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"Design, Development and In Vitro Characterization of Nano Formulation Containing Combine Drugs for Improving Topical Drug Delivery"

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ABSTRACT

This effort aimed to improve the distribution of topical medications by developing and characterising an *in vitro* gel formulation based on nanoparticles that included the combination of aloin and tretinoin. The objective was to develop a stable nanoformulation that might improve the medicine's skin penetration, bioavailability, and the elimination of side effects associated with conventional topical formulations. The creation of nanoparticles utilising an appropriate formulation process was followed by their mixing with a gel base to generate a system that functions effectively when applied topically. In the formulation that was created, physicochemical properties such as drug entrapment efficiency, viscosity, spreadability, in vitro drug release profile, and particle size were taken into consideration. After conducting FTIR spectrum analysis, it was determined that the excipients used in the formulation were compatible with both aloin and tretinoin. No significant interactions or structural changes were detected. It was confirmed that both tretinoin and alcohol, primary amine, alkane, imine/oxime, nitro, and aliphatic ether functionalities were present in the formulation by corresponding peaks. On the other hand, aloin exhibited the presence of amine salt, conjugated alkene, phenolic, and ester functional groups by corresponding peaks. The generated nanoparticle gel had sufficient physicochemical properties, excellent stability, and a sustained drug release pattern, all of which pointed to improved topical retention and controlled dispersion. Better treatment effectiveness and patient compliance are offered based on the results of the *in vitro* characterisation.

Keywords: - Nanoparticle gel, Aloin, Tretinoin, Topical drug delivery, Nanoformulation, FTIR analysis, particle and zeta analysis.

I. INTRODUCTION

Nanoparticle formulations prepared using biodegradable and biocompatible polymers have demonstrated excellent potential in enhancing drug delivery. Active substances can be encapsulated inside a protective matrix by using polymeric nanoparticles. This improves stability and minimises degradation **(Elmowafy*et al.*, 2023).**In addition, the encapsulated medicine is released gradually and under control by nanoparticle systems, which prolongs the therapeutic effect and decreases the frequency of dose. These systems also improve penetration through biological barriers due to their nanosized dimensions and enhanced surface properties. Among the polymers commonly employed in nanoparticle preparation, Eudragit polymers have been widely used because of their excellent stability, controlled release characteristics, biocompatibility, and film-forming ability **(Patra*et al.*, 2017).** Eudragit RS 100 is a copolymer widely utilized for sustained drug release formulations due to its low permeability and excellent encapsulation properties. Stabilizers such as polyvinyl alcohol (PVA) are frequently used during nanoparticle preparation to stabilize the emulsion system and prevent particle aggregation, thereby improving the uniformity and stability of the formulation **(Kashif*et al.*, 2017).**

In order to create nanoparticles, one can use one of several procedures, such as solvent evaporation, nanoprecipitation, emulsification, ionic gelation, or solvent diffusion **(Kumari, 2018).**Due to its simplicity, repeatability, and applicability for hydrophobic and moderately soluble medicines, the solvent evaporation method is one of the most often applied procedures among these. This method yields nanoparticles by dissolving the drug and then evaporating the solvent **(Wais*et al.*, 2016).**

The anthraquinone glycoside known as aloin is found naturally in plants like Aloe vera and others in the Aloe family. It is a key component in

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aloe vera, which gives the plant its healing effects **(Saleem, 2021).** Aromatic, anti-inflammatory, antibacterial, wound-healing, anti-cancer, laxative, and skin-protective properties are only a few of aloin's significant pharmacological actions. The medicinal and aesthetic uses of aloin have increased dramatically as a result of its healing capabilities; it is especially useful for the treatment of skin diseases, inflammation, and wounds **(Sánchez *et al.*, 2020).**

In spite of its potential biological effects, Aloin has few medicinal and therapeutic uses due to a number of physicochemical drawbacks. These include low permeability, photosensitivity, and quick degradation when exposed to oxygen, heat, light, and other environmental stresses. **(Sadiq*et al.*, 2022).**Also, aloin may have a negative effect on medication retention and membrane penetration when applied topically. Consequently, enhancing Aloin's stability, controlled release, penetration, and therapeutic efficacy can be achieved by the creation of an appropriate nanoformulation **(Bierhalz*et al.*, 2017).**

Dermatologists use retinoin to treat acne vulgaris, photoaging, hyperpigmentation, psoriasis, and other skin problems. **(Agha, 2022).**Tretinoin regulates epithelial cell development, collagen production, keratinisation, and skin cell turnover. Tretinoin is one of the most significant topical retinoids in clinical practice because it improves skin texture and reduces acne lesions **(de Campos Peseto*et al.*, 2016).**

Tretinoin has considerable therapeutic promise, but pharmaceutical use has downsides. Tretinoin degrades during storage and usage due to its great sensitivity to light, heat, and oxygen **(Raminelli*et al.*, 2018).** Traditional topical Tretinoin formulations don't manage skin penetration and release the drug quickly, which can cause peeling, dryness, burning, and skin irritation. Due to its limited chemical stability and water solubility, Tretinoin may reduce therapy efficacy and adherence **(Wu *et al.*, 2022).**

This research created and characterised a nanoparticle formulation comprising Aloin and Tretinoin using solvent evaporation. We examined the formulations' physicochemical properties and in vitro drug release to determine their suitability for topical medicine administration.

II. MATERIALS AND METHODS

2.1 Chemicals

Ethanol, methanol, and acetone came from reputable analytical reagent supplier RankemPvt. Ltd. Zes Bioscience Pvt.LD supplied Aloin and Tretinoin. Eudragit RS 100 acquired Evonik Industries. LobaChemiePvt. Ltd. supplied Triethanolamine, Polyvinyl Alcohol, and Propylene Glycol, while Suvidhinath Laboratories supplied Carbopol 940. The analytical (AR) solvents, chemicals, and phytochemical reagents used were from Rankem and HiMedia.

2.2 Pre-formulation studies of selected Drug

Pre-formulation research examines the physicochemical and analytical properties of prospective drugs. This research helps choose excipients and formulation methods by showing drugs' behaviour, compatibility, stability, identity, and purity. This study pre-formulated and analysed Tretinoin and Aloin before developing the nanoparticle-based gel. The examination included examining organoleptic properties, solubility, melting point, pH, λmax, calibration curves, and functional group analysis using FTIR spectroscopy**(Khanum, *et al.*, 2017).**
To produce an effective and stable topical nanoformulation, medication compatibility, stability, and appropriateness were evaluated.

2.2.1 Organoleptic Properties of selected Drug

Organoleptic evaluation is an important pre-formulation study used to identify and characterize drug substances based on their physical appearance and sensory characteristics. These properties include color, odor, texture, and physical state, which help in confirming the identity and purity of the selected drugs **(Ahirwar and Shukla, 2023).**

2.2.2 Solubility study of selected Drug

To find the best solvents for formulation, we tested how well Aloin and tretinoin dissolved in different types of water. Dimethyl sulfoxide (DMSO), distilled water, methanol, chloroform, acetone, and ethanol were among the solvents chosen. One milligram of the medicine was mixed with one millilitre of solvent in a sterile test tube for every experiment. The ingredients were combined with a vortex mixer and, if needed, heated gently in a water bath over boiling to facilitate disintegration. After that, we looked at the samples to see if the medicine had dissolved entirely, partly, or was still insoluble. For the creation of a stable and successful Nanoparticle formulation, this straightforward and methodical technique provide crucial direction for selecting acceptable solvents **(Jamalzadeh*et al.*, 2016).**

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2.2.3 Melting Point determination of selected Drug

This study discovered tretinoin and aloin's melting points using standard lab methods. A little quantity of each drug sample was melted in a capillary tube using melting point equipment. This was recorded at the precise temperature**(Malallah*et al.*, 2020).**

2.2.4 pHdetermination of selected Drug

The current study identified Tretinoin and Aloin pH by creating the correct medication solutions in the suitable solvent system. Normal laboratory settings were employed to evaluate pH values with a calibrated digital pH meter (**Mahapatra,*et al.*, 2023).**

2.2.5 Spectroscopic Analysis and Calibration of Aloin and tretinoin

- **Lambda (λ) max analysis**

Separate 1 mg/mL aloin and tretinoin methanol stock solutions were made. These were diluted to 1 mg/mL in the same solvent to make working standard solutions. The absorbance spectra were recorded using a Shimadzu 1700 double beam spectrophotometer to determine the wavelength of maximum absorbance (λmax) for both compounds by scanning each solution in the UV range of 200-800 nm. Separate 1 mg/mL aloin and tretinoin methanol stock solutions were made. These were diluted to 1 mg/mL in the same solvent to make working standard solutions. The absorbance spectra were recorded using a Shimadzu 1700 double beam spectrophotometer to determine the wavelength of maximum absorbance (λmax) for both compounds by scanning each solution in the UV range of 200-800 nm. **(Bruno *et al.*, 2023).**

- **Standard calibration curve analysis**

Aloin: Sodium hydroxide stock solution (1 mg/mL) was made. Using methanol as a solvent, standard solutions with concentrations of 10, 20, 40, 60, 80, and 100 µg/mL were created according to the specifications.

Tretinoin: A 1 mg/mL stock solution was diluted in methanol to create standard working solutions of 2, 4, 6, 8, 10, and 12 µg/mL. A Shimadzu UV-1700 double beam spectrophotometer was used to measure the absorbance of each solution at the previously established λmax. A standard calibration curve was generated for each medication by plotting absorbance against concentrations. In order to determine the linear range, correlation coefficient, and analytical approach for quantitatively estimating Tretinoin and Aloin, we employed this method **(Desai *et al.*, 2026).**

2.2.6 Fourier Transform Infrared (FT-IR) Spectroscopy of Aloin and tretinoin

We used Fourier Transform Infrared (FT-IR) spectroscopy to look at the aloin and tretinoin chemical structures and functional groups. Using 1 mg of each medication, a thin film was prepared for FT-IR examination. Using a Fourier transform infrared spectrophotometer, we scanned samples from 4000-400 cm^{-1} and recorded the resulting spectra. Functional group-specific peaks demonstrated the chemical stability of the medications. Analysis was repeated three times to ensure accuracy and reproducibility. This method provided crucial pharmacological structural data for formulation development **(Wang *et al.*, 2025).**

2.3 Formulation of Aloin and tretinoin loaded Nanoparticle formulation

Solvent evaporation using polymer eudragit RS 100 and stabiliser polyvinyl alcohol produced aloin and tretinoin nanoparticles. A 1:1 mixture of methanol dissolved correctly weighed amounts of Aloin and Tretinoin to make the organic phase. Stirring gently, Eudragit RS 100 was added as needed. The aqueous phase included 0.3% PVA by weight. The organic phase was gently introduced to the water phase while magnetically agitated. We let the combination alone for two hours to allow the solvent evaporate and nanoparticles develop. Washing and centrifuging produced nanoparticles that were vacuum dried or lyophilised. Keep the dried nanoparticles in sealed containers to measure their size, polydispersity index, zeta potential, encapsulation efficacy, and surface morphology **(Jain *et al.*, 2016).**

Table 1: Composition of nanoparticles formulation

Formulation Code	Drugs Aloin: Tretinoin (1:1 Ratio)	Eudragit RS 100 (mg)	Polyvinyl Alcohol (%)	Organic Solvent (Methanol: Acetone, mL)	Aqueous Phase (Water, mL)	Stirring Time (hrs)
Nanoparticles (F1)	1:1	300	0.3	5:5	10.0	2
Nanoparticles (F2)	1:1	250	0.3	5:5	10.0	2
Nanoparticles (F3)	1:1	200	0.3	5:5	10.0	2

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Nanoparticles (F4)	1:1	150	0.3	5:5	10.0	2
Nanoparticles (F5)	1:1	100	0.3	5:5	10.0	2

2.4 Evaluation parameter of Drug loaded Nanoparticle formulation

2.4.1 Physical appearance

The physical properties of the Aloin and Tretinoin-loaded Nanoparticle were carefully examined to assess their quality and stability. Visual inspection was performed to observe the color, consistency, and overall appearance of each formulation **(Narsa*et al.*, 2024).**

2.4.2 Particle Size

Using a particle size analyser equipped with dynamic light scattering (DLS), the nanoparticles containing aloin and tretinoin were assessed. **(Danaei*et al.*, 2018).**

2.4.3 Zeta Potential

A Malvern Zeta Sizer was used to assess the zeta potential of the nanoparticles loaded with aloin and tretinoin. The surface charge and colloidal stability of the formulation were evaluated in this way. **(Dong *et al.*, 2016).**

2.4.4 Scanning Electron Microscopy (SEM) Analysis of Drug loaded Nanoparticle formulation

Scanning electron microscopy (SEM) was used to examine the surface shape and structure of the nanoparticles that contained aloin and tretinoin. Using conductive glue, a little quantity of nanoparticle powder was painstakingly adhered to a metallic stub. A vacuum-applied thin coating of gold was used to increase conductivity. Subsequently, the samples were analysed using the appropriate accelerating voltage in a scanning electron microscope. The shape, surface roughness, and porosity of the Nanoparticle may be examined by taking high-resolution images. Drug entrapment, release behaviour, and formulation quality were examined using data on formulation shape and homogeneity supplied by this study. **(Khoshbakht*et al.*, 2020).**

2.4.5 Drug Entrapment Efficiency of Drug loaded Nanoparticle formulation

The quantity of drug effectively integrated into the nanoparticle matrix was quantified by determining the drug entrapment efficiency (EE%) of the Aloin and Tretinoin-loaded Nanoparticle. In order to extract the unbound medication from the nanoparticle, a specific volume of the suspension was subjected to high-speed centrifugation. To measure the quantity of unentrapped medicine, The aloin and tretinoin supernatant was examined at their λmax using a UV-Visible spectrophotometer. This formula was used to compute EE%:

$$EE\% = \frac{\text{Total drug} - \text{Free drug}}{\text{Total drug}} \times 100$$

Measurements were repeated three times to ensure accuracy and repeatability. To evaluate nanoparticle compositions' drug-loading capacity, stability, and therapeutic potential, entrapment efficiency must be measured **(Weng*et al.*, 2020).**

2.5 Preparation of Nanoparticle loaded Gel formulation

2.0 g of carbopol 940 and 1.8 g of carboxymethyl cellulose were combined in 100 mL of distilled water while stirring regularly to thoroughly hydrate and expand the polymers to create the 1:1 nanoparticle-loaded gel with Aloin and Tretinoin. A plasticiser and humectant, propylene glycol (1.0 mL) was added to the gel to improve its texture and make it more moisturising. Methyl paraben (0.3 g) was incorporated as a preservative to prevent microbial growth. Subsequently, 200 mg of the Nanoparticle containing the active drugs (Aloin and Tretinoin) was gradually added to the gel base with gentle stirring to achieve a homogeneous dispersion. Finally, triethanolamine was added dropwise in sufficient quantity to neutralize the Carbopol, leading to gel formation and adjusting the pH to a suitable level for topical application. The gel was thoroughly mixed to ensure uniform consistency and stored in airtight containers until further evaluation **(Agha, *et al.*, 2022).**

Table 2: Composition of Nanoparticle gel formulation

Ingredients	Amount of gel formulation
Carbopol 940	2.0 g

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Carboxymethyl cellulose (CMC)	1.8 g
Propylene glycol	1.0mL
Methyl paraben	0.3%
Aloin + Tretinoin Nanoparticle	200 mg
Triethanolamine	q.s. mL
Distilled water	q.s. mL

2.6 Quality Control Parameters of Aloin and Tretinoin loaded Nano Gel Formulation

Quality control evaluations were conducted on the gel formulations containing varying concentrations of aloin and tretinoin-loaded Nanoparticle to assess key physicochemical parameters such as pH, spreadability, and viscosity.

2.6.1 pH determination

We used a digital pH meter to ensure the Nano Gel formulation's stability and skin safety. **(Das and Wong, 2020).**

2.6.2 Spreadability

In order to find out how easy it was to apply and how uniformly it distributed throughout the skin, we tested the Nano Gel formulation's spreadability. In between two sterile glass slides, around 1 gram of the gel was put. The gel was allowed to spread equally under applied pressure by gently placing a predetermined weight (usually 500 grams) on the top slide and letting it stay for the normal length of 5 minutes. Carefully removing the weight after the allotted time allowed us to estimate the spread area's diameter or the distance the upper slide had moved. The gel's spreadability was calculated using the right method to assess its application and use.

$$S = (M \times L) / T$$

where the weight (M), the length (L), and the time (T) are the variables involved. In order to achieve a uniform and smooth skin covering, topical formulations with a high spreadability value are ideal **(Ali *et al.*, 2022).**

2.6.3 Viscosity of Nano Gel

A Brookfield viscometer was used to analyse the Nano Gel formulation's viscosity. This allowed us to evaluate its consistency, flow behaviour, and other important properties for topical administration **(Gaber*et al.*, 2023).**

2.7 *In-vitro* drug release

Nanogels loaded with Aloin and Tretinoin were tested for in vitro drug release using dialysis bag diffusion. Microgel was precisely doped onto a soaked dialysis membrane. Afterwards, the mixture was agitated at 100 rpm while submerged in 100 mL of a phosphate buffer solution with a pH of 7.4 and maintained at 37 ± 2 °C. Consistent replenishment of two millilitres of sample buffer was performed to sustain sink conditions. The samples were examined using a UV-Visible spectrophotometer at the appropriate wavelengths in order to measure the release of the medication. In order to ascertain the method of drug release, many kinetic models were used to compare release data. We utilised Higuchi, zero-order, and first-order models. To examine concentration-dependent medication release, the first-order kinetic model monitored the cumulative proportion of leftover medicine over time. **(Paarakh*et al.*, 2018).**

Higuchi developed a model that incorporates cumulative drug release and the square root of time. Correlation between cumulative medicine release % and time logarithm is established via the Korsmeyer-Peppas model.

Zero order kinetics

$$At = A0 - K0t \quad \text{------ Eq. (2)}$$

First order kinetics

$$LogC = logC0 - Kt/2.303 \quad \text{------- Eq. (3)}$$

Higuchi's Model

$$Q = [D\epsilon / \tau (2A - \epsilon Cs)\, Cst\,]1/2 \text{----------Eq. (4)}$$

Korsmeyer-Peppas model

$$Mt / M\infty = Kt^n \text{---------- Eq. (5)}$$

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III. RESULTS AND DISCUSSION

3.1 Pre-formulation study of drug

3.1.1 Organoleptic properties

Table 3: Organoleptic properties of Aloin and Tretinoin

Drug	Organoleptic properties	Observation (Aloin)	Observation (Tretinoin)
Aloin and Tretinoin	Color	Yellow to yellowish-brown	Yellow to light orange
	Odor	Characteristic odor	Characteristic faint odor
	Appearance	Crystalline powder	Crystalline powder
	State	Solid	Solid

3.1.2 pH and Melting point determination

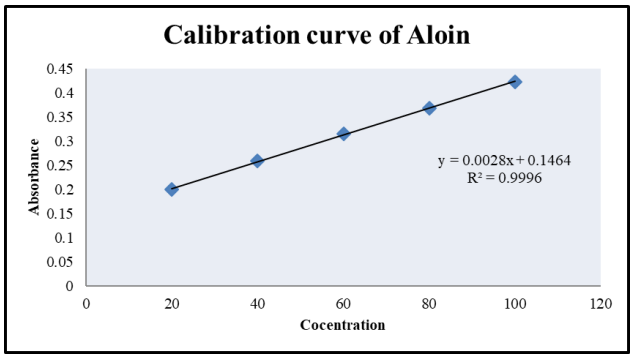
Table 4: pH and Melting point of Aloin and Tretinoin

Drugs	Observed (pH)	Observed (Melting point)	Reference (Melting point)
Aloin	4.43 pH	149.08°C	148°C-150°C
Tretinoin	6..56 pH	178.12°C	175°C-180°C

3.1.3 Calibration curve of Aloin

Table 5: Calibration curve of Aloin

Concentration (µg/ml)	Absorbance
20	0.200
40	0.258
60	0.315
80	0.368
100	0.422
Mean	**0.3126**
SD	**0.087612**



Graph 1: Calibration curve of Aloin

3.1.4 Calibration curve of Tretinoin

Table 6: Calibration curve of Tretinoin

Concentration (µg/ml)	Mean Absorbance
2	0.108
4	0.201
6	0.283
8	0.380
10	0.489
12	0.563
Mean	**0.337333**
SD	**0.173137**

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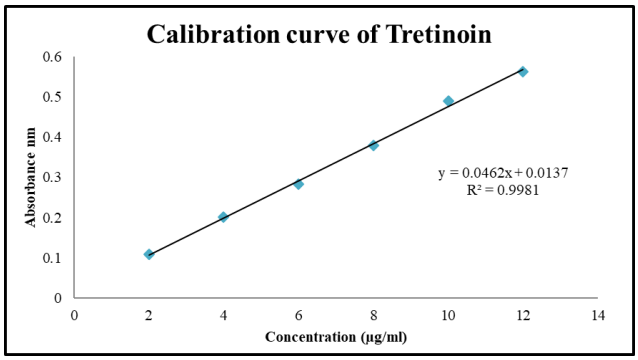
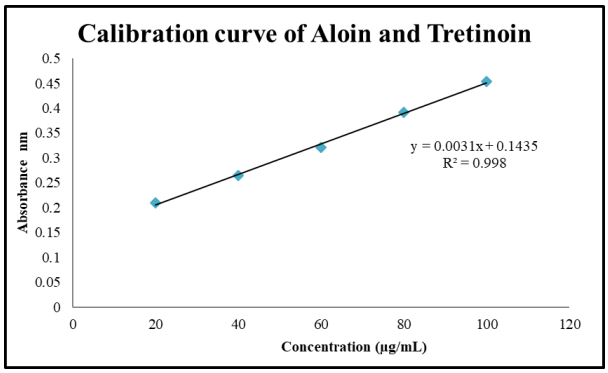


Graph 2: Calibration curve of Tretinoin

Table 7: Combined calibration curve of both drugs

Concentration (µg/mL)	Combined Absorbance (Aloin + Tretinoin)
20	0.209
40	0.265
60	0.321
80	0.392
100	0.453
Mean	**0.328**
SD	**0.09734**



Graph 3:Combined Calibration curve of Aloin and Tretinoin

3.1.5 Functional group identified by Infra-Red spectroscopy

Table 8: Interpretation of IR spectrum of Aloin

Peak obtained	Reference peak cm^{-1}	Functional group	Name of functional group
3395.76	3400-3300	N-H stretching	Primary amine
2978.86	3000-2800	N-H stretching	Amine salt
1619.58	1650-1600	C=C stretching	Conjugated alkene
1375.63	1390-1310	O-H bending	Phenol
1289.56	1310-1250	C-O stretching	Aromatic ester
1188.14	1210-1163	C-O stretching	Ester

Table 9: Interpretation of IR spectrum of Tretinoin

Peak obtained	Reference peak cm^{-1}	Functional group	Name of functional group
3753.58	4000-3000	O-H stretching	Alcohol
3448.49	3500- 3400	N-H stretching	Primary amine
2936.06	3000-2840	C-H stretching	Alkane

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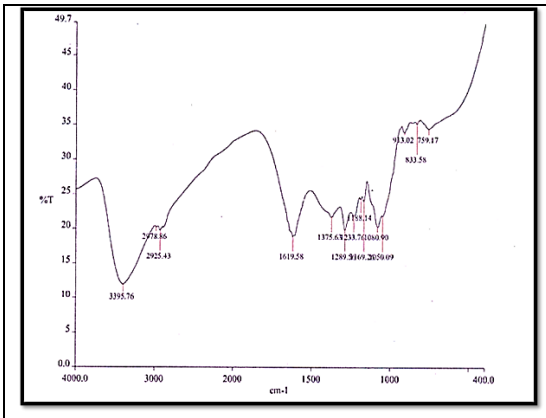
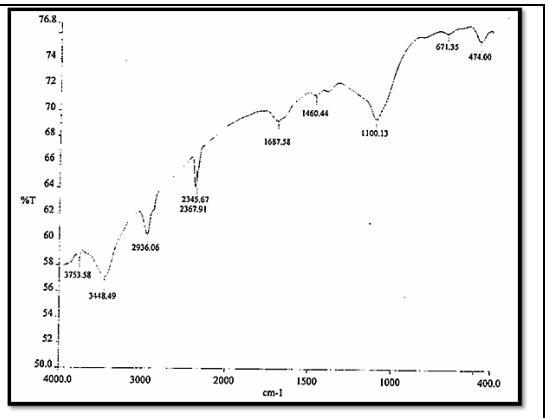
1687.58	1690-1640	C=N stretching	Imine / oxime
1460.44	1600-1300	N-O stretching	Nitro compound
1100.13	1150-1085	C-O stretching	Aliphatic ether



Graph 4: FTIR study of Aloin



Graph 5: FTIR study of Tretinoin

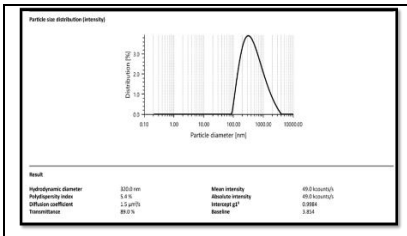
3.2 Characterization parameters of drug loaded Nanoparticle formulation

3.2.1 Physical appearance of Nanoparticle formulation

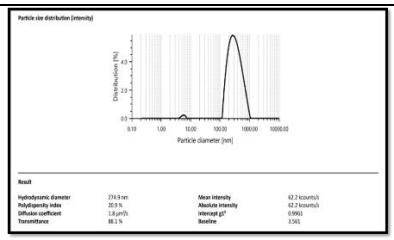
Table 10: Physical Appearance of Nanoparticle Formulation

Formulation	Parameters	Observation
Nanoparticles	Colour	Pale yellow
	Odors	odorless
	Appearance	Fine, free-flowing powder

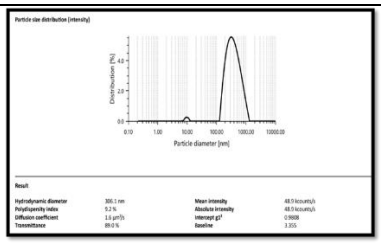
3.2.2 Particle Size determination



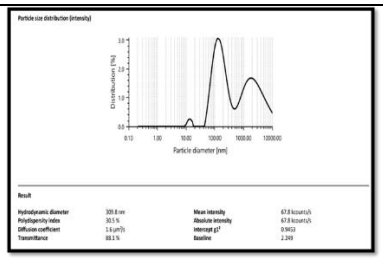
Graph 6: Particle size of Nanoparticle (F1)



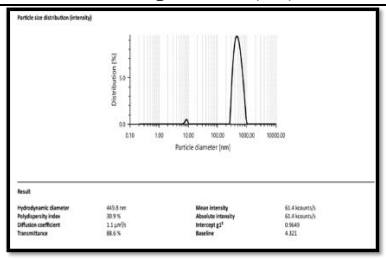
Graph 7: Particle size of Nanoparticle (F2)



Graph 8: Particle size of Nanoparticle (F3)



Graph 9: Particle size of Nanoparticle (F4)



Graph 10: Particle size of Nanoparticle (F5)

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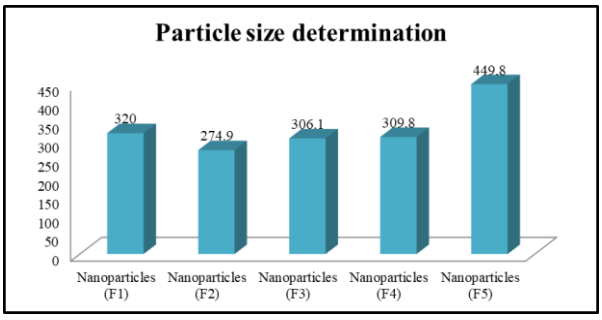
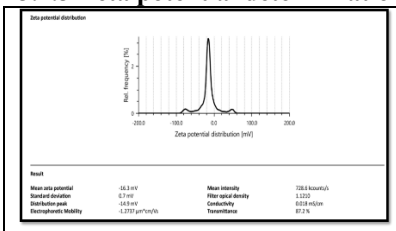
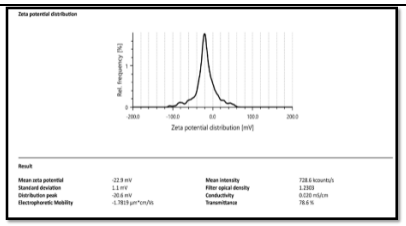


Graph 11: Graphical representation of particle size determination

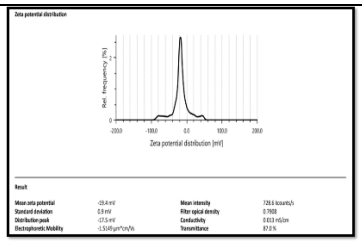
3.2.3 Zeta potential determination



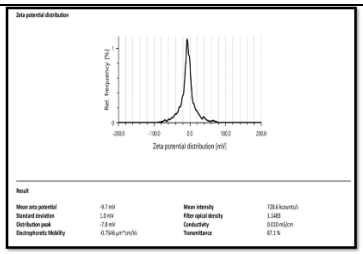
Graph 12: Zeta potential of Nanoparticles (F1)



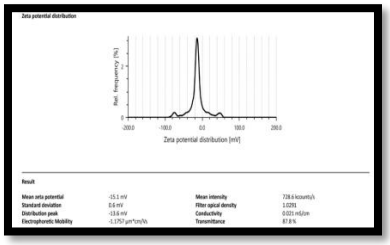
Graph 13: Zeta potential of Nanoparticles (F2)



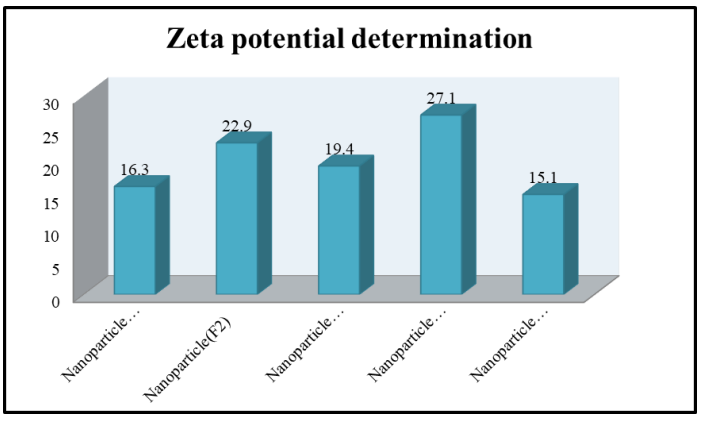
Graph 14: Zeta potential of Nanoparticles (F3)



Graph 15: Zeta potential of Nanoparticles (F4)



Graph 16: Zeta potential of Nanoparticles (F5)



Graph 17: Graphical representation of zeta potential determination

3.2.4 % (EE) Entrapment efficacy

Table 11: Entrapment efficacy

Formulations	Entrapment efficacy
Nanoparticle (F1)	72.43

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Nanoparticle(F2)	91.51
Nanoparticle (F3)	86.68
Nanoparticle (F4)	84.34
Nanoparticle (F5)	80.32

3.2.5 Scanning electron microscope (SEM) of F2 Formulation

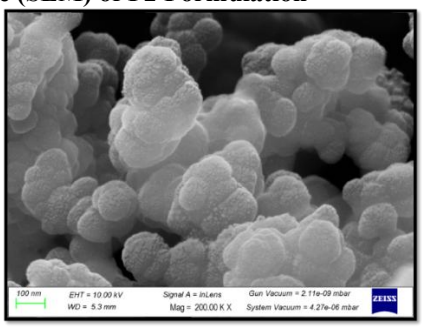

Figure 1: Scanning electron microscope (SEM)

3.3 Evaluation parameter of drug loaded nanogel formulation

3.3.1 Physical appearance

Table 12: Physical appearance

Parameter	Result
Colour	Light yellow
Odour	Odorless
Appearance	Smooth, translucent gel
Homogeneity	Uniform with no lumps or phase separation

Figure 2: Nanogel

3.3.2 Viscosity, Spreadability and pH of Nanogel

Table 13: Viscosity, Spreadability and pH of Nanogel

Formulation	Viscosity (Cps)	pH	Spreadability (g.cm/s)
Nanogel	4957±0.34 cps	6.21	11.32 g-cm/sec

3.3.3 *In-vitro* drug release

Table 14: Release kinetics study of optimized nanogel formulation

Time (Hr)	cumulative % drug released	% drug remaining	Square root time	log Cumu % drug remaining	log time	log Cumu % drug released
0	0	100	0.000	2.000	0.000	0.000
2	23.56	76.44	1.414	1.883	0.301	1.372
4	36.15	63.85	2.000	1.805	0.602	1.558
6	43.36	56.64	2.449	1.753	0.778	1.637

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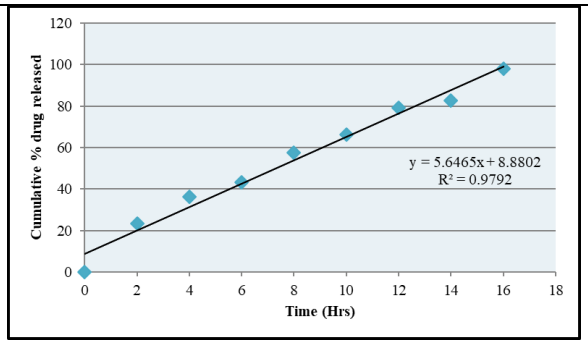
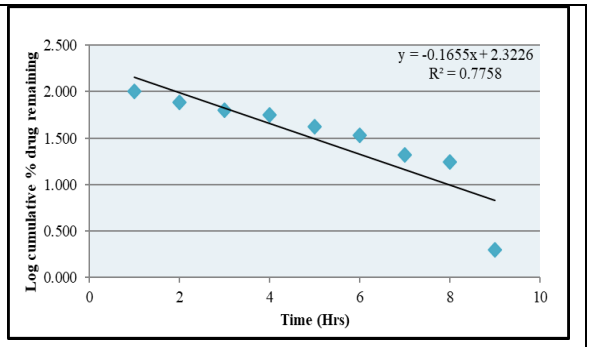
8	57.61	42.39	2.828	1.627	0.903	1.760
9	66.22	33.78	3.162	1.529	1.000	1.821
10	79.03	20.97	3.464	1.322	1.079	1.898
12	82.52	17.48	3.742	1.243	1.146	1.917
14	98.02	1.98	4.000	0.297	1.204	1.991

Table 15: Correlation value (R^2 value)

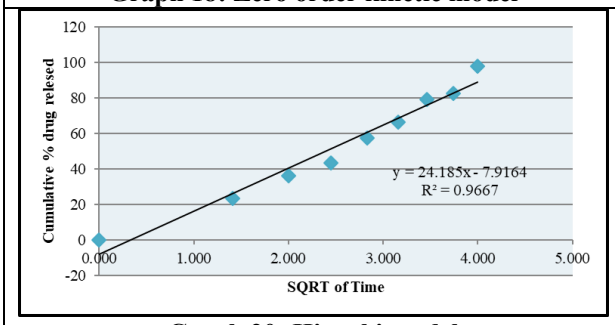
Formulation	Model	Kinetic parameter values
Nanogel	Zero Order	$R^2 = 0.979$
	First Order	$R^2 = 0.775$
	Higuchi	$R^2 = 0.966$
	Korsmeyer peppas	$R^2 = 0.808$



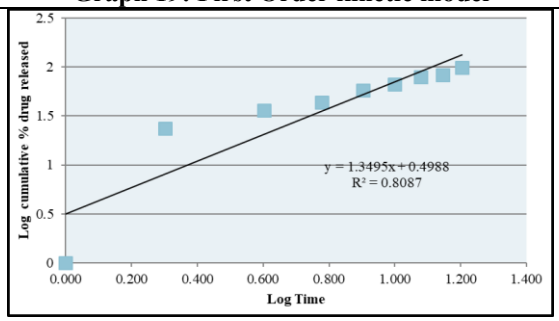
Graph 18: Zero order kinetic model



Graph 19: First Order kinetic model



Graph 20: Higuchi model



Graph 21: Korsmeyer-Peppas

IV. Discussion

This study generated, tested, and assessed topical Aloin and Tretinoin nanogel and nanoparticles. The drugs' organoleptic properties matched their standard values, suggesting purity and suitability for formulation development. Since Aloin and Tretinoin were poorly soluble in water but more soluble in organic solvents such methanol, ethanol, and DMSO, nanoparticle-based delivery techniques are needed to optimise their integration and therapeutic efficacy. The drugs' stability, compatibility, and identity were verified by pH and melting point tests. UV spectrophotometric study confirmed Beer-Lambert law compliance and validated the quantitative estimate technique, resulting in accurate λmax values and good linearity in calibration curves. FTIR tests confirmed drug chemical stability and identified different functional groups without severe incompatibilities.

Of all the nanoparticle formulations, F2 had the smallest particle size, the greatest zeta potential, and the maximum entrapment efficacy. Both its stability and its ability to encapsulate drugs appear to have improved. The synthesis of spherical nanoparticles with excellent structural integrity and little aggregation was verified by scanning electron microscopy. These particles have the potential to penetrate the skin deeply while allowing for regulated release of medications. The nanogel seemed like it might be a good topical treatment for patients based on its homogeneity, spreadability, viscosity, and pH. Medications were released in a regulated and sustained manner over the course of 14 hours in the in-vitro drug release experiment.

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Diffusion controlled drug release from the nanogel matrix, as release kinetics mostly matched the zero-order and Higuchi models.

In terms of stability, controlled drug release, topical drug administration, and overall physicochemical properties, the Aloin and Tretinoin nanogel shown promise. It is possible that the formulation has better therapeutic efficacy, longer pharmaceutical action duration, and more patient compliance than topical formulations.

V. CONCLUSION

The results indicate that the creation of nanoparticle gels containing Aloin and Tretinoin has great promise as a method for the topical administration of medications. Nanoparticles with ideal zeta potential, entrapment efficiency, and particle size were synthesised using this formulation approach. The physical stability, spreadability, pH, and viscosity of the system were enhanced upon combination with a gel basis for cutaneous administration of these nanoparticles. With near-zero-order kinetics and a sustained in-vitro drug release profile, the therapeutic effectiveness can be prolonged with less injection frequency. The nanoparticles' spherical form and microscopic size also have the potential to enhance the skin's ability to absorb and retain localised medications. Aloin and Tretinoin topical administration, patient compliance, and the efficacy of therapy might be enhanced by the optimised nanoparticle gel formulation, which could replace dermatological topical formulations.

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