticles equivalent to 5 mg of the drug was dissolved in methanol and stirred at 600 rpm for duration of 3 hours. The drug concentration in the resulting supernatant was then analyzed using a UV-visible spectrophotometer [10].

2.3.2. Entrapment Efficiency (EE)

Polymeric nanoparticles containing an equivalent of 5 mg of drug were dispersed in 2 ml of distilled water and subjected to ultracentrifugation at

10,000 rpm for 30 minutes at a temperature of 5°C. After centrifugation, the supernatant was carefully removed. The drug entrapment within the nanoparticles was calculated by subtracting the quantity of drug found in the supernatant from the total drug initially used in the formulation process [11].

The determination of entrapment efficiency was repeated three times per sample. The percentage drug entrapment was calculated using the following equation:

$$\text{Percent (\%)Drug entrapment} = \frac{\text{Amount of entrpped drug recoverd}}{\text{Total amount of drug}} X100$$

2.3.3. Particle Size Analysis

The particle size of the formulation was evaluated by appropriately diluting the sample and analyzing it using a Zetasizer (Malvern Instruments). This method allowed for the determination of the formulation's particle size [12].

2.3.4. Scanning electron microscopy

The surface characteristics of Teneligliptin nanoparticles were examined using a scanning electron microscope (SEM), model S-3700N. SEM is an analytical technique that utilizes a focused beam of electrons to scan the surface of a sample, generating a highly magnified image. This technique provides a two-dimensional visualization and offers insights into the sample's surface structure and elemental composition [13,14].

2.3.5. FT-IR Spectroscopy

FTIR analysis was performed to assess potential chemical interactions between the drug and polymer. The samples were examined over a spectral range of 400 to 4000 cm^{-1} using a Bruker Alpha-II instrument with a carbon black reference. To enhance signal intensity and minimize moisture interference, the detector was purged thoroughly with dry helium gas [15].

2.3.6. Differential Scanning Calorimetry (DSC)

The physical form of the active pharmaceutical ingredient (API) within the nanoparticles was assessed using differential scanning calorimetry (DSC), employing a Mettler Toledo DSC-250 instrument. The sample was subjected to a heating rate of 100 °C per minute, with the temperature range set from 25 °C to 300 °C. The analysis was conducted under a nitrogen atmosphere, maintaining a nitrogen purge flow rate of 20 mL per minute [16].

2.3.7. X-Ray Diffraction (XRD) Study

X-ray diffraction analysis of the powdered samples was performed using a Bruker D8 Advance X-ray diffractometer (USA) with Cu Kα radiation, operating at 40 kV and 25 mA. The scanning was conducted over a 2θ range of 10° to 60°. Diffraction patterns were obtained for both pure Teneligliptin and its solid nanoparticle formulation.

2.3.8. Zeta Potential Analysis

The surface charge of the nanoparticles was analysed using a Horiba Scientific instrument. One millilitre of the nanoparticle sample was taken and diluted with double-distilled water. To avoid agglomeration, the diluted sample was subjected to ultrasonication for five minutes using a bath sonicator. After this treatment, the zeta potential was measured by placing the sample in a transparent cuvette [17].

2.3.9. In vitro drug release

An In-vitro drug release study was conducted to examine the release kinetics of polymeric nanoparticles under sink conditions. The evaluation of drug release from the nanoparticles was performed using a USP Type II dissolution apparatus (Electro lab) operating at 50 rpm. The nanoparticle formulations were tested in distilled water as the dissolution medium an hour. At predetermined time intervals, 5 mL samples were withdrawn, filtered using Whatman filter paper No. 41, and appropriately diluted. The drug content in the samples was then analysed using UV spectrophotometry [18].

2.3.10. Stability study

Stability testing was conducted on the optimized batch, which exhibited the highest entrapment efficiency, drug release, and drug content. The formulation was stored using a Remi SC-6 Plus stability chamber under two temperature conditions: 25°C and 40°C. Under ICH guidelines, drug content was analysed after 45 and 90 days to assess any changes in the nanoparticle parameters [18].

3. Results and discussion:

3.1 Total Drug Content:

The drug content of Teneligliptin nanoparticles was evaluated for all nine formulation batches (F1 to F9) to assess the total amount of drug within the nanoparticulate system. The results, shown in Figure 2, reveal that the drug content varied between 90.94% to 99.06%, indicating effective drug loading across all formulations. Among all the batches, F7 exhibited the highest drug content 99.06%, while F2 recorded the lowest 90.94%.

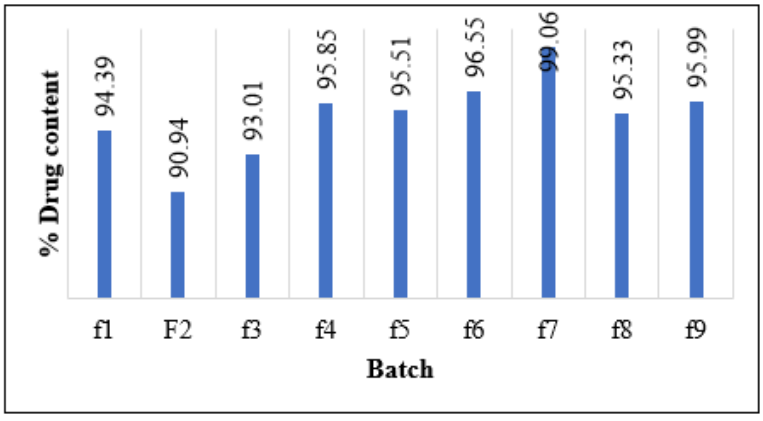

Figure 2: Percent (%) Drug content report of formulation F1 to F9.

3.2 Entrapment Efficiency

The entrapment efficiency of all nanoparticle formulations ranged from 93.95% (F2) to 99.17% (F7). The highest entrapment was observed in batch F7, indicating superior formulation parameters. The consistently high EE values across all batches reflect the robustness and reliability of the preparation method used for Teneligliptin nanoparticles, it is shown in figure 3.

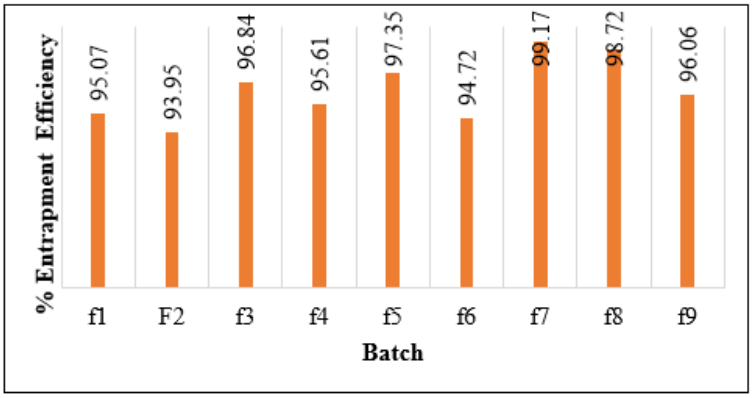

Figure 3: Percent Entrapment Efficiency report of Formulations F1 to F9.

3.3 Particle Size Analysis

Using a Horiba scientific instrument, the mean averaged particle size of the Teneligliptin nanoparticle has been determined. The size of each particle was determined using the scattering of dynamic light, and 0.3 ml of the substance was put into the viewing unit for examination. At room temperature, the size of particles was analyzed at a scattering angle of 90°C. The enormity has been converted to a size and shape distribution by combining 3 parallel measurements obtained while waving in Brownian motion. The particle size analysis of Teneligliptin nanoparticles across batches F1 to F9 was found to be within the range of 194.80 to 268.50 as shown in Figure. 4 and 5.

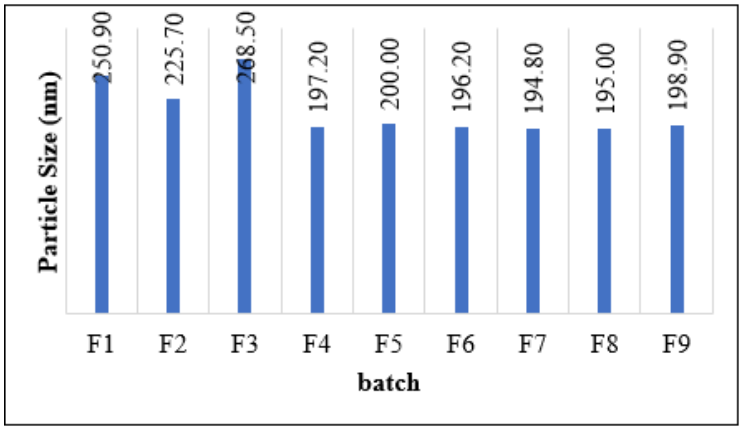

Figure 4: particle size report of formulation F1 to F9.

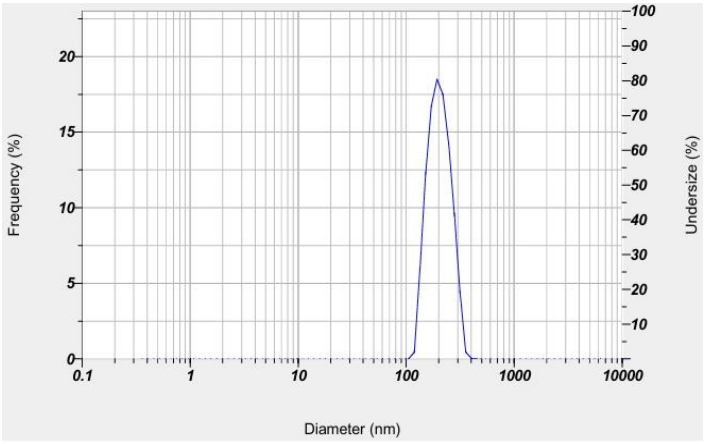

Figure 5: Particle Size Report of Optimized Batch F7.

3.4 Zeta Potential Analysis:

The net charge on particles was measured with the help of a Horiba scientific device. 1 ml of NP was collected and then diluted with double-distilled water. The scattered underwent a five-minute ultra-bath sonicator treatment to prevent agglomeration. Zeta potential had been determined following the extraction of the sample from the transparent cuvette. The Zeta potential of each batch of solid TG nanoparticles has been determined. The produced batches of NP were found to have a zeta potential ranging from 11.25 to -26.90 mV. As shown in Table 1 and Figure 6.

Batch	Zeta Potential (mV)
F1	-15.90
F2	-13.60
F3	-15.20
F4	-14.90
F5	-13.50
F6	-12.20
F7	-11.60
F8	-12.60
F9	-11.50

Table 2: Zeta potential report of formulation batches F1 to F9.

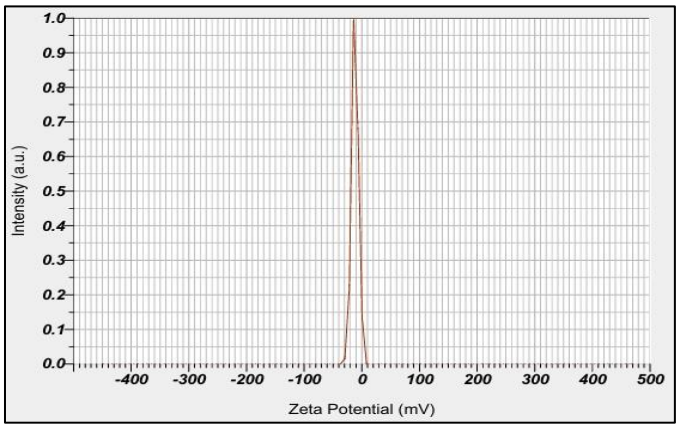

Figure 6: Zeta Potential Report of Optimized Batch F7.

3.5 Scanning Electron Microscopy

The Teneligliptin appeared as smooth surfaced, irregularly shaped and crystalline in nature. NP was observed to be small-sized, spherical in shape and porous in nature as shown in Figure 7.

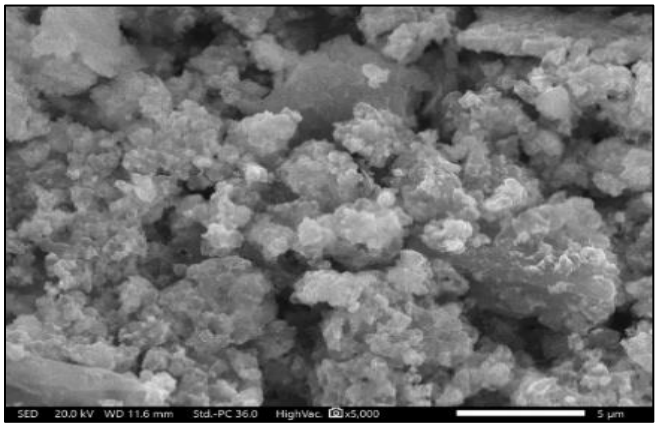

Figure 7: SEM Photographic Images of Optimized Batch F7.

3.6 FT-IR Spectroscopy

The FTIR analysis was conducted to confirm the chemical integrity of Teneligliptin and to investigate any possible interactions between the drug and the excipients used in the formulation of its nanoparticles. The characteristic absorption bands of pure Teneligliptin were identified and compared with those of

the nanoparticle formulation and individual excipients. Overall, the FTIR analysis confirms that Teneligliptin retains its chemical integrity upon formulation into nanoparticles, with no significant structural modifications. The slight shifts and the appearance of new peaks in the formulation spectrum suggest successful encapsulation and physical interactions with the excipients, without any chemical incompatibility or degradation of the drug. The FTIR spectra and its detail shown in figure 8, 9 and the interpretation data shown in table 2.

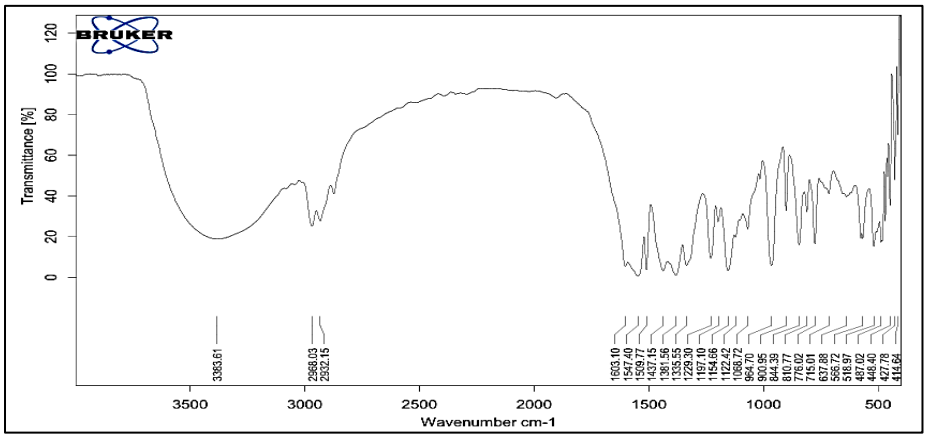

Figure 8: FTIR Spectra of Teneligliptin.

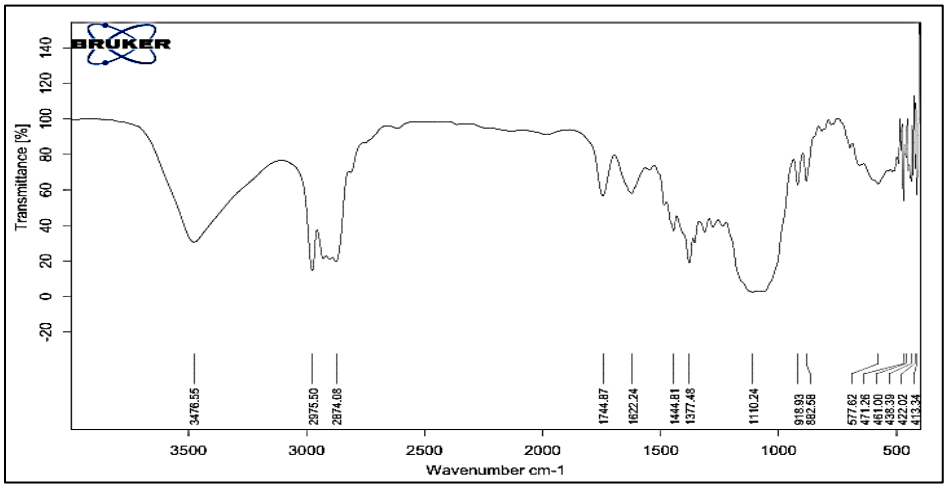

Figure 9: FTIR Spectra of Optimized Batch F7.

Functional Group	Absorbance Frequency Region (cm^{-1})	Pure Teneligliptin	Teneligliptin Nanoparticles
N–H Stretching	3350–3500	3338.61	3476.55
C–H Stretching	3000–2850	2938.09, 2926.15	2975.50, 2874.06
C=O Stretching	1750–1700		1744.87
C–N Stretching (Primary amine)	1390–1250	1342.15, 1252.56	1384.37
C–O Stretching	1300–1000	1172.66 – 1020.72	1102.24
Aromatic C=C / C=N Stretching	1600–1450	1603.10, 1507.17	1622.24
C–Cl Stretching	785–540	717.66, 480.49	577.62, 554.20, 486.09

Table 2: Data Interpretation of FTIR Spectra.

3.7 Differential Scanning Calorimetry (DSC):

DSC thermograms revealed a sharp endothermic peak at 231.10 °C for the TG sample, indicating high crystallinity and thermal stability. In contrast, the F7 formulation displayed a broader, lower-intensity peak at 177.99 °C with significantly reduced enthalpy, suggesting decreased crystallinity and possible drug amorphization. These thermal shifts confirm improved drug-excipient miscibility in F7, supporting its potential for enhanced solubility and bioavailability. The DSC thermogram for pure drug and optimized batch F7 is shown on figure 10 and 11.

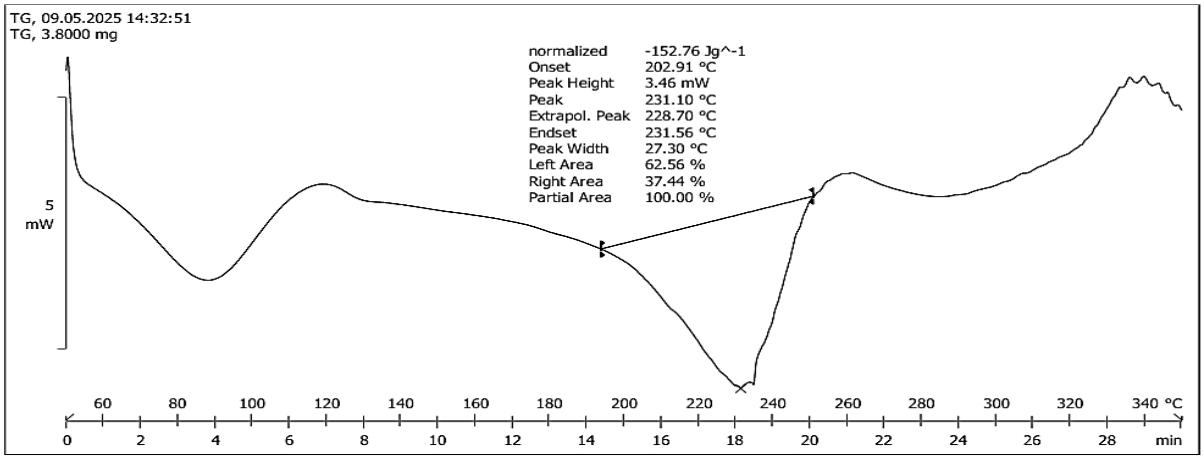

Figure 10: DSC Thermogram of Pure Drug (Teneligliptin).

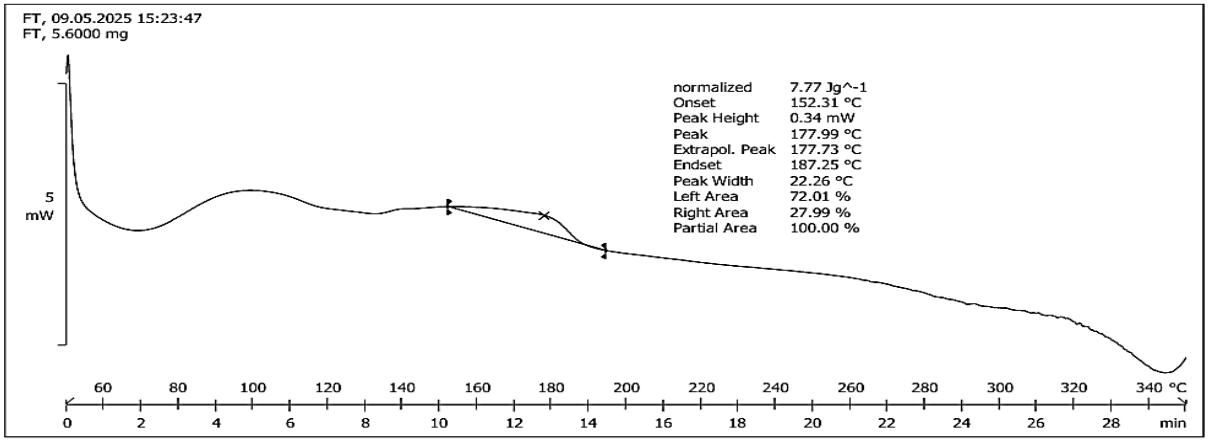

Figure 11: DSC Thermogram of Optimized Batch F7.

3.8 X-Ray Diffraction (XRD) Study:

The XRD pattern of pure Teneligliptin displays a broad peak around 20° 2θ, indicating its predominantly amorphous nature. In contrast, the optimized formulation F7 shows distinct and sharp peaks at 10.68°, 17.63°, 20.28°, and 25.60°, suggesting the presence of crystalline structures. The appearance of these peaks in F7 confirms a transformation from the amorphous state to a more crystalline form, likely due to interactions with excipients or processing conditions during formulation, It is shown in figure 12 for pure drug and optimized batch F7 in Figure 13

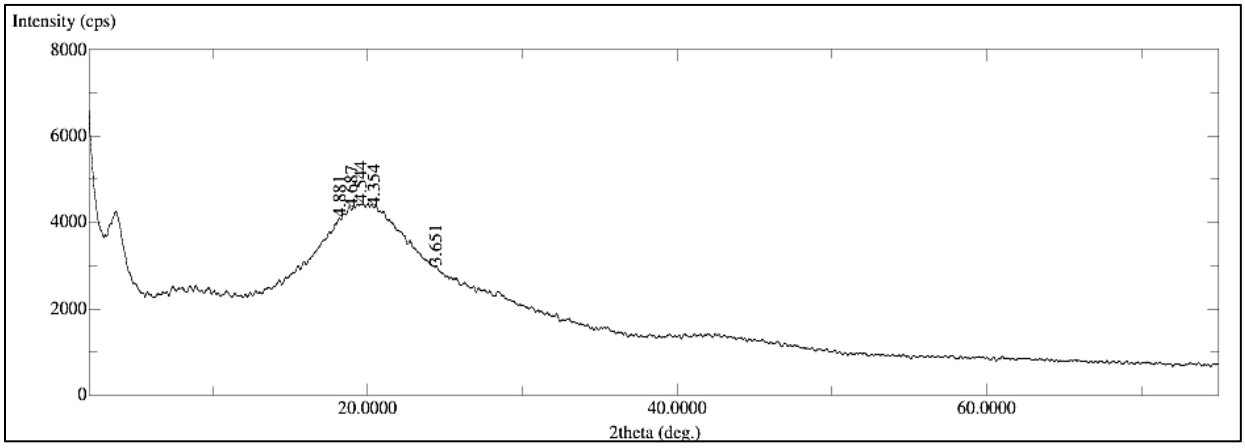

Figure 12: XRD Spectra of Pure Drug (Teneligliptin).

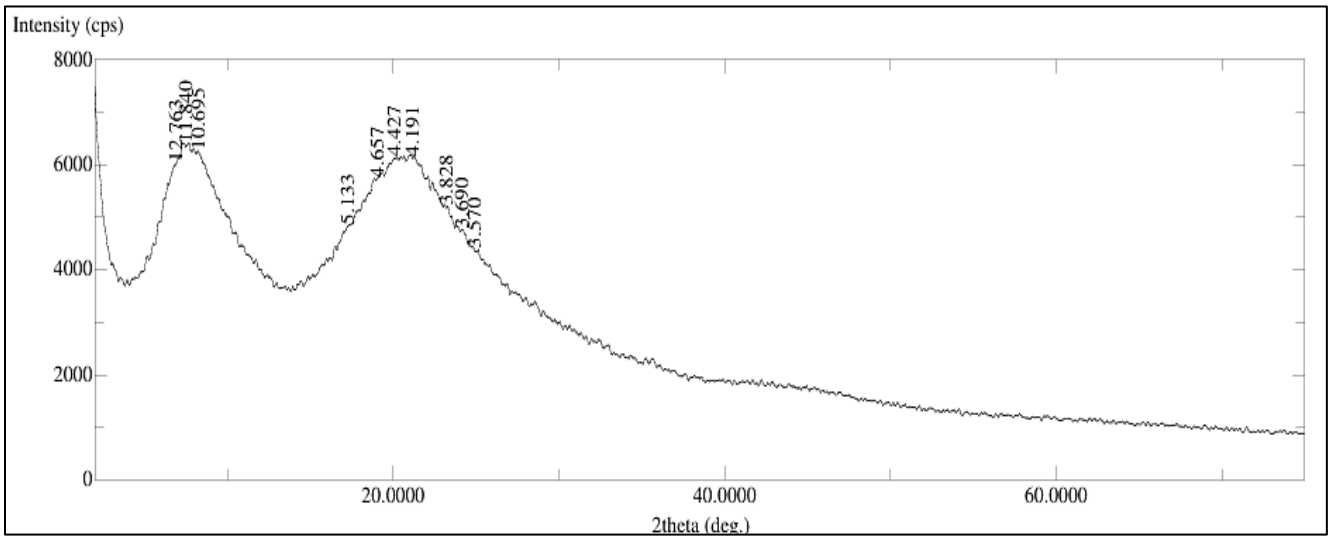

Figure 13: XRD Spectra of Optimized Batch F7.

3.9. In Vitro Drug Release:

The in vitro drug release profiles of nine different formulations (F1 to F9) were studied using a dissolution test conducted over 60 minutes. The cumulative percentage of drug release was recorded at 5-minute intervals and is presented in the table 3:

Time (min)	F1	F2	F3	F4	F5	F6	F 7	F8	F9
5	15.00	16.15	17.31	18.46	19.62	20.77	26.05	21.92	21.27
10	16.23	17.48	18.72	19.97	21.22	22.47	28.18	23.72	23.01
15	17.45	18.80	20.14	21.48	22.83	24.17	30.32	25.51	24.75
20	18.00	19.38	20.77	22.15	23.54	24.93	31.26	26.31	25.52
25	20.45	22.03	23.60	25.18	26.75	28.32	35.53	29.89	29.00
30	28.36	30.55	32.73	34.91	37.09	39.28	49.26	41.45	40.21
35	35.45	38.18	40.91	43.64	46.37	49.10	61.58	51.82	50.27
40	37.50	40.38	43.27	46.16	49.04	51.93	65.13	54.80	53.17
45	39.13	42.15	45.16	48.17	51.18	54.19	67.97	57.20	55.49
50	40.91	44.06	47.20	50.35	53.50	56.65	71.05	59.79	58.00
55	42.95	46.26	49.56	52.87	56.18	59.48	74.61	62.78	60.90
60	44.18	47.58	50.98	54.38	57.78	61.18	76.74	64.57	62.64

Table 3: In-Vitro Drug Release Study of all Batches.

The in-vitro dissolution study confirmed that the nanoparticle formulations significantly improved the dissolution rate of Teneligliptin. Among all the tested formulations, F7 was identified as the most promising, with the highest cumulative drug release. These findings suggest that formulation F7 may offer enhanced bioavailability and is suitable for further pharmacokinetic and in-vivo evaluations.

3.10 In-Vitro Drug Release Kinetics:

The in vitro drug release behaviour of nine different formulation batches (F1–F9) was assessed 60-minute period. All formulations showed a time-dependent increase in drug release, with batch F7 achieving the highest cumulative release of 76.74% at the end of the study, identifying it as the most effective formulation. To investigate the underlying release mechanism and kinetics, the data were fitted to five established kinetic models: Zero-order, First-order, Higuchi, Hixson–Crowell, and Korsmeyer–Peppas. The suitability of each model was determined through various statistical parameters, including the coefficient of determination (R^2), Akaike Information Criterion (AIC), Model Selection Criterion (MSC), along with kinetic parameters such as the rate constant (k) and release exponent (n).

Table 4 Regression Coefficient (R^2) Values of Drug Release Data Obtained from Various Kinetic Models and "n" Value (Diffusional Exponent) According Korsmeyer 's-Peppas. The detail kinetics release data shown in table 4 and Figure 14.

Drug Kinetic Modeling											
Formulation	**Zero Order**		**First Order**		**Higuchi**		**Hixson Crowell**		**Korsmeyer Peppas**		
	R2	k0	R2	k1	R2	kH	R2	kHC	R2	n	kKP
F1	0.8611	0.848	0.9175	0.011	0.9333	5.513	0.9038	0.003	0.9521	0.637	3.343
F2	0.8611	0.913	0.9208	0.012	0.9333	5.937	0.9071	0.004	0.9521	0.637	3.601
F3	0.8611	0.979	0.9240	0.013	0.9333	6.361	0.9103	0.004	0.9521	0.637	3.858
F4	0.8611	1.044	0.9268	0.014	0.9333	6.786	0.9135	0.004	0.9521	0.637	4.115
F5	0.8611	1.109	0.9294	0.016	0.9333	7.210	0.9165	0.005	0.9521	0.637	4.373
F6	0.8611	1.174	0.9315	0.017	0.9333	7.634	0.9195	0.005	0.9521	0.637	4.630
F7	0.8611	1.473	0.9350	0.024	0.9333	9.575	0.9307	0.007	0.9521	0.637	5.807
F8	0.8611	1.240	0.9332	0.018	0.9333	8.057	0.9223	0.005	0.9521	0.637	4.886
F9	0.8611	1.202	0.9323	0.018	0.9333	7.816	0.9207	0.005	0.9521	0.637	4.740

Table 4: In-Vitro Drug Release Kinetics.

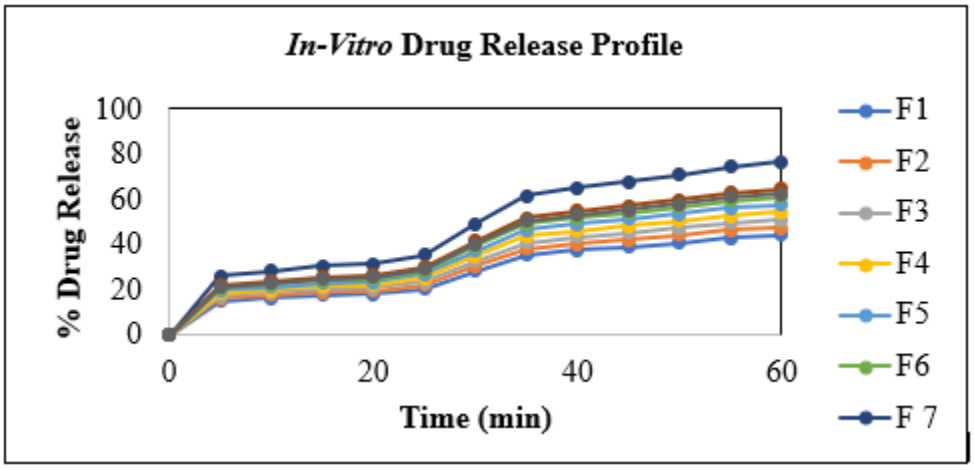

Figure 14: In-Vitro Release Profile of the Formulations F1 to F9.

The Korsmeyer–Peppas model best described drug release across all formulations, with a high R^2 of 0.9521, lowest AIC, and highest MSC values, indicating an anomalous (non-Fickian) diffusion mechanism. The average release exponent ($n \approx 0.637$) suggests that a combination of diffusion and polymer matrix relaxation/erosion controls the release. Zero-order kinetics showed the poorest fit, while First-order, Higuchi, and Hixson–Crowell models fit moderately but were inferior to Korsmeyer–Peppas. Among batches, F7 exhibited the highest release rate constant (k = 5.807) and the most favorable statistical parameters, confirming its rapid and controlled drug release via a balanced non-Fickian mechanism, making it the optimal formulation for further development.

3.11 Stability Studies:

Stability testing was conducted on the optimized nanoparticle batch, which exhibited high entrapment efficiency, drug content, and drug release. The formulation was stored under two temperature conditions—25°C and 40°C—to evaluate stability. As per ICH guidelines, drug content was analyzed at 45 and 90-day intervals to assess any variations in entrapment efficiency, drug release, and drug content. The outcomes are presented in Table 5. The nanoparticles remained stable throughout the testing period under the specified conditions, confirming compliance with ICH stability standards. The stability data of optimized batch is shown in table 5.

Storage condition	**Entrapment Efficiency (%)**			**Drug Content (%)**			**% Drug Release at 1 hr.**		
	Initial	**45 Days**	**90 Days**	**initial**	**45 Days**	**90 Days**	**Initial**	**45 Days**	**90 Days**
25°C	99.17	98.75	98.43	99.06	98.60	98.10	76.74	75.87	75.20
40°C	99.17	98.58	98.09	99.06	98.25	97.85	76.74	75.55	74.93

Table 5: Stability Study of NP of Optimized Batch F7.

Conclusion

It is concluded that the prepared nanoparticles of Teneligliptin were evaluated for all the parameters, including drug content, entrapment efficiency, particle size, zeta potential, morphological analysis, thermal and crystallinity studies, and in vitro drug release behavior. The results demonstrated successful formulation of nanoparticles using the nanoprecipitation method with Ethyl Cellulose as the polymer. Among the nine batches developed (F1–F9), formulation F7 was identified as the optimized batch due to its superior performance, showing the highest drug content (99.06 %), entrapment efficiency (99.17 %), optimal particle size

(194.80 nm), and maximum drug release (76.74 % at 60 minutes). Zeta potential values indicated stable colloidal dispersion, and characterization techniques (SEM, FT-IR, DSC, XRD) confirmed the formation of stable nanoparticles with modified physicochemical properties. Drug release followed the Korsmeyer–Peppas kinetic model, suggesting a controlled, non-Fickian mechanism. Stability studies confirmed that the optimized formulation remained stable under ICH storage conditions over 90 days. Therefore, the developed Teneligliptin nanoparticles, particularly batch F7, represent a promising approach for enhancing solubility, bioavailability, and therapeutic efficacy in the management of Type 2 Diabetes Mellitus.

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References

1. Atkinson MA, Eisenbarth GS. (2001). Type 1 diabetes: new perspectives on disease pathogenesis and treatment. *The Lancet*. Jul 21;358 (9277):221-229.
2. Weyer C, Bogardus C, Mott DM, Pratley RE. (1999). The natural history of insulin secretory dysfunction and insulin resistance in the pathogenesis of type 2 diabetes mellitus. *The Journal of clinical investigation*. Sep 15;104(6):787-794.
3. Abutaleb MH. (2016). Diabetes mellitus: an overview. *Pharm Pharmacol Int J*.;4(5):406-111.
4. Surampudi PN, John-Kalarickal J, Fonseca VA. (2009). Emerging concepts in the pathophysiology of type 2 diabetes mellitus. Mount Sinai Journal of Medicine: *A Journal of Translational and Personalized Medicine*. Jun;76(3):216-226.
5. Nathan DM. (1993). Long-term complications of diabetes mellitus. New *England journal of medicine*. Jun 10;328(23):1676-1685.
6. Yellanki Sk, Mangilal T. Preparation and in vitro evaluation of metoprolol-loaded bovine serum albumin nanoparticles. Asian Journal of Pharmaceutical and Clinical Research. 2021 Jan 5:213-217.
7. Nirmala D, Sai KB, Sudhakar M. (2023). Formulation and evaluation of simvastatin nanoparticles. *Asian Journal of Pharmacy and Technology*.;13(3):183-188.
8. Mirsasaani SS, Hemati M, Dehkord ES, Yazdi GT, Poshtiri DA. (2019). Nanotechnology and nano biomaterials in dentistry. In Nano biomaterials in clinical dentistry Jan 1 (pp. 19-37). *Elsevier*.
9. Vijaya Bhaskar N, Ravi Prakash P, Devanna N. (2015). Formulation and characterization of Simvastatin nanoparticles loaded transdermal patch. *Journal of chemical and pharmaceutical research*.;7(7):1084-1093.
10. Amulyaratna Behera AB, Sahoo SK. (2012). Preparation and evaluation of glibenclamide-loaded biodegradable nanoparticles. *Tropical Journal of Pharmaceutical Research* June; 11 (3): 345-350.
11. Anitha A, Deepa N, Chennazhi KP, Nair SV, Tamura H, Jayakumar R. (2011). Development of mucoadhesive thiolated chitosan nanoparticles for biomedical applications. *Carbohydrate Polymers*. Jan 1;83(1):66-73.
12. Lam PL, Wong WY, Bian Z, Chui CH, Gambari R. (2017). Recent advances in green nanoparticulate systems for drug delivery: efficient delivery and safety concern. *Nanomedicine*. Feb 1;12(4):357-385.
13. Jahangirian H, Lemraski EG, Webster TJ, Rafiee-Moghaddam R, Abdollahi Y. (2017). A review of drug delivery systems based on nanotechnology and green chemistry: green nanomedicine. *International journal of nanomedicine*. Apr 12:2957-2978.
14. Ahamed MN, Sankar S, Kashif PM, Basha SH, Sastry TP. (2015). Evaluation of biomaterial containing regenerated cellulose and chitosan incorporated with silver nanoparticles. *International Journal of Biological Macromolecules*. Jan 1; 72:680-686.
15. Ahmad MB, Shameli K, Darroudi M, Yunus WM, Ibrahim NA. (2009). Synthesis and characterization of silver/clay/chitosan bio-nanocomposites by UV-irradiation method. *American Journal of Applied Sciences*.;6(12):2030.
16. Anitha A, Deepa N, Chennazhi KP, Nair SV, Tamura H, Jayakumar R. (2011). Development of mucoadhesive thiolated chitosan nanoparticles for biomedical applications. *Carbohydrate Polymers*. Jan 1;83(1):66-73.
17. Archana, D., Singh, BK., Dutta, J., Dutta, PK., 2013. In vivo evaluation of chitosan PVA-titanium dioxide nano dressing as wound dressing material. *Carbohydrate Polymers*, 95(1), 530-539.

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