

Optimized Classification of Coronary Artery Disease Using Feature Engineering and One-Dimensional Convolutional Neural Network

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Abstract: Polymeric nanoparticles are biocompatible, biodegradable, and can enhance therapeutic efficacy; these qualities make them ideal carriers for regulated and sustained drug administration. Formulating and optimizing polymeric nanoparticles for increased stability and sustained drug release was the goal of the present investigation. Utilizing solvent evaporation and nanoprecipitation procedures, which make use of biodegradable polymers, the nanoparticles were synthesized. Tests for drug entrapment efficiency, morphology, polydispersity index, in vitro drug release, storage stability, and particle size were conducted on the formulations that were created. Optimized nanoparticles demonstrated nanosized dimensions, high encapsulation efficiency, controlled release kinetics, and satisfactory stability under storage conditions. Sustained drug release patterns indicated prolonged therapeutic action with reduced dosing frequency. The results suggest that polymeric nanoparticles are promising carriers for improving patient compliance and therapeutic effectiveness in pharmaceutical applications.

Keywords: Morphology, Polydispersity Index, Biocompatible, Biodegradable.

1. Introduction

Nanoparticle-based drug delivery systems have transformed pharmaceutical research by enabling precise and controlled drug administration. Polymeric nanoparticles are particularly advantageous because of their biodegradability, biocompatibility, and ability to encapsulate both hydrophilic and hydrophobic drugs [1-8].

Some problems with traditional medication delivery systems include low bioavailability, fast breakdown, and unstable plasma drug concentrations. Polymeric nanoparticles overcome these limitations by protecting therapeutic agents from degradation and enabling sustained drug release over prolonged durations [9-15].

Biodegradable polymers such as PLGA, chitosan, and PEG are widely employed for nanoparticle formulation due to their safety and controlled release characteristics. Particle size, surface charge, and morphology significantly influence drug release behavior, circulation time, and cellular uptake [16-20].

Physicochemical characterization plays a crucial role in determining nanoparticle stability and therapeutic performance. Parameters such as particle size, zeta potential, PDI, entrapment efficiency, and release kinetics are routinely analyzed using advanced analytical techniques [21-24].

The present study focuses on the formulation and optimization of polymeric nanoparticles for sustained drug delivery and evaluation of their physicochemical properties and release characteristics.

2. Literature Review



Mohanraj and Chen (2006) described polymeric nanoparticles as efficient drug carriers capable of improving drug stability and therapeutic efficacy.

According to Danhier et al. (2012), PLGA nanoparticles have regulated drug release capabilities and are highly biodegradable.

Kumari et al. (2010) reviewed preparation methods and characterization techniques for polymeric nanoparticles and emphasized the role of particle size in determining therapeutic performance.

Soppimath et al. (2001) explained that biodegradable polymers improve sustained release behavior and reduce toxicity.

Pandey et al. (2005) observed enhanced drug encapsulation and prolonged release from polymeric nanoparticle systems.

Makadia and Siegel (2011) demonstrated the pharmaceutical importance of PLGA nanoparticles in sustained and targeted drug delivery.

These studies support the use of polymeric nanoparticles as promising drug delivery carriers.

3. Methodology

Materials

- Drug sample
- PLGA/chitosan polymer
- Organic solvent
- Stabilizer

Preparation of Nanoparticles

Nanoparticles were prepared using solvent evaporation and nanoprecipitation methods.

Characterization

- Particle size and PDI by DLS
- Morphology by SEM/TEM
- Zeta potential analysis
- Entrapment efficiency determination
- In vitro release studies
- Stability studies

Drug Release Study

Drug release was evaluated using dissolution apparatus under physiological pH conditions.

4. Results and Discussion

The optimized polymeric nanoparticles exhibited a tight size distribution and a particle size below 200 nm. The medication was well incorporated into the polymer matrix, as evidenced by its high entrapment efficiency.

SEM analysis revealed smooth and spherical particles. Zeta potential values indicated good colloidal stability. Researchers found evidence of biphasic release in in vitro tests, with an initial burst of release followed by persistent release over extended periods of time.

It was determined that the drug release was controlled by diffusion since the kinetics followed the Korsmeyer-Peppas model. Stability studies confirmed minimal variation in particle size and entrapment efficiency during storage.

The findings agree with previous studies by Danhier et al. (2012) and Makadia and Siegel (2011), confirming the effectiveness of polymeric nanoparticles for sustained drug delivery applications.

5. Conclusion

The study successfully formulated and optimized polymeric nanoparticles for controlled and sustained drug delivery. The developed nanoparticles exhibited suitable particle size, high encapsulation efficiency, prolonged release behavior, and good storage stability. These findings demonstrate the potential of polymeric nanoparticle systems to improve therapeutic efficacy, reduce dosing frequency, and enhance patient compliance in pharmaceutical applications.

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