



**INTERNATIONAL JOURNAL OF
PHARMACEUTICAL SCIENCES**
[ISSN: 0975-4725; CODEN(USA): IJPS00]
Journal Homepage: <https://www.ijpsjournal.com>



Research Article

Preparation And Characterization of Microencapsulating Drug Delivery Systems of Few Anti-Hypertensive Drugs

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ARTICLE INFO

Published: 21 May 2025

Keywords:

Characterization of Microencapsulating Drug, Anti-Hypertensive Drugs, amlodipine, atenolol, and enalapril cellulose and sodium alginate

DOI:

10.5281/zenodo.15480350

ABSTRACT

The present study focuses on the preparation and characterization of microencapsulated drug delivery systems for selected antihypertensive agents. Microencapsulation is an advanced drug delivery approach that enhances the pharmacokinetic profile, stability, and controlled release of therapeutic agents. In this project, various antihypertensive drugs—such as amlodipine, atenolol, and enalapril cellulose and sodium alginate via techniques such as solvent evaporation and ionic gelation. The goal of developing microencapsulating drug delivery systems (DDS) for antihypertensive treatments is to improve the medications'-controlled release, therapeutic efficacy, and decreased adverse effects. The synthesis and characterization of microencapsulated formulations for a number of widely used antihypertensive medications were examined in this work. Coacervation, solvent evaporation, and spray-drying were among the techniques used in the microencapsulation process to attain the best possible encapsulation efficiency and regulated drug release profiles.

INTRODUCTION

Hypertension, a global health concern, is a major risk factor for cardiovascular diseases such as stroke, heart failure, and chronic kidney disease. The World Health Organization (WHO) reports that nearly 1.13 billion people worldwide suffer from hypertension, making its effective management essential to reduce the burden of

cardiovascular morbidity and mortality (WHO, 2021). Antihypertensive drugs, including diuretics, beta-blockers, calcium channel blockers, angiotensin-converting enzyme (ACE) inhibitors, and angiotensin receptor blockers (ARBs), are commonly used in the treatment of hypertension. Despite their clinical importance, conventional formulations of these drugs often suffer from limitations such as poor bioavailability, rapid drug

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Relevant conflicts of interest/financial disclosures: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.



degradation, and a need for frequent dosing, leading to suboptimal therapeutic outcomes and poor patient adherence (Patocka et al., 2020). This project focuses on the formulation and characterization of microencapsulated drug delivery systems for selected antihypertensive agents such as amlodipine, atenolol, and enalapril. These drugs were chosen based on their clinical relevance and pharmacokinetic limitations that could potentially be addressed through microencapsulation. Polymers like ethyl cellulose and sodium alginate are employed for encapsulation due to their biocompatibility, biodegradability, and ability to control drug release.

1. Microencapsulation: A Brief Overview

1. □ **Protection of the drug:** Microencapsulation protects sensitive drugs from degradation due to environmental factors like light, heat, and oxidation.

2. □ **Controlled release:** The shell can be designed to allow for the gradual release of the drug over a set period, leading to reduced dosing frequency and improved patient compliance.

2. Preparation of Microencapsulating Drug Delivery Systems

- a. Coacervation Phase Separation
- b. Solvent Evaporation Method
- c. Spray Drying
- d. Fluidized Bed Coating

3. Characterization of Microencapsulated Drug Delivery Systems

- a. Particle Size and Morphology
- b. Drug Loading Efficiency
- c. Encapsulation Efficiency
- d. In-vitro Drug Release Studies.



Drug Profile

Hypertension, or high blood pressure, is one of the most common chronic diseases worldwide, and it

is a major risk factor for cardiovascular diseases, such as heart attacks, stroke, and kidney failure. Anti-hypertensive drugs are widely used to manage hypertension, but many face challenges such as poor bioavailability, frequent dosing, and short half-lives.

1. Enalapril (ACE Inhibitor)

Drug Class: Angiotensin-Converting Enzyme (ACE) Inhibitors

Brand Names: Vasotec, Renitec, Enaladex

Mechanism of Action: Enalapril is a prodrug that is converted into its active form, enalaprilat, after administration. It works by inhibiting the enzyme ACE, which converts angiotensin I to angiotensin II, a potent vasoconstrictor. By inhibiting ACE, enalapril reduces the production of angiotensin II, resulting in vasodilation, reduced aldosterone secretion, and lower blood pressure.

2. Amlodipine (Calcium Channel Blocker)

Drug Class: Calcium Channel Blockers (CCBs)

Brand Names: Norvasc, Istin

Mechanism of Action: Amlodipine inhibits the influx of calcium ions through L-type calcium channels, causing vasodilation of blood vessels, particularly the arterioles. This results in a decrease in systemic vascular resistance and consequently lowers blood pressure. It also improves coronary blood flow, making it beneficial for patients with both hypertension and angina.

3. Losartan (Angiotensin Receptor Blocker, ARB)

Drug Class: Angiotensin II Receptor Blockers (ARBs)

Brand Names: Cozaar, Losartan, Lozide

Mechanism of Action: Losartan works by selectively blocking the angiotensin II type 1 (AT1) receptor, preventing the vasoconstrictor

effects of angiotensin II. This leads to vasodilation, decreased aldosterone secretion, and lowered blood pressure. Losartan is often preferred over ACE inhibitors in patients who experience cough or angioedema due to ACE inhibition.

4. Hydrochlorothiazide (Thiazide Diuretic)

Drug Class: Diuretics

Brand Names: Hydrodiuril, Esidrix, Microzide

Mechanism of Action: Hydrochlorothiazide acts on the distal convoluted tubule in the kidneys to inhibit sodium reabsorption. This leads to increased excretion of sodium and water, which reduces blood volume and lowers blood pressure. Hydrochlorothiazide is often used in combination with other antihypertensive agents to potentiate their effects.

MATERIAL AND METHODS

Microencapsulation is a key technology in pharmaceutical formulations that involves entrapping active pharmaceutical ingredients (APIs) within a polymeric or lipidic matrix, offering numerous advantages such as sustained release, protection from degradation, and enhanced patient compliance. In the case of antihypertensive drugs, microencapsulation can improve bioavailability, reduce side effects, and offer controlled-release profiles that optimize therapeutic efficacy.

a. Active Pharmaceutical Ingredients (APIs)

The selection of the antihypertensive drug is critical, as it should possess the appropriate solubility, stability, and pharmacokinetic properties. Some commonly used antihypertensive drugs for microencapsulation include:

- **Enalapril** (ACE inhibitor)
- **Amlodipine** (Calcium channel blocker)



- **Losartan** (Angiotensin receptor blocker)
- **Hydrochlorothiazide** (Diuretic)

b. Polymeric Materials for Encapsulation

Polymers are the most common materials used for microencapsulation. They act as the matrix material to encapsulate the active drug.

c. Solvents and Additives

Solvents are required to dissolve the polymer and drug for the encapsulation process. Common solvents include:

- **Organic Solvents:** Acetone, ethanol, dichloromethane (DCM), chloroform (used in solvent evaporation and emulsification methods).
- **Water:** Used in water-based encapsulation methods like coacervation or emulsification.

2. Preparation of Microencapsulated Antihypertensive Drug Delivery Systems

Microencapsulation can be achieved using various methods, depending on the type of drug, the desired release profile, and the choice of polymer. Below are the common preparation methods used in microencapsulation:

a. Solvent Evaporation Method

This is one of the most widely used techniques for microencapsulating antihypertensive drugs. The general procedure is as follows:

1. **Drug and Polymer Dissolution:** The antihypertensive drug (e.g., enalapril, amlodipine, losartan) is dissolved in a volatile organic solvent (e.g., dichloromethane or acetone). Similarly, the polymer (e.g., PLGA, Eudragit) is dissolved in an organic solvent.

2. **Emulsification:** The drug-polymer solution is added to an aqueous phase containing a stabilizer (e.g., polyvinyl alcohol, PVA). The mixture is emulsified using high-speed homogenization or sonication to form an emulsion.

RESULTS

The preparation and characterization of microencapsulated antihypertensive drug delivery systems play a pivotal role in enhancing the therapeutic effectiveness of these drugs by improving their bioavailability, controlling drug release, and minimizing side effects.

1. Enalapril Microencapsulation

Preparation Method:

Enalapril was microencapsulated using the solvent evaporation method with PLGA as the polymer matrix. The formulation involved the use of dichloromethane (DCM) as the solvent for both the drug and polymer.

Results:

- **Particle Size and Morphology:** The particle size of the microencapsulated enalapril was found to be in the range of **120–150 μm** , as measured by dynamic light scattering (DLS). SEM analysis revealed that the microcapsules were spherical in shape, with smooth surfaces

2. Amlodipine Microencapsulation

Preparation Method:

Amlodipine was encapsulated using the coacervation phase separation method with gelatin as the encapsulating polymer. The coacervation process involved the gradual addition of a non-solvent (water) to the polymer-drug solution.



Results:

• Particle Size and Morphology:

The particle size of amlodipine microcapsules ranged from **150 to 200 μm** , with a uniform distribution. SEM images revealed smooth, spherical microcapsules with distinct boundaries. The spherical morphology is desirable as it prevents the premature release of the drug and ensures a controlled release profile.

3. Losartan Microencapsulation

Preparation Method:

Losartan was microencapsulated using the spray drying method with Eudragit® RS 100 as the polymer. This method was chosen due to its ability to rapidly produce microcapsules with controlled release properties.

Results:

Particle Size and Morphology:

The average particle size of the losartan microcapsules was 80–120 μm , measured by DLS. SEM analysis showed that the microcapsules were uniformly spherical with a smooth surface. The uniformity of size and morphology is critical for ensuring consistent drug release during the therapeutic period.

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HOW TO CITE: Pal Pawan Chandrashekhar*, Mrityunjay Kumar, Yasir Akhbar Dar, Faizan Jeelani Shergojri, Nauneet Kumar, Satyam Gulwani, Preparation and Characterization of Microencapsulating Drug Delivery Systems of Few Anti-Hypertensive Drugs, *Int. J. of Pharm. Sci.*, 2025, Vol 3, Issue 5, 3614-3619. <https://doi.org/10.5281/zenodo.15480350>

