RESEARCH
www.commprac.com
ISSN 1462 2815

# FORMULATION AND EVALUATION OF ALLOPURINOL AND DICLOFENAC SODIUM EMULGEL FOR THE MANAGEMENT OF GOUT

**Vikash Singh Bhadouria [1], Sushma Verma [2]*, Pankaj Tyagi [3] and MVNL Chaitanya [4]**

[1,2] Department of Pharmaceutics, Noida Institute of Engineering and Technology (Pharmacy Institute), Greater Noida.
*Corresponding Author Email: sushmaverma76@gmail.com
[3] Department of Biotechnology, Noida Institute of Engineering and Technology, Greater Noida. Email: pankaj.tyagi@niet.co.in
[4] Department of Pharmaceutical Science, Lovely Professional University, Phagwara, Punjab. Email: mvnl.28207@lpu.co.in

**DOI: 10.5281/zenodo.12723210**

**Abstract**

**BACKGROUND:** Emulgels offer a promising approach to delivering poorly water-soluble drugs through a gelled system. When gels and emulsions are combined, they form an emulgel a hybrid that merges the properties and benefits of both emulsions (either oil-in-water or water-in-oil) and gels, created by incorporating a gelling agent. This dual advantage makes emulates an attractive medium for transdermal drug delivery. **OBJECTIVE:** The objective of this study was to develop an emulgel formulation containing Allopurinol, an anti-gout medication, and Diclofenac Sodium, a nonsteroidal anti-inflammatory drug (NSAID). The goal was to enhance the penetration and systemic availability of these drugs while reducing the severe gastric distress commonly associated with their oral administration. The emulgel was formulated using carbopol 940 as the gelling agent and propylene glycol as the penetration enhancer. The emulsion was prepared and then incorporated into the gel base. **RESULT:** In our study of eight emulgel formulations (EG1 to EG8), EG7 emerged as the best. It showed the highest drug content (91.05%) and drug release (89.75%), good spreadability (27.33 gm.cm/s), and extrudability (16 g/cm²). Despite a slightly lower pH (6.3), it remained suitable for topical use. With a viscosity of 5998.7 mPas, EG7 ensures both ease of application and retention on the skin, making it the optimal formulation. **CONCLUSION:** This study developed an emulgel containing Allopurinol and Diclofenac Sodium to enhance drug penetration and minimize gastric distress from oral use. Among eight formulations, EG7 was the best, with high drug content (91.05%) and release (89.75%), good spreadability (27.33 gm.cm/s), and extrudability (16 g/cm²). Despite a slightly lower pH (6.3), it is suitable for topical use, and its viscosity (5998.7 mPas) ensures easy application and good skin retention. EG7 shows promise for effective transdermal delivery of these drugs, offering an alternative to oral administration.

**Keywords:** Emulgel, Gout, Allopurinol, Hydrophobic Drugs, Diclofenac Sodium.

## INTRODUCTION

One or more joints that are swollen and painful are referred to as arthritis. Joint stiffness and pain are the main symptoms of arthritis, and they get worse with age. There are two primary forms of arthritis: rheumatoid arthritis and osteoarthritis [1]. High blood uric acid levels can cause inflammatory arthritis, also known as "gout," in certain persons. Abrupt and intense bouts of pain, swelling, and soreness are caused by needle-like crystals that grow in the joints as a result of elevated blood levels of uric acid. Warmth and redness also appear.[2] Gout is the best type of inflammatory arthritis. Emulgels are emulsions that are mixed with a gelling agent to create a gel, either of the water-in-oil or oil-in-water kind. Drugs that are hydrophobic or weakly soluble in water are shown to work better in emulsified gels, which are stable formulations.[3]

They have a high patient acceptance rate because they combine the benefits of topical medication administration with the qualities of both gel and emulsions.[4] The main goal of the study was to create an emulgel that included the goudal allopurinol, an inhibitor of the xanthine oxidase enzyme, and the NSAID diclofenac sodium to improve medication absorption and penetration as well as therapeutic efficacy. The created formulations attempt to minimize the severe adverse effects induced by oral traditional preparations of the offered medications, while also addressing decreases in uric acid levels and gout-related pain and edema.[5]

## MATERIALS AND METHODS

### Materials:

Alembic Pharmaceutical Pvt. Ltd. of Vadodara, Gujarat, India, gave away Febuxostat. A free sample of diclofenac sodium was received by Sun Pharmaceuticals Pvt. Ltd. in Dewas, M.P., India. The suppliers of Span 20, Tween 20, and Carbopol 934 were Loba Chemicals Pvt. Ltd. in Mumbai, India. Analytical-grade chemicals and solvents were utilized for the production of the formulation.[6]

### Software

Design Expert 13.0: Micro Math Inc., USA was used to formulate topical emulgel.

### Experimental design

Initially, the primary variables and their concentrations were determined by preliminary testing. Three variables were chosen as the independent factors out of all the excipients: mentha oil, carbopol 940, and liquid paraffin. The drug release and viscosity were the chosen dependent parameters. The concentrations of the independent variables (listed in Table 2) were chosen following a preliminary screening process.[7, 8]

### Preformulation studies

Preformulation studies are essential steps in the development of pharmaceutical formulations. They involve the characterization of the physical, chemical, and mechanical properties of drug substances to aid in the design of optimal drug delivery systems. Here, we present the preformulation studies of two active pharmaceutical ingredients (APIs): allopurinol and diclofenac sodium.[9, 10]

### Pseudo-ternary phase diagrams

Based on solubility studies, a light liquid paraffin was chosen as the oil phase. Tween-80 and Span 80 were selected as the surfactant and cosurfactant, respectively, with distilled water as the aqueous phase.[11] The surfactant and cosurfactant (Smix) were mixed at various mass ratios to study the phase diagrams. Oil and Smix were combined in ratios from 1:9 to 9:1, creating sixteen different mixtures.[12] Pseudo-ternary phase diagrams were developed using aqueous titration, with the physical state of the nanoemulsion noted on the diagram. As shown in Fig 1, This detailed approach ensured a comprehensive study of the phase boundaries and the formation of stable, transparent, and easily flowable o/w nanoemulsions. [13]

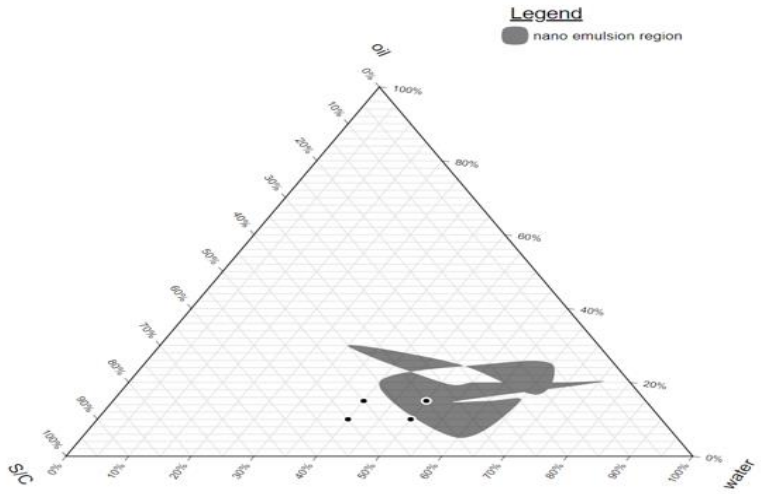



**Fig 1: Pseudo ternary phase diagram**

## Preparation of allopurinol and diclofenac sodium-loaded nanoemulsion

Different formulas were selected from the nanoemulsion region from each phase diagram constructed. The oily phase of the emulsion was prepared by mixing 1 milliliter of span 80 with 7.5 milliliters of light liquid paraffin.[14] The aqueous part of the emulsion was prepared by taking tween 80 and thoroughly mixing it with water. Keepers After adding methyl and propylparaben to propylene glycol and stirring to create a solution, medications (dicofenac sodium and allopurinol) were combined and dissolved in ethanol. The resulting solutions were combined with the aqueous phase and heated separately to 70–80°C. [15] The oily phase was added to the aqueous phase and thoroughly mixed after both solutions had been heated. As seen in Fig.2,

## Emulgel's preparation

A gelling agent in varying amounts was used to make the formulations in each batch. The emulgel's gel phase was created by dissolving carbopol 940 in water and stirring it continuously. Triethanolamine (TEA) was used to alter the pH of the mixture. The obtained emulsion was then gradually stirred into the gel to create an emulgel.[16, 17] As seen in Fig.2, Physical assessment tests were performed on all topical emulgels, as indicated in Table.

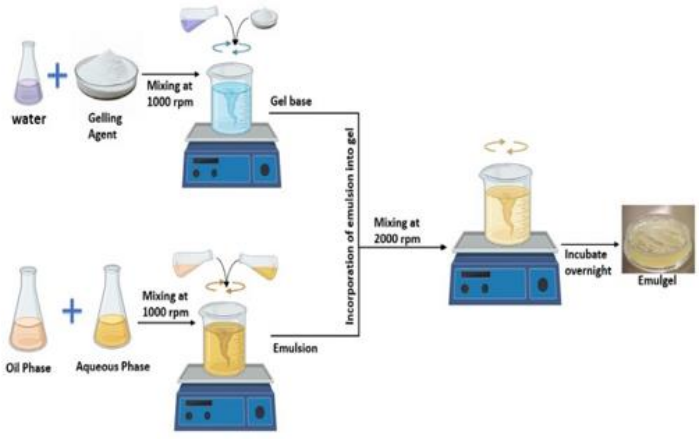



**Fig 2: Method of preparation of emulgel.**

## Optimization of formulation

To ascertain how each independent variable impacted the dependent ones, researchers employed one of 23 distinct factorial designs, contingent upon the results of the pilot testing. [18, 19] Tables No. 1 and 2 list the independent variables and dependent factors that were employed in the design. Using this design, eight trial batches were produced. Table 3

**Table 1: List of dependent and independent variables in $2^3$ factorial designs**

| | | |
|---|---|---|
| **A. Independent factors** | A | Concentration of Liquidparaffin |
| | B | Concentration ofCarbopol 940 |
| | C | Concentration of Mentha oil |
| **B. Dependent Factors** | $Y_1$ | Viscosity |
| | $Y_2$ | Drug release |

**Table 2: Independent variables and their concentrations used for formulations**

| Sr. No. | Independent variables | Coded levels | |
|---|---|---|---|
| | | -1 | +1 |
| 1 | The concentration of Liquid paraffin (ml) | 5 | 7.5 |
| 2 | Concentration of Carbopol 940 (gm) | 0.5 | 1.5 |
| 3 | Concentration of Mentha oil (ml) | 2 | 4 |

**Table 3: DOE formulation Batches**

| Contents | EG1 | EG2 | EG3 | EG4 | EG5 | EG6 | EG7 | EG8 |
|---|---|---|---|---|---|---|---|---|
| Allopurinol (mg) | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 |
| Diclofenac sodium (mg) | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 |
| Liquid Paraffin (ml) | 5 | 5 | 7.5 | 5 | 7.5 | 5 | 7.5 | 7.5 |
| Carbopol 940 (gm) | 1.5 | 0.5 | 0.5 | 1.5 | 1.5 | 0.5 | 0.5 | 1.5 |
| Tween 80 (ml) | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 |
| Propylene glycol (ml) | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 |
| Methyl paraben (gm) | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| Propyl paraben (gm) | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 |
| Span 80 (ml) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Mentha oil (ml) | 4 | 2 | 4 | 2 | 4 | 2 | 4 | 2 |
| Ethanol | q.s. | q.s. | q.s. | q.s. | q.s. | q.s. | q.s. | q.s. |
| Triethanolamine | q.s. | q.s. | q.s. | q.s. | q.s. | q.s. | q.s | q.s. |
| Distilled water (ml) | q.s. | q.s. | q.s. | q.s. | q.s. | q.s. | q.s. | q.s. |

## Physical evaluation of topical emulgel

Visual inspections were performed to ensure a high-quality standard in terms of color, finish, and uniformity. [20]

## Appearance/color

Physical analysis of the prepared topical emulgel was observed.

## pH

The pH of the formulation's one percent aqueous solution was determined by employing a temperature- and pH-calibrated digital meter. [21]

## Viscosity

A Brookfield viscometer with spindle 50 and 50 rpm was used to measure the resultant emulgel's viscosity three times at room temperature.

### Spreadability

For the experiment, two glass slides of conventional size were employed. Between the two slides, an emulgel was put to create a sandwich that measured 60 mm. After cleaning the slide surfaces of excess emulgel, the slides were securely affixed to a stand. The top slide was given a 20 g weight, and the reaction time to the weight's contact on it—60 mm of movement—was timed. The experiment was run three times to determine the meantime, and spreadability was determined using a predetermined formula. [22, 23]

Spreadability = (Weight × Length) / Time

### Extrudability

The standard collapsible aluminum tubes were filled with the formulas (10 gm), and the ends were sealed shut. The weight of each tube was accurately noted. The tubes were then clamped between two glass slides to seal them. A 500 g weight was placed over the slides, and the cap was removed. The amount that was extruded was gathered, and weighed, and a percentage was calculated to determine the formulation's extrudability. Extrudability values of more than 90% were regarded as exceptional, more than 80% as good, and more than 70% as fair. [24, 25]

### In-vitro diffusion study

Franz diffusion cells with a 25 ml cell capacity were employed in the drug release investigations. A single section of the cellophane membrane received a homogenous application of 1 gram of the formulation. A pH 7.4 Phosphate Buffer solution was placed inside the receptor chamber and swirled with a magnetic stirrer. At appropriate intervals, fresh buffer solutions were added to 1.0 ml aliquots that were collected. A UV-visible spectrophotometer operating at 227 and 237 nm was used to ascertain the drug concentration in the acquired samples following the proper dilution process. This made it possible to evaluate the drug's efflux across the membrane about time. [26, 27]

### Release Kinetics

There are several theories and mathematical models that explain how medications are extracted from pharmaceutical formulations. By creating kinetic models from in vitro drug release data, one may look at the underlying process of drug release. [28, 29]

### Stability study

A four-week physical stability test was conducted on the emulgel at two different temperatures and relative humidity levels (250°C±20°C, 60% RH ± 5% and 400°C±20°C, 75 % RH ± 5%). As seen in Tables 10 and 11. [30, 31]

## RESULT

### Physical evaluation

The prepared emulgels had a glossy look, a smooth, uniform texture, and a white, thick, creamy consistency. as indicated in Table number 4.

**Table 4: Physical evaluation of formulated emulgel**

| Batch code | Color | Grittiness | Phase separation |
|---|---|---|---|
| EG1 | Off-White | - | None |
| EG2 | White | - | None |
| EG3 | Off-White | - | None |
| EG4 | White | - | None |
| EG5 | Off-White | - | None |
| EG6 | White | - | None |
| EG7 | White | - | None |
| EG8 | White | - | None |

## Drug content uniformity

The drug content of the formulated Emulgel was estimated spectrophotometrically at 227 and 237 nm. shown in Fig. 3

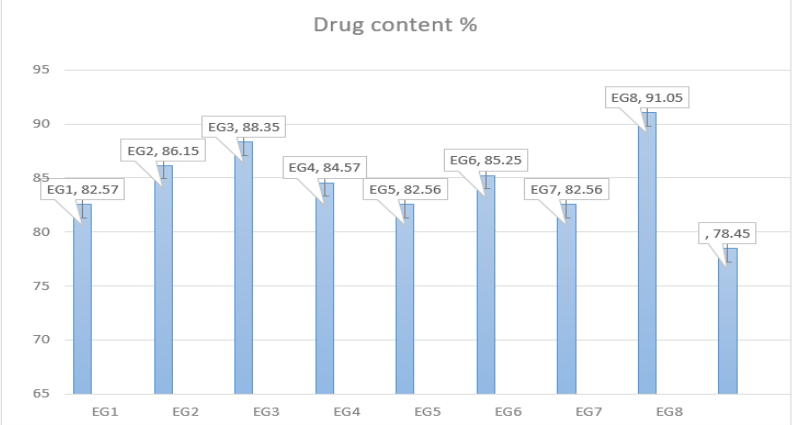



**Fig 3: Drug content %**

## Spreadability

Every formulation was put through a spreadability test. According to the spreadability, a little shear can readily spread the Emulgel. As the concentration of the polymer increases, the emulgel's spreadability diminishes. Spreadability is crucial because it demonstrates how emulgel behaves when it is taken out of the tube. All formulations were confirmed to have spreadability within the limitations. as seen in Figure 4.

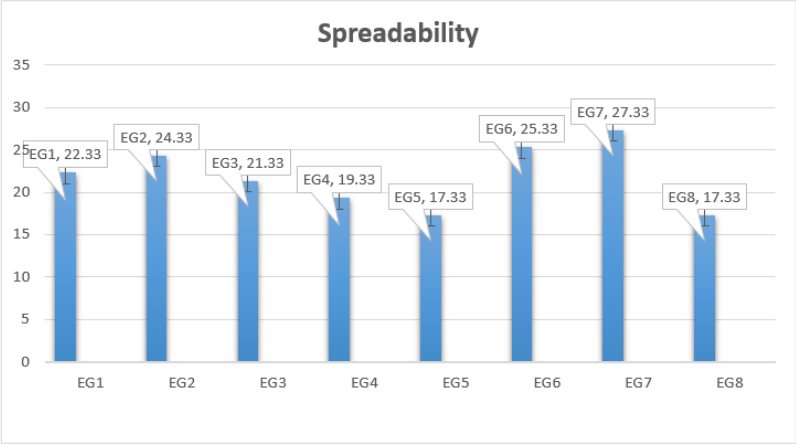



**Fig 4: Spreadability of emulgel**

## pH

A digital pH meter was used to examine the pH of the prepared formulations. pH of each prepared batch was examined in triplicates and average values were calculated. As seen in fig.5

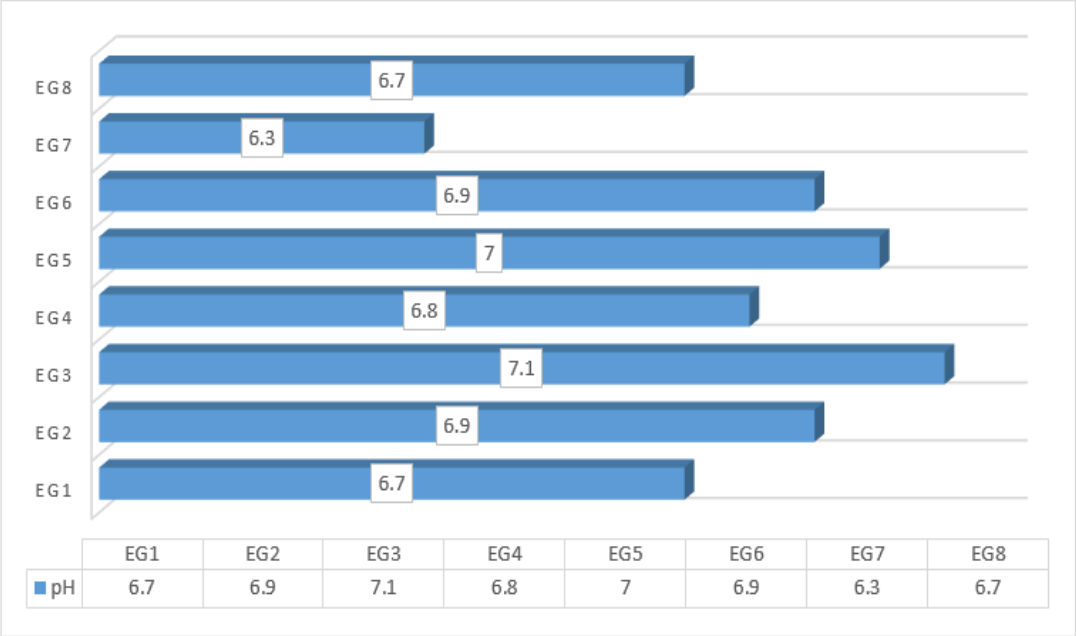



**Fig. 5: pH of formulated emulgel**

**Transmission electron microscopy. –** The nanoemulsion appeared dark and with bright surroundings and a positive image (Fig. 6). The droplet size ranged between 19 and 78 nm and was in agreement with the droplet size distribution measured using photon correlation spectroscopy

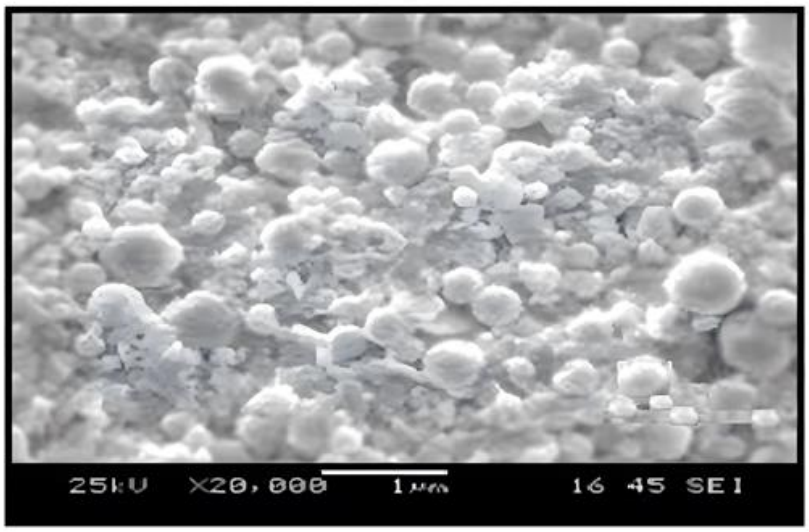



**Fig 6: Transmission electron microscopic positive image of nanoemulsion.**

**Table 5: Factorial design variables with their responses**

| Formulation | Factor1 (A) | Factor2 (B) | Factor 3 (C) | pH | Viscosity (m.Pas) | Spradability (gm.cm/sa) | Extrudability (g/cm²) | Drug content(%) | Drug Release(%) |
|---|---|---|---|---|---|---|---|---|---|
| EG1 | -1 | +1 | -1 | 6.7± 0.02 | 16204.5± 1.2 | 22.33 ± 1.2 | 16.1± 1.2 | 82.57 ± 1.2 | 62.35 ± 1.25 |
| EG2 | -1 | -1 | -1 | 6.9± 0.03 | 8570.5± 1.2 | 24.33 ± 2.1 | 17± 2.1 | 86.15 ± 1.1 | 77.54 ± 2.75 |
| EG3 | +1 | -1 | +1 | 7.1± 0.03 | 8347.7± 1.2 | 21.33 ± 3.2 | 16± 3.2 | 88.35 ± 2.2 | 87.52 ± 3.10 |
| EG4 | -1 | +1 | -1 | 6.8± 0.02 | 11300.2± 1.2 | 19.33 ± 3.7 | 13± 3.7 | 84.57 ± 1.7 | 67.56 ± 6.65 |
| EG5 | +1 | +1 | -1 | 7.0± 0.03 | 15506.3± 1.2 | 17.33 ± 2.5 | 12.5± 2.5 | 85.25 ± 2.5 | 71.27 ± 2.45 |
| EG6 | -1 | -1 | +1 | 6.9± 0.02 | 6201.4± 1.2 | 25.33 ± 2.1 | 15± 2.1 | 82.56 ± 2.7 | 68.75 ± 3.45 |
| EG7 | +1 | -1 | -1 | 6.3± 0.02 | 5998.7± 1.2 | 27.33 ± 3.7 | 16± 3.7 | 91.05 ± 1.5 | 89.75 ± 3.50 |
| EG8 | +1 | +1 | -1 | 6.7± 0.02 | 15750.5± 1.2 | 17.33 ± 1.5 | 13± 1.5 | 78.45 ± 2.1 | 62.42 ± 3.47 |

± Mean value with a standard deviation of three replicates

**Table 6: Viscosity ANOVA analysis**

| Source | Sum of Squares | df | Mean Square | F-value | p-value | Source |
|---|---|---|---|---|---|---|
| **Model** | 1.145 | 3 | 3.817 | 9.24 | 0.0285 | significant |
| A-Liquid paraffin | 1.383 | 1 | 1.383 | 0.3350 | 0.5937 | |
| B-Carbopol 934 | 1.098 | 1 | 1.098 | 26.60 | 0.0067 | |
| C-Mentha oil | 3.288 | 1 | 3.288 | 0.7963 | 0.4226 | |
| **Residual** | 1.652 | 4 | 4.129 | | | |
| **Cor Total** | 1.310 | 7 | | | | |

These can indicate a problem with your data or model, or they might be a symptom of a large block effect. For every empirical model, confirmation runs should be carried out. Adeq Precision is used to calculate the signal-to-noise ratio. Ideally, the ratio should be greater than 4. You have a sufficiently strong signal with a ratio of 6.629. This model may be used to explore the design space.

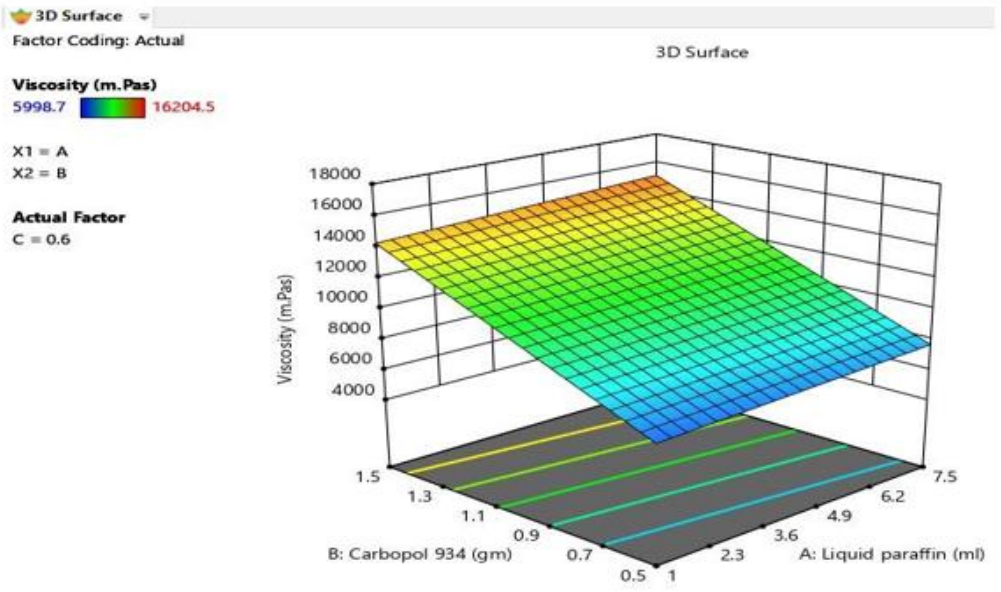
**Table 7: $R^2$ value for viscosity Fit Statistics**

| | | | |
|---|---|---|---|
| **Std. Dev.** | 2031.94 | **$R^2$** | 0.8740 |
| **Mean** | 10984.98 | **Adjusted $R^2$** | 0.7794 |
| **C.V. %** | 18.50 | **Predicted $R^2$** | 0.4958 |
| | | **Adeq Precision** | 6.6290 |

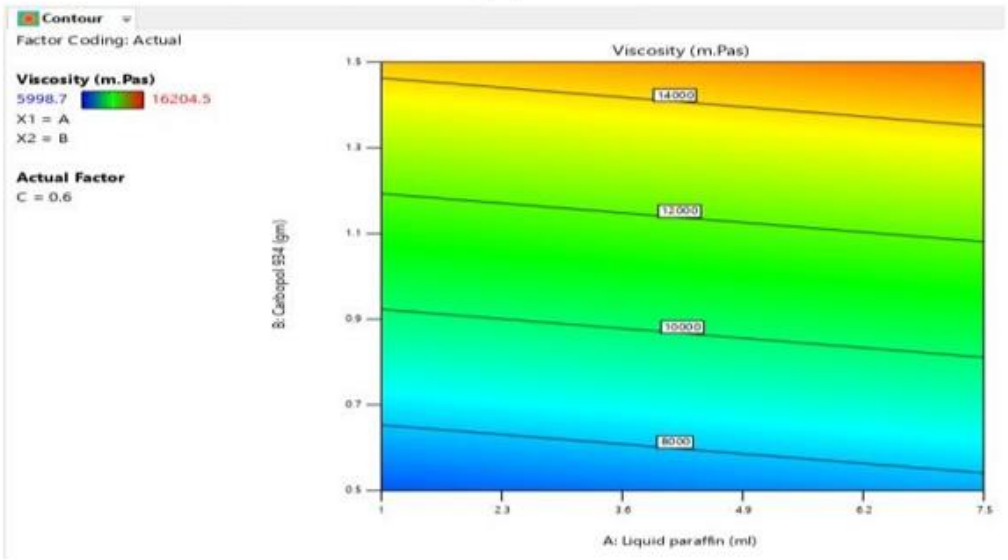
The final formula for viscosity based on coded factors: +10984.98 +415.82 A +3705.40 B + 641.05C The final equation is based on real variables. -815.89615 + 127.94 + 7410.80 + 6410.50 is the viscosity. Concerning the real factors, the appropriate equation may be used to forecast the result for a certain amount of each element. The model has an F-value of 9.31, which indicates statistical significance. 2.82 percent of the time, an F-value this high could only result from random chance. A p-value of less than 0.05 indicates the importance of the model terms. The model term B is crucial in this situation. A model term is not significant if its evaluation is higher than 0.1. In case your model has a lot of words that aren't essential to support hierarchy, you can consider doing a model reduction.

The Adjusted R2 of 0.7807 differs from the Expected R2 of 0.4987 by more than 0.2, which is not as close as one might assume. It might be a sign of a massive block effect, or it could be a problem with your model and/or data. Considerations include finding outliers, converting answers, and minimizing models. Every empirical model should be tested using confirmation runs. Adeq Precision allows for the determination of the signal-to-noise ratio. Ideally, the ratio should be greater than 4. Your ratio of 8.606 indicates a strong enough signal. This model may be used to explore the design space. Formula Using Coded Elements +4.29+0.0553A -0.1005B - 0.0448 C is the drug release. Equation in Terms of Actual Factors

Drug Release = +4.684 + 0.0170A – 0.2010 B –0.4479 C




(a)




(b)

**Fig. 7: (a) & (b) 3Dimentional response surface plots and contour plot for the viscosity of topical emulgel**

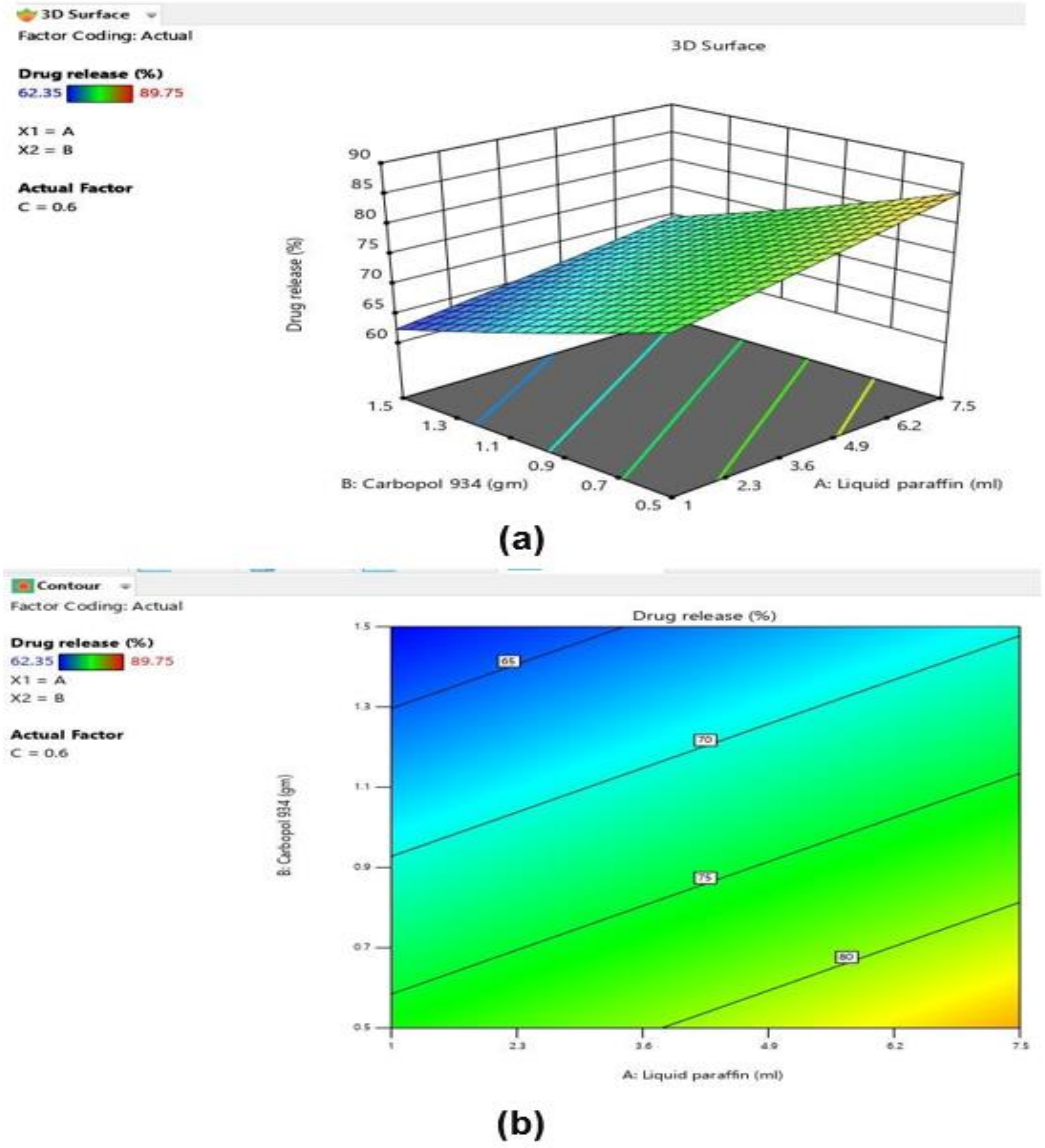



**Fig 8: (a) & (b) Three Dimensional response surface plots and Contour plots for drug release of topical emulgel**

**Table 8: Response 2 Drug release**

| Source | Sum of Squares | df | Mean Square | F-value | p-value | |
|---|---|---|---|---|---|---|
| **Model** | 0.1213 | 3 | 0.0404 | 9.31 | 0.0282 | significant |
| A-Liquid paraffin | 0.0244 | 1 | 0.0244 | 5.63 | 0.0767 | |
| B-Carbopol 934 | 0.0808 | 1 | 0.0808 | 18.60 | 0.0125 | |
| C-Mentha oil | 0.0160 | 1 | 0.0160 | 3.69 | 0.1270 | |
| **Residual** | 0.0174 | 4 | 0.0043 | | | |
| **Cor Total** | 0.1387 | 7 | | | | |

**Table 9: Fit Statistics**

| | | | |
|---|---|---|---|
| **Std. Dev.** | 0.0659 | **$R^2$** | 0.8747 |
| **Mean** | 4.29 | **Adjusted $R^2$** | 0.7807 |
| **C.V. %** | 1.54 | **Predicted $R^2$** | 0.4987 |
| | | **Adeq Precision** | 8.6061 |

**Table 10: The Stability study of emulgel formulations at 25°C ± 2°C/60%**

| Emulgel | pH | Viscosity(mPas) | Spreadability (cm/s) | Extrudability | Drug release |
|---|---|---|---|---|---|
| EG1 | 6.7±0.02 | 16204.5±50 | 18±0.03 | 64±4.6 | 62.35±0.91 |
| EG2 | 6.9±0.03 | 8570.5±45 | 16±0.02 | 81.2±5.6 | 77.54±1.35 |
| EG3 | 7.1±0.03 | 8347.7±35 | 14.2±0.45 | 80±4.3 | 87.52±1.25 |
| EG4 | 6.8±0.02 | 11300.2±43 | 15.5±0.14 | 74.2±5.3 | 67.56±1.10 |
| EG5 | 7.0±0.03 | 15506.3±78 | 13.0±1.42 | 72±3.1 | 71.27±0.65 |
| EG6 | 6.9±0.02 | 6201.4±48 | 16.5±0.09 | 78±4.6 | 68.75±2.05 |
| EG7 | 6.3±0.02 | 5998.7±69 | 14.5±0.03 | 92±5.6 | 89.75±0.02 |
| EG8 | 6.7±0.02 | 15750.5±61 | 14.5±0.11 | 71±4.6 | 62.42±0.37 |
| ± Mean value with a standard deviation of three replicates | | | | | |

**Table 11: The Stability study of emulgel formulations at 40°C ± 2°C/75% RH ± 5%**

| Emulgel | pH | Viscosity(mPas) | Spreadability(cm/s) | Extrudability(Pa) | Drug release |
|---|---|---|---|---|---|
| EG1 | 6.5±0.01 | 16201.7±50 | 18±0.01 | 64±4.5 | 62.32±0.80 |
| EG2 | 6.7±0.02 | 8570.3±42 | 15±0.02 | 80.2±5.5 | 75.55±1.32 |
| EG3 | 7.0±0.01 | 8345.5±37 | 14.1±0.47 | 81±4.2 | 86.37±1.15 |
| EG4 | 6.7±0.02 | 11302.1±42 | 15.5±0.14 | 75.2±5.2 | 65.70±1.07 |
| EG5 | 6.8±0.03 | 15505.2±75 | 13.0±1.41 | 71±3.0 | 71.25±0.55 |
| EG6 | 6.9±0.01 | 6202.5±45 | 15.5±0.07 | 75±4.5 | 67.85±2.15 |
| EG7 | 6.3±0.02 | 5997.5±65 | 14.7±0.02 | 93±5.7 | 89.70±0.11 |
| EG8 | 6.2±0.03 | 15747.7±62 | 14.5±0.10 | 72±4.5 | 62.50±0.25 |
| ± Mean value with a standard deviation of three replicates | | | | | |

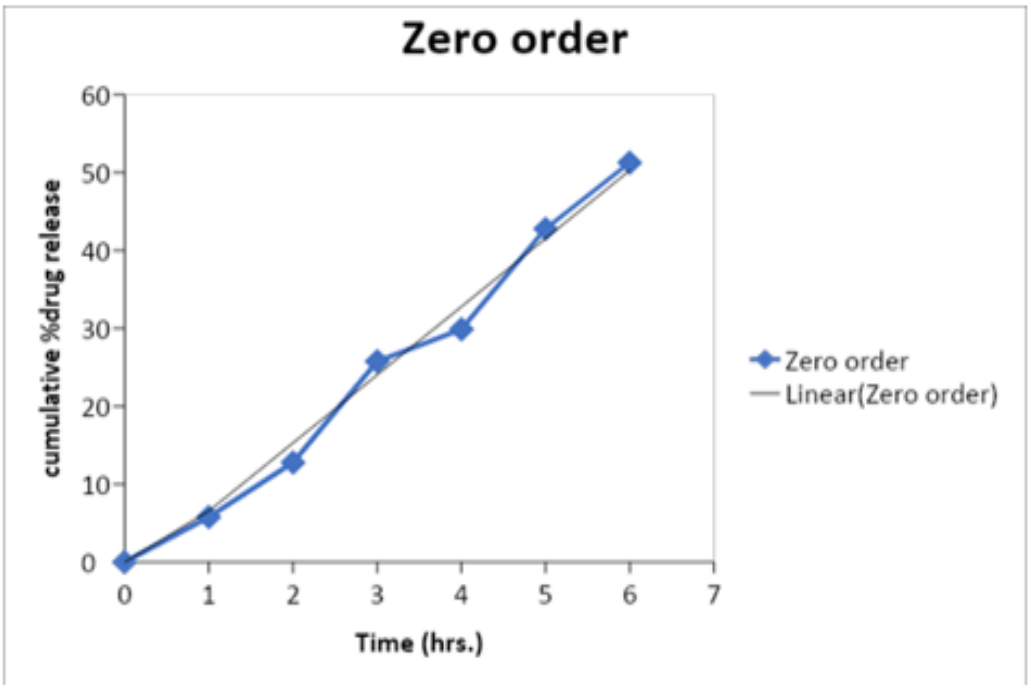



**Fig 9: Zero-order drug release kinetics for optimized formulation**

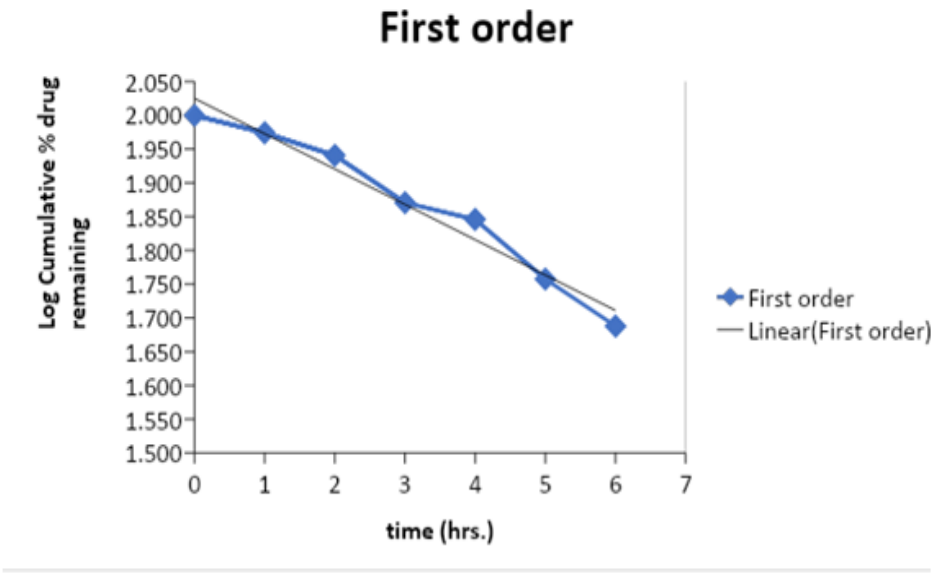



**Fig 10: First-order drug release kinetics for optimized formulation**

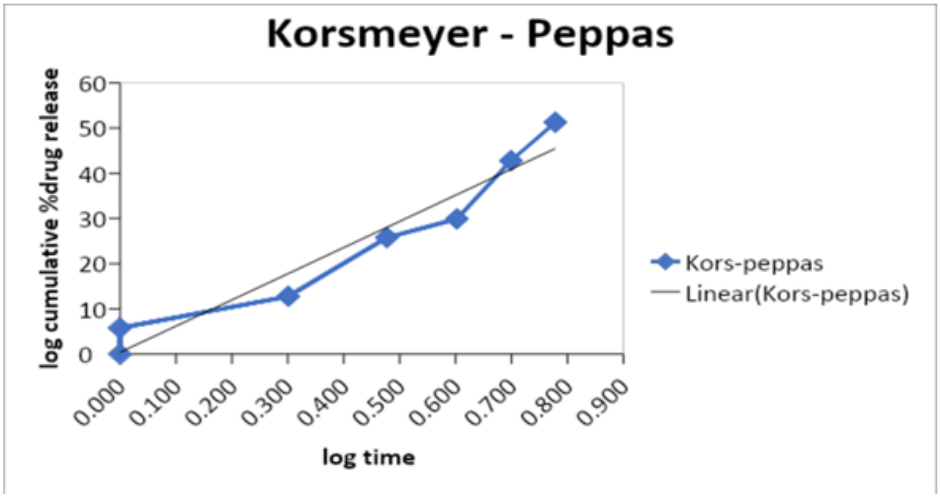



**Fig 11: Korsmeyer- Peppas drug release kinetics for optimized formulation**

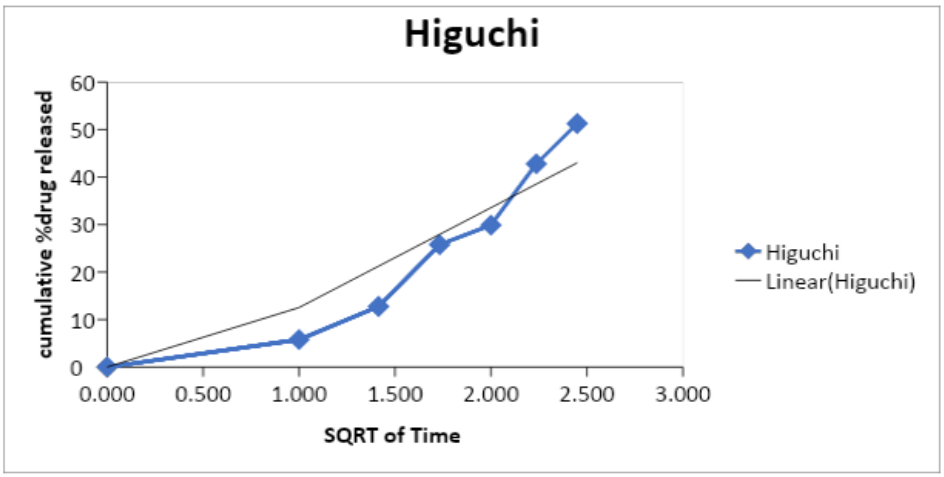



**Fig 12: Higuchi model drug release kinetics for optimized formulation**

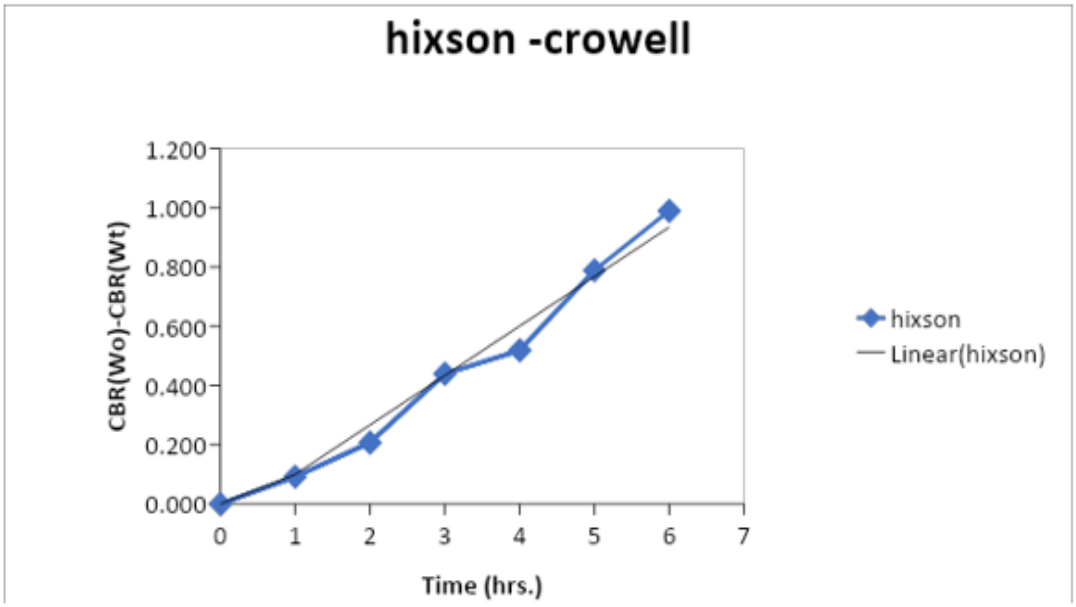



**Fig 13: Hixson-Crowell model drug release kinetics for optimized formulation**

**Table 12: The regression coefficients obtained from model fitting**

| MODEL | Linear Regression Coefficient($R^2$) | K Value |
|---|---|---|
| Zero-order | 0.988 | 8.74 |
| First-order | 0.968 | 0.05 |
| Korsmeyer and Peppas | 0.941 | 57.93 |
| Higuchi | 0.864 | 21.02 |
| Hixon-Crowell | 0.977 | 0.16 |

Using the matching equation in terms of real factors, one may anticipate the result for a certain amount of each element.

### Kinetics of drug release

Researchers were able to get more insight into the kinetics or mechanism of drug release by fitting in vitro release data from various formulations using a variety of kinetic models.

## RESULT

EG7 exhibited the highest drug content (91.05%) and drug release (89.75%) among all formulations, indicating excellent bioavailability and efficacy. The formulation also showed good spreadability (27.33 gm.cm/s) and extrudability (16 g/cm²), ensuring ease of application and dispensing.

While the pH of 6.3 is slightly lower than the ideal skin pH range, it is still within an acceptable range for topical formulations. The viscosity of 5998.7 mPas ensures a good balance between ease of application and retention on the skin.

## DISCUSSION

This study on allopurinol Diclofenac sodium-loaded emulgel for gout demonstrates a significant improvement over previous formulations, with an 89.75% cumulative drug release as compared to the 58.58% release in prior studies [32].

The emulgel's unique combination of emulsion and gel properties enhances allopurinol's solubility and permeability, ensuring a more efficient and rapid drug delivery. This makes the emulgel formulation superior for managing acute gout attacks, providing both rapid and sustained drug release for better patient outcomes. Further research and clinical trials are needed to fully establish its therapeutic benefits and potential for widespread use in gout management.

## CONCLUSION

In the current research, an emulgel containing Allopurinol and Diclofenac Sodium was successfully formulated and evaluated. The formulations were prepared using varying concentrations of carbopol 940 as the gelling agent. The method proved to be straightforward and efficient, yielding positive results. The emulgel formulations underwent physicochemical evaluations, including rheological studies, spreadability tests, and in vitro drug release studies. The results indicated that all formulation batches (EG7) possessed acceptable physical properties. It was also observed that drug release varied with the concentration of the polymer used. Notably, batches EG7 exhibited superior in vitro drug release, with 89.70% release, respectively. Consequently, batches were identified as the optimized batches, demonstrating the best performance among all tested formulations. In conclusion, the emulgel formulation of Allopurinol and Diclofenac Sodium shows promise as a drug delivery system, potentially mitigating the issues associated with conventional administration routes.

### References

1) Ashara KC, Paun JS, Soniwala MM, Chavada JR, Mori NM. Micro-emulsion based emulgel: a novel topical drug delivery system. Asian pacific journal of tropical disease. 2014 Jan 1;4:S27-32.

2) Tao H, Mo Y, Liu W, Wang H. A review on gout: Looking back and looking ahead. International Immunopharmacology. 2023 Apr 1;117:109977.

3) Ragab G, Elshahaly M, Bardin T. Gout: An old disease in a new perspective–A review. Journal of advanced research. 2017 Sep 1;8(5):495-511.

4) Iliopoulos G. Understanding and treating gout: A narrative review. Achaiki Iatriki. 2020:87.

5) Phutane KR, Patil SS, Adnaik RS, Nitalikar MM, Mohite SK, Magdum CS. Design and development of allopurinol emulgel. Research Journal of Pharmacy and Technology. 2014;7(7):733-6.

6) Azam F, Alqarni MH, Alnasser SM, Alam P, Jawaid T, Kamal M, Khan S, Alam A. Formulation, in vitro and in silico evaluations of anise (Pimpinella Anisum L.) essential oil emulgel with improved antimicrobial effects. Gels. 2023 Jan 28;9(2):111.

7) Badruddoza AZ, Zahid MI, Walsh T, Shah J, Gates D, Yeoh T, Nurunnabi M. Topical drug delivery by Sepineo P600 emulgel: Relationship between rheology, physical stability, and formulation performance. International Journal of Pharmaceutics. 2024 Jun 10;658:124210.

8) Yousuf M, Khan HM, Rasool F, Khan KU, Usman F, Ghalloo BA, Umair M, Babalghith AO, Kamran M, Aadil RM, Al Jaouni SK. Chemical profiling, formulation development, in vitro evaluation and molecular docking of Piper nigrum Seeds extract loaded Emulgel for anti-Aging. Molecules. 2022 Sep 14;27(18):5990.

9) Dos Santos RS, Bassi da Silva J, Vecchi CF, da Silva Souza Campanholi K, Rosseto HC, de Oliveira MC, Garcia FP, Balbinot RB, de Castro Hoshino LV, Nakamura TU, Nakamura CV. Formulation and performance evaluation of emulgel platform for combined skin delivery of curcumin and propolis. Pharmaceutical Development and Technology. 2023 Jul 3;28(6):559-70.

10) Khan BA, Ali A, Hosny KM, Halwani AA, Almehmady AM, Iqbal M, Alharbi WS, Abualsunun WA, Bakhaidar RB, Murshid SS, Khan MK. Carbopol emulgel loaded with ebastine for urticaria: Development, characterization, in vitro and in vivo evaluation. Drug Delivery. 2022 Dec 31;29(1):52-61.

11) Rajora A, Kohli K, Nagpal K. Formulation of Itraconazole Loaded Clove Oil based Nanoemulsion using Pseudoternary Phase Diagram for Improved Thermodynamic Stability. Indian Journal of Pure & Applied Physics (IJPAP). 2024 Feb 19;62(2):124-32.

12) Mohamed JM, Nasreen A, Mohaini A, Ahmad M, El-Sherbiny M, Eldesoqui MB, Dawood AF, AlMadani M, Ibrahim AM, El-Mansi AA. Optimization of capsaicin microemulgel: a comprehensive in vitro evaluation and pseudo ternary diagram. Chemical Papers. 2024 Jan 4:1-0.

13) Moghimipour E, Salimi A, Leis F. Preparation and evaluation of tretinoin microemulsion based on pseudo-ternary phase diagram. Advanced pharmaceutical bulletin. 2012 Dec;2(2):141.

14) Md S, Alhakamy NA, Aldawsari HM, Kotta S, Ahmad J, Akhter S, Shoaib Alam M, Khan MA, Awan Z, Sivakumar PM. Improved analgesic and anti-inflammatory effect of diclofenac sodium by topical nanoemulgel: formulation development—in vitro and in vivo studies. Journal of chemistry. 2020;2020(1):4071818.

15) Wang Z, Mu HJ, Zhang XM, Ma PK, Lian SN, Zhang FP, Chu SY, Zhang WW, Wang AP, Wang WY, Sun KX. Lower irritation microemulsion-based rotigotine gel: formulation optimization and in vitro and in vivo studies. International Journal of Nanomedicine. 2015 Jan 14:633-44.

16) Estabragh MA, Bami MS, Dehghannoudeh G, Noudeh YD, Moghimipour E. Cellulose derivatives and natural gums as gelling agents for preparation of emulgel-based dosage forms: A brief review. International Journal of Biological Macromolecules. 2023 Apr 19:124538.

17) Jeengar MK, Rompicharla SV, Shrivastava S, Chella N, Shastri NR, Naidu VG, Sistla R. Emu oil based nano-emulgel for topical delivery of curcumin. International journal of pharmaceutics. 2016 Jun 15;506(1-2):222-36.

18) Jain A, Gautam SP, Gupta Y, Khambete H, Jain S. Development and characterization of ketoconazole emulgel for topical drug delivery. Der Chemica Sinica. 2010.

19) Yang C, Shen Y, Wang J, Ouahab A, Zhang T, Tu J. Cationic polymer-based micro-emulgel with self-preserving ability for transdermal delivery of diclofenac sodium. Drug delivery. 2015 Aug 18;22(6):814-22.

20) Ahmad J, Gautam A, Komath S, Bano M, Garg A, Jain K. Topical nano-emulgel for skin disorders: Formulation approach and characterization. Recent patents on anti-infective drug discovery. 2019 May 1;14(1):36-48.

21) Sharma DL, Seth AK, Shah N, Chauhan SP, Aundhia C. Preparation and characterizaton of aceclofenac loaded topical emulgel. Pharmatutor Pharmacy Infopedia. 2013.

22) Khan BA, Ullah S, Khan MK, Alshahrani SM, Braga VA. Formulation and evaluation of Ocimum basilicum-based emulgel for wound healing using animal model. Saudi pharmaceutical journal. 2020 Dec 1;28(12):1842-50.

23) Vanpariya F, Shiroya M, Malaviya M. Emulgel: A Review. International Journal of Science and Research (IJSR). 2021;10:847.

24) Shah RS. Formulation and evaluation of Turmeric emulgel. Asian Journal of Pharmacy and Technology. 2021;11(3):213-9.

25) Talat M, Zaman M, Khan R, Jamshaid M, Akhtar M, Mirza AZ. Emulgel: An effective drug delivery system. Drug Development and Industrial Pharmacy. 2021 Aug 3;47(8):1193-9.

26) Jain A, Deveda P, Vyas N, Chauhan J, Khambete H, Jain S. Development of antifungal emulsion based gel for topical fungal infection (s). IJPRD. 2011;2(12):18-22.

27) Srivastava N, Patel DK, Rai VK, Pal A, Yadav NP. Development of emulgel formulation for vaginal candidiasis: Pharmaceutical characterization, in vitro and in vivo evaluation. Journal of drug delivery science and technology. 2018 Dec 1;48:490-8.

28) Kumar PM, Patel MR, Patel KR, Patel NM. Emulgels: a novel approach to topical drug delivery. Int J Univ Pharm Bio Sci. 2013;2(1):134-48.

29) Salem HF, Kharshoum RM, Abou-Taleb HA, Naguib DM. Nanosized nasal emulgel of resveratrol: preparation, optimization, in vitro evaluation and in vivo pharmacokinetic study. Drug Development and Industrial Pharmacy. 2019 Oct 3;45(10):1624-34.

30) Kang SN, Lee E, Lee MK, Lim SJ. Preparation and evaluation of tributyrin emulsion as a potent anti-cancer agent against melanoma. Drug delivery. 2011 Feb 1;18(2):143-9.

31) Şentürk TB, Barak TH, Çağlar EŞ, Nath EÖ, Özdemir ZÖ. In vitro evaluation of skin related enzyme inhibitory effect and emulgel formulation development studies of onobrychis argyrea subsp. argyrea with phytochemical analysis. Chemistry & Biodiversity. 2024 Mar 17:e202400139.

32) Kandav GU, Bhatt DC, Jindal DK. Formulation and evaluation of allopurinol loaded chitosan nanoparticles. Int J Appl Pharm. 2019;11(3):49-52.