

Formulation and Evaluation of Metformin Hydrochloride Mucoadhesive Controlled Release Tablets using Pullulan-tris (2-aminoethyl) amine (PUL-TAEA) Polymer

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ABSTRACT: The present study aimed to formulate and evaluate mucoadhesive controlled release tablets of Metformin Hydrochloride using Pullulan-tris (2-aminoethyl) amine (PUL-TAEA) polymer to enhance bioavailability and patient compliance. Metformin Hydrochloride suffers from a short half-life and extensive first-pass metabolism, making it an ideal candidate for controlled release systems. The tablets were prepared using direct compression method, employing PUL-TAEA, HPMC, and Carbopol as mucoadhesive polymers. Pre-compression and post-compression parameters, drug-polymer compatibility, and in-vitro dissolution studies were performed. The optimized formulation (F3) exhibited sustained release up to 12 hours with strong mucoadhesive strength and uniform physicochemical characteristics. The release kinetics followed non-Fickian diffusion, suggesting an anomalous transport mechanism. The study concluded that PUL-TAEA can serve as an effective mucoadhesive polymer for controlled drug delivery of Metformin Hydrochloride.

Keywords: Metformin Hydrochloride, Mucoadhesive Tablet, Pullulan-tris (2-aminoethyl) amine, Controlled Release, Bioavailability.

I. INTRODUCTION

Diabetes Mellitus is a chronic metabolic disorder characterized by persistent hyperglycemia resulting from defects in insulin secretion, insulin action, or both. Metformin Hydrochloride, a biguanide, is the first-line therapy for Type 2 Diabetes Mellitus but has limitations such as short biological half-life and low bioavailability. Controlled release mucoadhesive systems provide an opportunity to prolong gastric residence and maintain steady plasma concentrations. This research explores the formulation of Metformin Hydrochloride tablets using PUL-TAEA polymer to achieve sustained release and improved mucoadhesion.

II. MATERIALS AND METHODS

A. Materials

Metformin Hydrochloride was obtained as a gift sample. PUL-TAEA polymer, HPMC K15M, Carbopol, and Lactose were procured from certified suppliers and used as received.

B. Formulation Development

Tablets were prepared via direct compression using varying ratios of PUL-TAEA, HPMC, and Carbopol. The composition of formulations (F1–F9) is shown in **Table 1**.

Table 1. Composition of Mucoadhesive Controlled Release Tablets

Ingredients(mg)	Formulation code								
	F1	F2	F3	F4	F5	F6	F7	F8	F9
Metformin Hydrochloride	500	500	500	500	500	500	500	500	500
Pullulan-TAEA	50	100	150	-	-	-	-	-	-
Carbopol934P	-	-	-	50	75	100	-	-	-
HPMCK100M	-	-	-	-	-	-	100	150	200
Lactose	232	182	132	232	207	182	182	132	82
PVP K30	10	10	10	10	10	10	10	10	10
Magnesium Stearate	3	3	3	3	3	3	3	3	3
Talc	5	5	5	5	5	5	5	5	5
Total	800	800	800	800	800	800	800	800	800

C. Evaluation Parameters

Pre-compression parameters such as angle of repose, bulk and tapped density, Carr’s index, and Hausner’s ratio were determined. Post-compression parameters included hardness, thickness, friability, weight variation, drug content, swelling index, and mucoadhesive strength.

D. In-Vitro Drug Release

Dissolution studies were carried out using USP Type II apparatus in 0.1N HCl at $37 \pm 0.5^\circ\text{C}$ and 50 rpm.

III. RESULTS AND DISCUSSION

A. Physical Characterization

All formulations showed good flow properties and acceptable hardness (5–7 kg/cm²). The friability was below 1%, indicating good mechanical strength. Drug content ranged from 98–102%.

Table 2. Evaluation Parameters of Optimized Formulation (F3)

Parameter	F1	F2	F3	F4	F5	F6	F7	F8	F9
Hardness(Kg/cm ²)	5.1	5.4	5.5	4.3	4.5	4.7	4.5	4.9	4.8
Weightvariation (%)	2.6	0.7	1.8	0.8	1.4	2.5	2.2	0.8	2.2
Thickness (mm)	2.5	2.3	2.2	2.5	2.5	2.4	2.5	2.4	2.4
Friability(%)	0.67	0.61	0.62	0.68	0.65	0.63	0.68	0.62	0.66
%DrugContent	98.15	98.26	98.89	97.58	98.18	98.37	95.20	98.04	97.84
MucoadhesiveStrengt h (N)	0.25	0.31	0.45	0.21	0.32	0.40	0.13	0.18	0.22
SwellingIndex(%)	125	145	178	122	157	209	89	118	232

B. FTIR Analysis

FTIR spectra confirmed the absence of chemical interaction between Metformin Hydrochloride and PUL-TAEA polymer.

Table 3:FTIR studies of Metformin Hydrochloride

Bond	Characteristicwave number cm ⁻¹	PureMetforminHydrochloridewavenumbercm ⁻¹
N-H stretch	3400-3100	3370.74, 3326.76, 3294.70, 3174.47
N-Hband	1650–1580	1625.23, 1568.17, 1583.11
C-Nstretching	1220-1020	1038.30, 1060.50, 1166.44
N-H wag	910–665	636.82, 735.87, 799.42

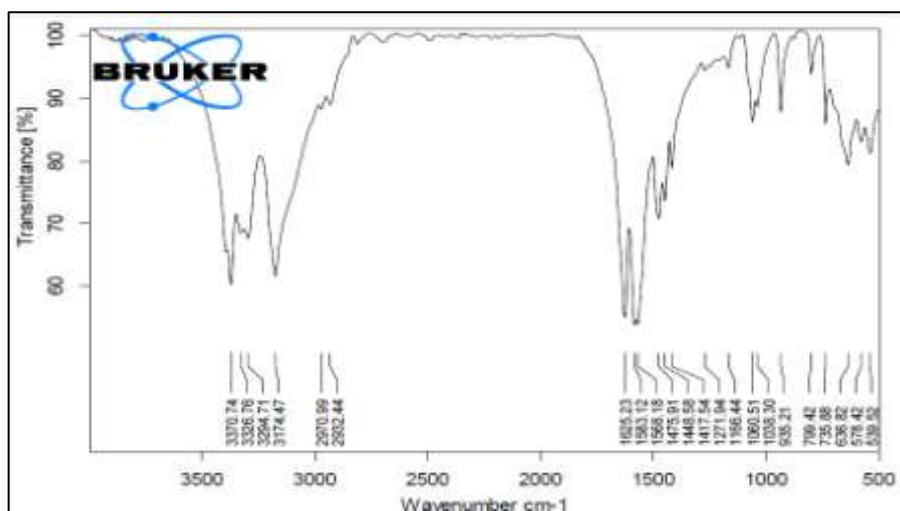


Figure 1: FTIR Spectrum of Metformin Hydrochloride

C. Drug Release Studies

The optimized formulation (F3) exhibited sustained drug release up to 12 hours (97.6%

cumulative release). The release followed non-Fickian diffusion, suggesting a combination of diffusion and erosion mechanisms.

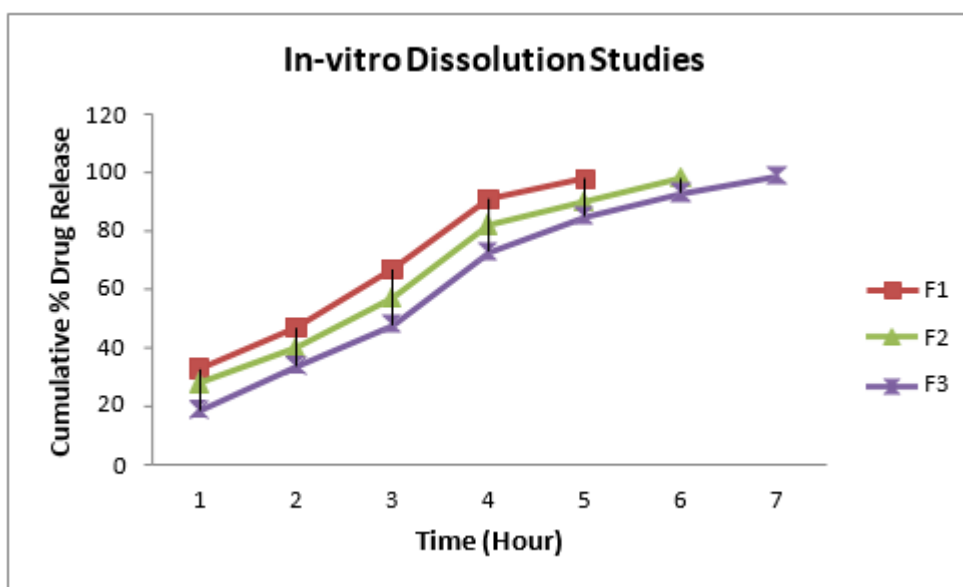


Figure 2: Drug Release Profile of Optimized Formulation (F3)

D. Mucoadhesive Strength and Swelling Index

Increased polymer concentration enhanced mucoadhesive strength due to improved hydration and polymer chain interpenetration with mucin.

IV. CONCLUSION

A stable mucoadhesive controlled release tablet of Metformin Hydrochloride was successfully developed using Pullulan-tris (2-aminoethyl) amine (PUL-TAEA) polymer. The optimized formulation achieved sustained drug release for 12 hours with good mucoadhesive and mechanical properties, confirming its potential as a novel excipient for oral controlled release systems.

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