

Nanoparticle-Based Gel Delivery of Suzetrigine for Enhanced Pain Management

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Abstract - Suzetrigine is a novel, selective sodium channel ($Na_v1.8$) inhibitor developed for the management of moderate to severe pain, offering an effective non-opioid alternative for analgesia. Despite its promising pharmacological profile, conventional delivery of Suzetrigine may face challenges such as variable bioavailability, frequent dosing, and potential systemic side effects. To overcome these limitations, the present work focuses on the development of a novel drug delivery system (NDDS) for Suzetrigine aimed at enhancing therapeutic efficacy and patient compliance. The novel delivery approach is designed to provide controlled and targeted drug release, thereby maintaining optimal plasma drug concentrations over an extended period

Keywords: Suzetrigine, Analgesic, Opioids, Sodium channel blocker, Opioid use disorder, Novel analgesic

I. INTRODUCTION (HEADING 1)

Pain is one of the most common reasons for medicine use and hospital consultation. In pharmaceutics, the problem is not only how to provide analgesic activity, but also how to deliver the drug at the correct rate, to the correct site, and for the required duration. A thesis centered on suzetrigine therefore needs to examine both the pharmacology of the molecule and the dosage-form strategy chosen to improve its performance. For formulation scientists, this means that an ideal analgesic system should support reliable dosing, acceptable onset, sufficient duration, and minimal avoidable toxicity. Many conventional analgesics are effective, yet their success may be limited by gastrointestinal irritation, central nervous system effects, repeated dosing, or systemic exposure that exceeds the needs of a local pain condition. These concerns have encouraged research into non-opioid agents, smarter carriers, and dosage forms that improve drug residence at the site of interest.

II. LITERATURE SURVEY

Bishal Sarkar et al. (2025)

Nanogels are next-generation smart and stimuli-responsive nanocarriers for drug delivery, characterized by high water capacity, excellent biocompatibility, tunable size, and environmental responsiveness.

Moon Sup Yoon et al. (2025)

Dual-drug delivery systems using hydrogel–nanoparticle composites have emerged as a versatile platform for achieving controlled, targeted, and efficient delivery of two distinct therapeutic agents.

METHOD OF PREPARATION OF NANOGEL

Emulsion Solvent Diffusion Method:

The aqueous solution of drug is solubilized in an organic layer. Polymer and gelling agent are dissolved in water to form the drug phase, which is added drop wise to the aqueous phase has been homogenized for 30 minutes at 6000 rpm. When an emulsion is homogenized into a Nano droplet by a homogenizer, an oil/ water emulsion is created.⁴² to create

nanogel, Triethanolamine is added to the oil in water emulsion and continuously stirred for an hour at 8000 rotations per minute.

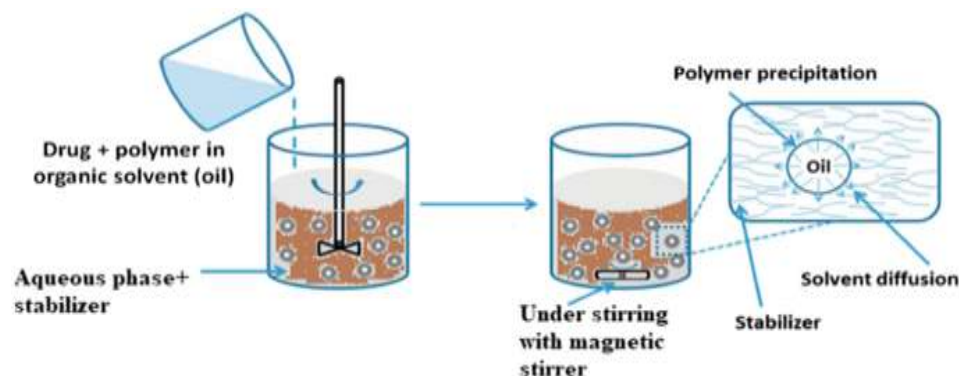


Fig No.1: Emulsion Solvent Diffusion Method

Evaporation of the Solvent Method:

During two hours of treatment, the drug-polymer mixture is injected into the designated area of the aqueous phase. This process is accompanied by continuous stirring at 1000 rpm, facilitated by a magnetic stirrer.⁴⁶ The Nano sponges obtained as a consequence are further subjected to filtration, followed by a drying process in a hot air oven maintained at a temperature of 40°C for 24 hours.⁴⁷ Finally, the dried Nano sponges are carefully transferred into vials for storage. To achieve a homogeneous dispersion, it is recommended to immerse the polymer in water for 2 hours before the initiation of gel formation.^{48,49} Subsequently, the polymer should be subjected to agitation at a rotational speed of 6000 rpm. The pH is modified with the use of a pH-adjusting agent. Subsequently, the aqueous dispersion is combined with the optimized Nano sponge suspension and permeation enhancers.

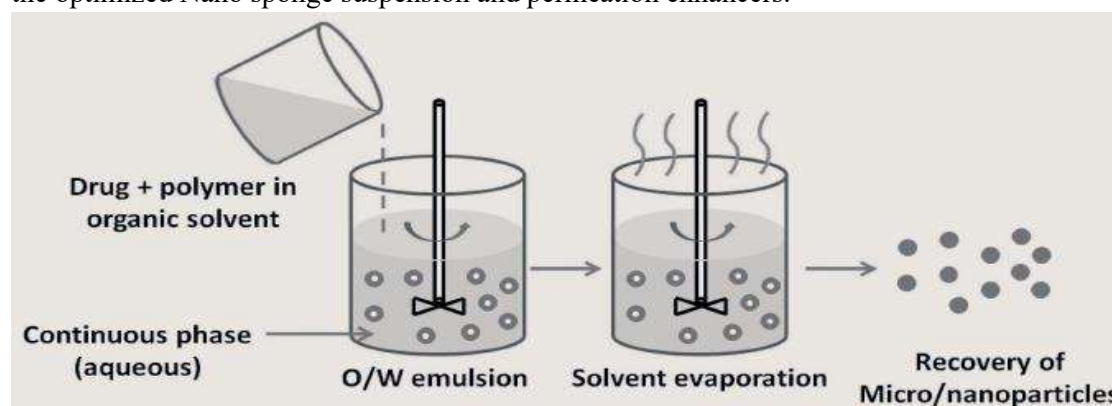


Fig No.2: Evaporation of the Solvent Method

EVALUATION PARAMETER

Pre-Formulation Studies

Pre-formulation studies were used to understand the identity and basic behavior of the drug before formulation.

UV Calibration and λ_{max} Method

UV spectrophotometry was used as the basic analytical technique for drug estimation. The uploaded findings reported that suzetrigine showed absorbance at 194 and 250 nm, but the maximum absorbance used for analysis was 250 nm in distilled water. This wavelength was therefore selected as λ_{max} for quantitative estimation.

Spreadability and Viscosity Methods

Spreadability testing was used to compare how readily each gel could be applied. In general, this parameter becomes more relevant when the product is intended for external or surface application.

RESULT AND DISCUSSION

• Calibration curve of Suzetrigine

UV Spectroscopy After studying the UV spectra of Suzetrigine, it was found that drug shows absorbance at 194 and 250 nm but maximum absorbance was at 250 nm when solution is prepared in distilled water. So, 250 nm was considered as λ_{max} . UV spectra Suzetrigine is shown in Figure

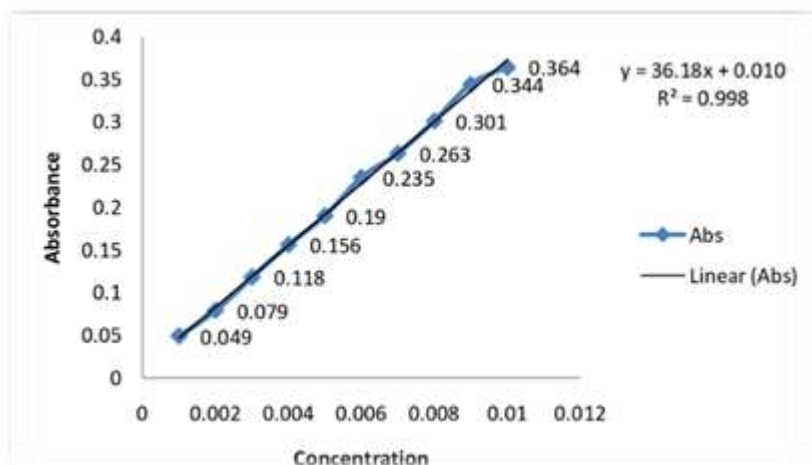


Fig No.3: Calibration curve of Suzetrigine

• **Effect of change in pH on λ_{max}**

λ_{max} of drug was observed by making its solution in different pH to check the effect of pH on λ_{max} . Result of the same is given in Table 5. There was no significant change in λ_{max} of Suzetrigine at different pH. So calibration plot can be constructed by using distilled water and can be used for quantitative evaluation purpose; though the medium of evaluation of release is phosphate buffer pH 7.4.

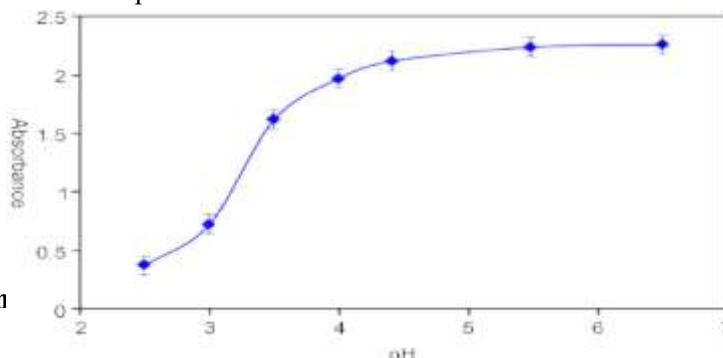
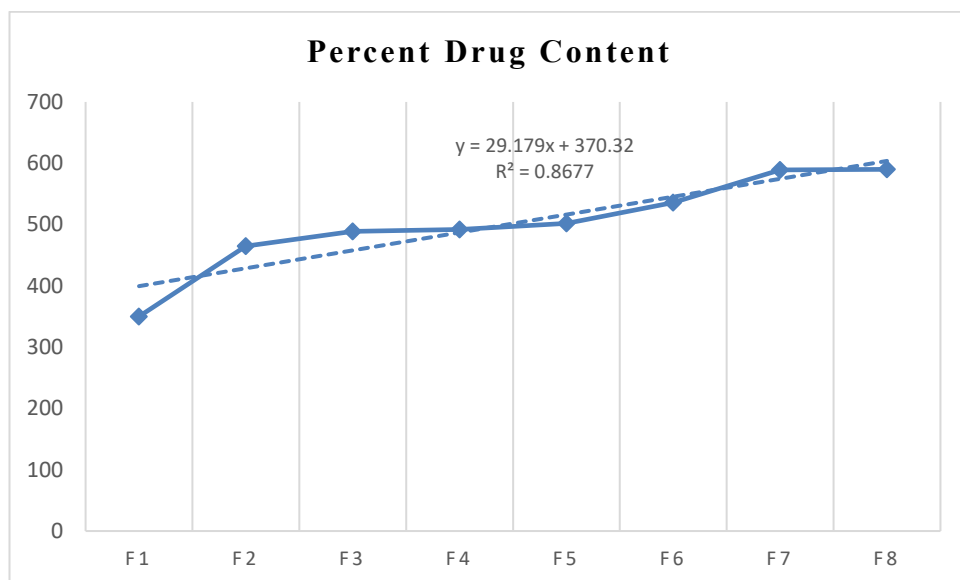


Fig No.4: Effect of change in

• **% Drug Content:**

The drug content of all the formulations from F1 to F8. There is no much difference in the drug content of each formulation. So, the effect of polymers ratios is less considerable here

Formulation Code	Drug content
F1	82.16 %
F2	86.78 %
F3	84.70 %
F4	83.45 %
F5	80.24 %
F6	81.54 %
F7	82.45 %
F8	84.67 %



III. CONCLUSIONS

The present thesis organized a suzetrigine nanoparticle-based gel project into full academic format while preserving the uploaded Result and Discussion section as the core experimental chapter. The combined evidence shows that suzetrigine could be assessed analytically at 250 nm that the drug remained compatible with the main polymeric system on FTIR and DSC interpretation, and that physically acceptable gels with nanosized characteristics could be prepared. A second consideration is the relationship between material selection and patient-facing performance. A semisolid system can appear simple, but its final behavior depends on dispersion quality, polymer hydration, pH control, viscosity, release rate, and storage stability. When these factors are considered together, the dosage form becomes a structured platform for controlled delivery rather than a simple mixture of drug and excipients. The updated thesis presents a coherent project that begins with a current pain-management problem and ends with practical formulation recommendations.

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