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Formulation And Evaluation Of Solid Lipid Nanoparticles Of Tropicamide

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Abstract:
Solid lipid nanoparticles (SLNs) represent a significant advancement in the field of nanotechnology, offering a versatile and efficient platform for drug delivery and biomedical applications. These nanoparticles are composed of biocompatible lipids that remain solid at room and body temperatures, allowing them to encapsulate both hydrophilic and hydrophobic therapeutic agents effectively. Their nanoscale dimensions provide unique advantages, such as enhanced drug stability, improved bioavailability of poorly water-soluble drugs, and controlled or targeted release profiles. SLNs can be synthesized using various methods, including high-pressure homogenization, solvent emulsification, ultrasonication, and double emulsion techniques. These approaches produce uniform particles with customizable surface properties, enabling functionalization for ligand-mediated targeting or tailored pharmacokinetics. The lipid matrix not only improves drug solubility but also reduces the risk of toxicity, as the components are generally recognized as safe and are often derived from physiological sourcesApplications of SLN technology extend across multiple routes of administration oral, parenteral, topical, pulmonary, and more facilitating their integration into therapies for diseases requiring precision in drug delivery. They have shown promise in advancing the delivery of anticancer drugs, vaccines, genetic materials, and cosmetic agents. The continued development of SLNs is opening new possibilities for controlled, site-specific therapy and holds substantial potential for the future of nanomedicine.

Keywords: *Solid lipid nanoparticles (SLN), Tropicamide, Ocular drug delivery, In-situ gel formulation, Sustained release, Bioavailability enhancement*

INTRODUCTION

History of nanotechnology of solid lipid nanoparticles (sln):

Nanotechnology is an emerging technology from 9th centurial, and also involves in critical modern science, the scientific illustration property of nano particles come made with Michael Faraday latest function prestigious publications called the preliminary association of aureate to light, the use of nanoparticles in the field of drug transport was first initiated on late 1950's and early 1960's the first oral taking was examined by Professor Peter paul Speiser and his team.

HISTORY OF SOLID LIPID NANOPARTICLES:

The first documentary of nanoparticles have been published by K. Eric Drexler of with the cosmic stepping stone, a Massachusetts organization of applied sciences in 1981. In 1991, as a chance to the perform the colloidal transporters like emulsions, vesicles and various small and minute particles of solid-lipid nanoparticles. Solid lipid nanoparticles are low small lipid transducers sizing from 50 to 1000nm widely used for the property of enhancing the activity of pharmaceutical substance. The solid lipid nanoparticles are physiochemically stable, manufactured on large scale and brought in going production which is productively low.

SOLID LIPID NANOPARTICLES:

Solid Lipid Nanoparticles (SLNs) primarily consist of lipids and stabilizing agents, often incorporating surfactants and coating substances. This delivery system is widely utilized as an excipient and offers multiple advantages over conventional carriers like emulsions, liposomes, and polymeric nanoparticles. SLNs feature a solid, hydrophobic lipid core enveloped by a single layer of phospholipids, allowing efficient encapsulation and transport of lipophilic drugs. Typically, these nanoparticles are formed using high-pressure homogenization, yielding particles around 80 to 100 nanometers in size. This method helps maintain lower production temperatures and appropriate emulsion concentrations to minimize initial drug burst and promote controlled, sustained release. Due to their solid matrix, SLNs improve the stability of sensitive drugs by slowing their degradation and providing prolonged release. They have gained significant attention in drug delivery research, especially for ocular applications, where they enhance corneal absorption, extend drug residence time, and improve bioavailability. Overall, SLNs are valued for

their physical and chemical stability, biocompatibility, and prolonged shelf-life, often maintaining stability for at least two years. They present a promising alternative to traditional drug carriers because of these favorable properties.

EXPERIMENTAL INVESTIGATION

PRE-FORMULATION STUDY

FORMULATION & EVALUATION OF SOLID LIPID NANOPARTICLES (SLNs)

Preparation of 1% w/v Tropicamide-Loaded SLNs

Tropicamide-loaded SLNs were developed using the ionotropic gelation method. Tropicamide and various lipid ratios were dissolved in a 1:1 methanol and chloroform mixture. The organic solvents were completely evaporated using a rotary evaporator, leaving a lipid film, which was then melted at a temperature 5°C above the lipid's melting point.

This lipidic mass was added gradually (dropwise) into an aqueous surfactant solution containing Tween 80, polyethylene glycol, and Span 20, along with 1% w/v calcium chloride, under ultrasonication at 37±0.5°C. The aqueous phase volume was adjusted to 30 ml using distilled water, and the temperature was synchronized with the lipid phase.

The resulting mixture was homogenized at 2500 rpm for 30 minutes at 70°C to generate a coarse oil-in-water (o/w) emulsion, which was then sonicated for 25 minutes using a probe sonicator. Mannitol at 1% w/v was added as a cryoprotectant. The final SLN dispersion was lyophilized at –40°C under 0.010 mbar vacuum, then cooled to room temperature and stored at 4°C.

EVALUATION OF BASIC GELLING PROPERTIES

GELLING STRENGTH

A 100 ml measuring cylinder was filled with about 50 grams of the prepared gel in order to assess its gelling strength. The measurement was taken by pressing a fixed weight into the gel until it reached a depth of 5 cm. The strength and firmness of the gel at body temperature were indicated by the force needed, which was expressed in g/cm^2.

VISCOSITY

Using a Brookfield DV-II+ digital viscometer, the viscosity of the gel bases was measured. This information revealed the gels' consistency and flow characteristics under typical rheological circumstances.

SPREADABILITY COEFFICIENT

A portion of the gel was placed between two glass slides to test its spreadability, and it was compressed for five seconds using a weight of 1000 g. The time it took for the upper slide to move a specific distance as a result of the gel spreading was measured after a separate 50 g weight was placed on top of it. The following formula was used to determine the spreadability

S = ML/T, where:

- M = Applied mass (g)
- L = Length moved (cm)
- T = Time taken (s)

FORMULATION OF SLN ENRICHED IN GELS

To improve ocular drug delivery and achieve sustained release, the previously prepared Tropicamide-loaded SLNs were added to chitosan gel formulations at varying concentrations.

PHYSICOCHEMICAL EVALUATIONS

VISUAL APPEARANCE

In order to check for opacity, turbidity, or any indications of physical instability, the formulations were visually assessed for clarity and uniform appearance against a magazine background.

PH

To verify compatibility with the ocular surface, the pH of SLN-enriched gels with different chitosan concentrations was assessed using a calibrated digital pH meter.

GELLING STRENGTH

To measure the depth of penetration, freshly made 50 g gel samples were put in 100 ml cylinders at 37°C and weighed. The gel's consistency and structural integrity at physiological temperature were indicated by the gelling force, which was measured in g/cm2

RESULT AND DISCUSSION:

characterization of tropicamide

Evaluation of SLN

Entrapment Efficiency (EE)

Despite formulations, a greater involvement was initially observed when the particle magnitude was reduced. The tense net appear area of the particles increases further. EE provides the volume of drug entrapped in the solid lipid found between 67% and 91% percent, as appeared from the table. In spite of the medicating adhesive, a somewhat shorter transpire is provided in pursuit of the majority of particles, but the most area appears on the part of medicating entrapment.

Percentage Yield

When the SLN was being formed, the percentage gave way and the entire deal was later executed, which was once completely useless. Particularly in the freeze-drying contract, the production yield percentage was estimated. The yield percentages from the formulations range from 96.54±1.77 percent to 72.97±1.88 percent.

Physical evaluation of Gel

Viscosity

With the use of a Brookfield field viscometer, striking viscosity with respect to gel bases was determined by administering a small-scale partake adapter and spindle number. The striking viscosity ranged from 212 cp to 237 at 26 ± 0 point 5ºC, and from 225 ± 1 point 12 to 245 ± 1 point 45 for the carbopol gel.

Spreadability coefficient

Between 20.2±0.23 gm/sec and 33.6±0.24 gm/sec, the spreadability coefficient associated with chitosan solidifies base ranged, while for carbopol gel, it ranged from 18.5±0.21 gm/sec to 20.6±0.25 gm/sec. The range of the alginate gel was 19.8±0.33 gm/sec to 21.8±0.14 gm/sec. A summary of the findings was provided in Table 5.13 and Figures 5.20 to 5.22.

Gelling strength

The gelling strength of carbopol gel ranged from 135.98 gm/cm2 to 140.25 gm/cm2, while that of chitosan gel base ranged from 110.12 gm/cm2 to 118 gm/cm2. The range of the alginate gel was 145–21 gm/cm* to 150–25 gm/cm*. A summary of the findings was provided.

CONCLUSION:

Tropicamide in-situ gels based on solid lipid nanoparticles (SLN) are a promising development in the field of ocular drug delivery. With topical administration, this formulation seeks to enable sustained release straight to the eye while also greatly increasing drug bioavailability. To evaluate the physicochemical compatibility of SLNs with the in-situ gel system, a thorough set of characterization studies was carried out, including FTIR and DSC analyses. An ideal SLN-enriched chitosan-based in-situ gel was created by using partitioning and solubility data to guide the lipid selection process. The optimal formulation was evaluated in vitro using Franz diffusion cells.

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