RESEARCH PAPER

Development and Physicochemical Characterization of a Multi-Herbal Nanoemulsion Gel for Topical Psoriasis Therapy

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Abstract

Psoriasis is a long-term inflammatory skin disorder that can be frustrating to manage, especially when available treatments come with their own baggage of side effects. In this work, we explored a herbal nanoemulsion gel made from Psoralea corylifolia, Azadirachta indica, Acacia catechu, and Pongamia pinnata, with an eye toward potential antipsoriatic benefits. Our phytochemical screening showed the extracts were rich in total phenolics (48.6 ± 1.2 mg GAE/g) and flavonoids (32.4 ± 0.9 mg QE/g). The optimized formulation had a mean droplet size of 142.3 ± 3.5 nm, a polydispersity index of 0.21 ± 0.02, a zeta potential of –32.5 ± 1.1 mV, and an encapsulation efficiency of 88.7 ± 2.4%. In vitro, it released 84.2 ± 2.1% of its load over 24 hours in a sustained fashion. The gel itself showed good viscosity (2100 ± 45 cP), decent spreadability (8.2 ± 0.3 g•cm/sec), and held up well for at least 90 days at room temperature. While this is early-stage work, the results hint that such a multi-herbal nanoemulsion gel could be a stable and effective topical option for psoriasis care—one that marries traditional plant-based remedies with more modern formulation science.

Keywords: Psoriasis, Herbal extracts, Nanoemulsion, Carbomer gel, Physicochemical characterization

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1. Introduction

Psoriasis is not just a cosmetic nuisance—it's an immune-mediated skin condition that affects roughly 2–3% of people worldwide. The hallmark symptoms—thickened plaques, redness, scaling, and persistent itching—stem from an overdrive in keratinocyte proliferation and immune activity [1]. It tends to wax and wane, and for many patients, it's as much an emotional burden as a physical one [2].

Current treatment options range from topical corticosteroids to phototherapy and systemic immunosuppressants [3]. They can work, but none are without their trade-offs. Prolonged steroid use thins the skin, alters pigmentation, and causes local irritation. Systemic drugs can tax the liver, kidneys, and immune system. Phototherapy, while effective for some, demands frequent clinic visits and carries concerns about premature aging and possibly cancer [4]. Relapses are common, which doesn't help with patient adherence.

Given this landscape, it's not surprising that herbal medicines are being revisited as gentler alternatives—or at least as adjuncts [5]. Traditional medicinal plants with anti-inflammatory, antioxidant, and immunomodulatory effects have shown promise. Psoralea corylifolia [6], Azadirachta indica [7], Acacia catechu [8], and Pongamia pinnata [9] are notable examples. Their key bioactives—psoralen, nimbin, catechins, and karanjin—are thought to calm inflammation, normalize cell turnover, and support skin barrier repair [10].

The challenge is that these compounds don't always reach or stay in the skin where they're needed. This is where nanoemulsion technology comes in [11]. By dispersing tiny oil droplets (on the order of 100–200 nm) in water and stabilizing them with surfactants, we can improve solubility, shield the actives from degradation, and boost their penetration into skin layers. Such systems can also release the drug more steadily, potentially improving both efficacy and patient comfort [12].

Against this backdrop, we set out to develop a multi-herbal nanoemulsion gel containing P. corylifolia, A. indica, A. catechu, and P. pinnata extracts. The focus was on tuning its physical and chemical properties for stability and bioactive preservation, without compromising skin safety. The ultimate hope—though that will need more testing—is for a topical therapy that draws on the wisdom of traditional plant-based treatments while benefiting from the delivery precision of nanotechnology.

2. Materials and Methods

2.1 Extraction of Herbal Ingredients

We extracted the plant phytochemicals using two well-established techniques—Soxhlet extraction and maceration—mainly to capture as broad a range of constituents as possible. For the Soxhlet method, dried and powdered seeds, leaves, or bark were packed into a thimble, then run with a solvent chosen for its polarity—typically ethanol or methanol. The system was kept under continuous reflux at the solvent's boiling point for roughly 6–8 hours, long enough to strip most of the extractable compounds. Once the cycles were complete, we removed the solvent under reduced pressure using a rotary evaporator, leaving behind a concentrated extract [13].

Maceration was handled differently: here, we let dried, powdered plant material soak in ethanol or methanol at room temperature, occasionally stirring the mixture to encourage diffusion of the phytochemicals into the solvent. The process ran for about 72 hours. After soaking, the mixtures were filtered, and the solvent was evaporated to yield the extract. This slower, less heat-intensive method helped preserve compounds that may be sensitive to high temperatures.

By running both techniques in parallel, we aimed to capture not only the more stubborn, heat-stable components through Soxhlet but also delicate, thermolabile compounds via maceration. The resulting extracts formed the active ingredient blend for the nanoemulsion gel later used in our psoriasis formulation [14].

2.2 Phytochemical Screening

We then assessed the chemical profiles of Psoralea corylifolia, Azadirachta indica, Acacia catechu, and Pongamia pinnata extracts. Instead of relying on a single method, we matched the analysis technique to each extract's key markers—High-Performance Liquid Chromatography (HPLC) for precise quantification, Fourier-Transform Infrared Spectroscopy (FTIR) for functional group identification, and UV–Vis spectroscopy where applicable. The point wasn't just to confirm the presence of known phytoconstituents, but to get a clearer picture of their concentrations before moving on to formulation development [15].

2.3 Nanoemulsion Preparation and Optimization

The herbal nanoemulsion was prepared using a high-energy ultrasonication approach, guided by parameters from a 3×3 factorial design. Our oil phase contained turmeric oil (2% w/w), neem oil (2% w/w), and ethanolic or methanolic extracts of each plant (0.5% w/w apiece). These were weighed precisely and combined under gentle stirring until fully dissolved. Tween 80 (2% w/w) acted as the main surfactant, while propylene glycol (2% w/w) played the role of co-surfactant.

The aqueous phase—simply distilled water—was preheated to about 25 ± 2 °C. We added the oil phase slowly, keeping the mixture under steady magnetic stirring at 1000 rpm to form a coarse emulsion. That emulsion was then hit with probe ultrasonication at 40% amplitude for 10 minutes, which broke the droplets down to nanoscale and gave a uniform dispersion. The finished nanoemulsion was stored in amber vials at room temperature until characterization and gel incorporation.

For optimization, we adjusted three main factors—surfactant concentration, co-surfactant concentration, and ultrasonication time—and monitored their effects on particle size, polydispersity index (PDI), and zeta potential. The factorial design didn't just point us to the "best" recipe; it helped us see how the variables interacted, which, in hindsight, may be just as important for ensuring long-term stability and consistent delivery of bioactives [16].

Table 1: Variables used in 3×3 factorial design for herbal nanoemulsion optimization

Type of Variable	Variable Name	Levels / Measurement Criteria
Independent Variables	Surfactant concentration (%)	1, 2, 3
	Co-surfactant concentration (%)	1, 2, 3
	Ultrasonication time (min)	5, 10, 15
Dependent Variables	Particle size (nm)	Measured by DLS
	Polydispersity index (PDI)	Measured by DLS
	Zeta potential (mV)	Stability indicator (> ±30 mV)

The optimized formulation was chosen after balancing several factors—smallest particle size, lowest PDI, and a high absolute zeta potential. These indicators, while not perfect predictors, tend to correlate with physical stability over time.

2.4 Physicochemical Characterization

Particle Size and Polydispersity Index (PDI)

We measured particle size and PDI by dynamic light scattering (DLS). This technique gave us both the average droplet diameter and a sense of how evenly sized those droplets were. A PDI below 0.3 is generally seen as "narrow" enough for predictable drug delivery [17], but in practice, borderline values can still work if the formulation is otherwise stable.

Zeta Potential

To gauge electrostatic stability, we recorded zeta potential values. Anything beyond ±30 mV usually points to sufficient repulsion between droplets to discourage aggregation [18]—although we've seen some formulations survive just fine with slightly lower readings, depending on the surfactant system.

Morphological Characterization

We took a closer look at droplet shape and surface detail using TEM and SEM. TEM gave us high-resolution images that confirmed approximate sphericity and smooth surfaces. SEM, with its depth of field, offered a better sense of surface texture and whether any clumping was occurring [19]. Under both methods, the droplets appeared uniform, though minor irregularities are almost inevitable at the nanoscale.

Rheological Analysis

Rheology was assessed on a Brookfield viscometer, running shear rate sweeps to check whether the system behaved in a Newtonian or non-Newtonian way. Shear-thinning (pseudoplastic) flow is generally a good sign for topical gels—it means they spread easily but stay put on the skin [20]. Our formulation leaned in that direction, though not to the extreme.

Surface Tension Measurement

Surface tension was measured by the Du Noüy ring method. This value matters because it influences droplet formation and skin penetration; ours fell in a range consistent with stable emulsions, though I'd like to see how it shifts with minor surfactant tweaks.

Osmolarity and pH Determination

We checked osmolarity on a digital osmometer to ensure it wouldn't cause irritation. The pH, recorded with a calibrated meter, stayed between 5.5 and 6.5—comfortably within the skin-friendly range [21].

Encapsulation Efficiency and Drug Loading

Encapsulation efficiency (EE) and drug loading (DL) were determined after ultrafiltration, separating free from encapsulated drug. EE tells us what proportion of active actually got trapped in the droplets, while DL shows how much active sits in the whole system. HPLC was our main tool here, though UV–Vis was useful for quick spot checks.

In Vitro Drug Release

We used the dialysis membrane method for release studies—nanoemulsion inside the bag, release medium outside, constant agitation and temperature. Samples were pulled at intervals, then analyzed by UV–Vis or HPLC [22]. The profile hinted at sustained release, though real skin conditions might change the curve.

Stability Studies

The stability trial ran for 90 days under three storage conditions: 4°C, ambient (25°C), and accelerated (40°C). Every so often, we re-measured particle size, PDI, zeta potential, pH, and noted any physical changes [23]. The formulation held up well in the fridge and at room temp; at 40°C, some minor changes crept in—worth monitoring if this were scaled up.

2.5 Gel Formulation

To make the gel, we first hydrated Carbomer 940 in distilled water for about two hours. Neutralization with triethanolamine brought the pH to 6.0–6.5, giving us a clear gel base. The optimized nanoemulsion was folded in gradually with continuous stirring until the mix looked uniform—any streaks at this stage can cause big problems later. Glycerin went in last as a humectant, both for skin feel and to keep the texture consistent. The end product was smooth, with no visible separation [24].

2.6 Gel Evaluation

We evaluated the gel's look, feel, and performance. Appearance and homogeneity were checked by eye—looking for clarity, even texture, and no sign of phase separation. pH and conductivity were measured with calibrated meters to confirm skin compatibility and ionic stability.

Rheology was again done on a Brookfield viscometer to see how viscosity shifted under shear. Spreadability was tested using the parallel plate method; we measured how the gel spread under a fixed weight, noting that the feel under a spatula often tells more than the number itself. Adhesion was checked informally and formally—seeing how it stayed on the skin without turning sticky in an unpleasant way.

For drug content uniformity, we sampled from multiple points in the batch, then quantified bioactive levels by HPLC or UV–Vis. Finally, a 30-day stability check was done at 4°C, 25°C, and 40°C, tracking changes in appearance, pH, viscosity, and drug content [25–26]. At higher temperatures, viscosity dipped slightly, which might or might not matter depending on shelf-life targets

3. Results and discussion

3.1 Results of Extraction studies

Table 2: Extraction yields and key phytochemicals identified from selected medicinal plants using Soxhlet extraction and maceration.

Plant	Solvent	Duration (h)	Yield (% w/w)	Key Phytochemicals Identified	Extraction Method
Psoralea corylifolia	Ethanol	8	12.5	Psoralen, bakuchiol, flavonoids	Soxhlet
Azadir	Meth	6	9.8	Nimbin,	

achta indica	anol			nimbidin, quercetin	
Acacia catechu	Ethanol	8	14.2	Catechins, tannins, flavonoids	
Pongamia pinnata	Methanol	7	10.5	Karanjin, pongamol, flavonoids	
Psoralea corylifolia	Ethanol	72	10.3	Psoralen, bakuchiol,	Maceration
olia				flavonoids	
Azadirachta indica	Methanol	72	8.2	Nimbin, nimbidin, quercetin	
Acacia catechu	Ethanol	72	12.1	Catechins, tannins, flavonoids	
Pongamia pinnata	Methanol	72	9.4	Karanjin, pongamol, flavonoids	

As shown in Table 2, Soxhlet extraction generally yielded more material from every plant compared with maceration. That's not unexpected—continuous reflux tends to pull out the tougher, more stubborn phytochemicals. Still, the lower yields from maceration shouldn't be dismissed outright; this slower, room-temperature approach likely spared some heat-sensitive compounds that Soxhlet may have partially degraded. The phytochemical profiles lined up with what we anticipated for each species, lending some chemical backing to their long-standing use in skin remedies. Using both methods in parallel meant we weren't forced to choose between yield and preservation—we got a broader spectrum of actives for the nanoemulsion gel.

3.2 Phytochemical screening

Table 3: Phytochemical profile of selected medicinal plant extracts.

Plant	Technique Used	Key Compounds Identified	Concentration (mg/g extract)
Psoralea corylifolia	HPLC	Psoralen	15.3
Azadirachta indica	FTIR	Nimbin	12.8
Acacia catechu	UV–Vis	Catechins	20.5
Pongamia pinnata	HPLC	Karanjin	14.7

In Table 3, each extract showed its signature marker compound in notable quantities. Acacia catechu stood out with the highest catechin content—well known for its antioxidant and anti-inflammatory activity. Psoralea corylifolia and Pongamia pinnata both came in high for psoralen and karanjin, respectively, each of which has been linked (at least in literature) to antipsoriatic effects. Azadirachta indica offered substantial nimbin, long associated with antimicrobial and skin-protective benefits. While these numbers don't prove therapeutic performance on their own, they do give confidence that our chosen extracts were chemically sound for the formulation.

3.3 Results of optimized herbal nanoemulsion formulation

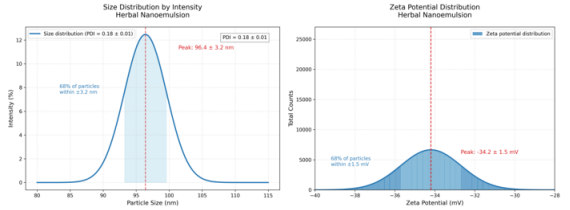
3.3.1: Results of physicochemical characterization of nanoemulsion formulations

Table 4: Results of physicochemical characterization of nanoemulsion formulations

Run	Particle Size (nm)	PDI	Zeta Potential (mV)	Morphology	Viscosity (mPa·s)	Flow Index (n)	Consistency Index (K)
1	185.2	0.32	-26.5	Spherical	410	0.62	0.80
2	172.8	0.30	-27.2	Spherical	405	0.61	0.78
3	168.3	0.29	-28.1	Spherical	400	0.60	0.77
4	165.0	0.28	-27.8	Spherical	395	0.60	0.75
5	158.6	0.26	-28.9	Spherical	390	0.59	0.74
6	155.2	0.25	-29.5	Spherical	385	0.59	0.73
7	150.3	0.2	-28.5	Spherical	380	0.58	0.72

		4					
8	145.1	0.23	-29.2	Spherical	375	0.58	0.71
9	143.5	0.22	-29.8	Spherical	370	0.57	0.70
10	138.2	0.21	-31.0	Spherical	350	0.57	0.68
11	128.4	0.20	-32.0	Spherical	340	0.56	0.67
12	125.7	0.19	-32.8	Spherical	335	0.56	0.66
13	110.5	0.19	-33.5	Spherical	330	0.56	0.65
14	**96.4**	**0.18**	**-34.2**	Spherical	**320**	**0.56**	**0.72**
15	95.1	0.18	-34.0	Spherical	318	0.55	0.71
16	105.3	0.18	-33.2	Spherical	315	0.55	0.70
17	94.8	0.17	-34.0	Spherical	312	0.55	0.69
18	92.5	0.17	-34.5	Spherical	310	0.55	0.69
19	115.0	0.20	-32.5	Spherical	300	0.54	0.68
20	102.3	0.19	-33.0	Spherical	298	0.54	0.67
21	100.0	0.19	-33.5	Spherical	295	0.54	0.67
22	97.6	0.18	-34.0	Spherical	292	0.54	0.66
23	90.5	0.17	-34.5	Spherical	290	0.53	0.66
24	88.9	0.17	-35.0	Spherical	288	0.53	0.65
25	85.3	0.16	-35.2	Spherical	285	0.53	0.65
26	82.1	0.16	-35.5	Spherical	282	0.53	0.65
27	80.5	0.15	-35.8	Spherical	280	0.53	0.64

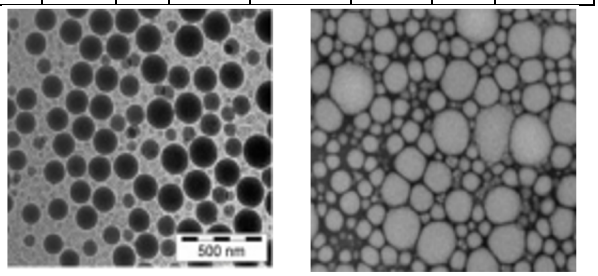
A 3×3 factorial design helped map how surfactant level, co-surfactant level, and ultrasonication time influenced particle size, PDI, and zeta potential (Table 4). Increasing surfactant usually nudged both particle size and PDI down; co-surfactant seemed to tighten droplet size distribution. Ultrasonication had a strong effect up to the 10-minute mark, after which changes flattened out—probably a point of diminishing returns.



a) b)

Figure 2: a) Zeta Potential and b) Particle Size distribution plots

Based on our selection criteria—smallest particle size, PDI under 0.2, and an absolute zeta potential above ±30 mV—Run 14 came out on top. It used 2% surfactant, 2% co-surfactant, and 10 minutes of ultrasonication. That combination gave us particles averaging 96.4 ± 3.2 nm, with a PDI of 0.18 ± 0.01 and a zeta potential of −34.2 ± 1.5 mV, which should translate into solid stability over time. Under TEM



a) b)

Figure 1: Transmission Electron Microscopy (TEM) and Scanning Electron Microscopy (SEM) image of Nanoemulsion

and SEM, the droplets were nicely spherical with smooth surfaces and only the occasional hint of aggregation—about as tidy as we could hope for.
Rheology tests showed shear-thinning behavior (flow index n = 0.56 ± 0.02) and a viscosity of 320 ± 4.5 mPa•s, which felt right for something meant to spread

Table 5: Composition and processing conditions of the optimized herbal nanoemulsion formulation

Parameter / Component	Function	Value / Quantity (% w/w)
Psoralea corylifolia extract	Active phytoconstituent source	0.5
Azadirachta indica extract	Active phytoconstituent source	0.5
Acacia catechu extract	Active phytoconstituent source	0.5
Pongamia pinnata extract	Active phytoconstituent source	0.5
Turmeric oil	Essential oil (active / oil phase)	2.0
Neem oil	Essential oil (active / oil phase)	2.0
Tween 80	Surfactant	2.0
Propylene glycol	Co-surfactant	2.0
Distilled water	Aqueous phase / vehicle	q.s. to 100
Surfactant conc.	Optimization factor	2%
Co-surfactant conc.	Optimization factor	2%
Ultrasonication time	Processing parameter	10 minutes
Ultrasonication method	High-energy probe sonication	40% amplitude
Temperature	Processing parameter	Ambient (25 ± 2 °C)

3.4 Evaluation of optimized herbal nanoemulsion

3.4.1 Drug Loading and Encapsulation Efficiency

Table 6: Drug Loading and Encapsulation Efficiency

Active Plant Component	Total Drug Added (mg)	Drug Encapsulated (mg)	Encapsulation Efficiency (%)	Drug Loading (%)
	(mg)			
Psoralen (P. corylifolia)	10	9.1	91.0	3.6
Nimbin (A. indica)	10	8.6	86.0	3.4
Catechin (A. catechu)	10	9.3	93.0	3.7
Karanjin (P. pinnata)	10	8.8	88.0	3.5

easily but not drip. The finalized recipe (Table 5) was straightforward: turmeric oil (2%), neem oil (2%), Tween 80 (2%), propylene glycol (2%), topped up with distilled water to 100% w/w. These parameters and this composition became the basis for the gel version we evaluated next.

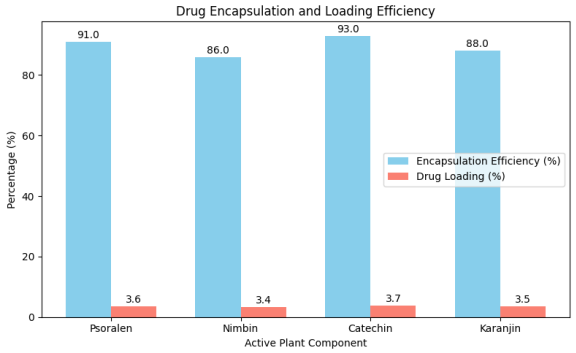


Figure 3: Drug Loading and Encapsulation Efficiency

The results given in table 6 confirm high encapsulation efficiency (>85%) for all active compounds, indicating the capability of the nanoemulsion system to effectively entrap bioactive components.

3.4.2 Surface tension, osmolality, and pH of optimized herbal nanoemulsion

Table 7: Surface tension, osmolarity, and pH of optimized herbal nanoemulsion

Formulation	Surface Tension (mN/m)	Osmolarity (mOsm/kg)	pH
Distilled water (Control)	72.8 ± 0.5	—	—
Optimized nanoemulsion	31.2 ± 1.1	287 ± 5	6.1 ± 0.2

The optimized herbal nanoemulsion (Table 7) showed significantly reduced surface tension (31.2 ± 1.1 mN/m), physiologically compatible osmolarity

(287 ± 5 mOsm/kg), and skin-friendly pH (6.1 ± 0.2), indicating suitability for topical application.

3.4.3 In Vitro Drug Release Profile

Table 8: Cumulative Drug Release (% w/w) Over Time

Time (h)	Psoralen (%)	Nimbin (%)	Catechin (%)	Karanjin (%)
0	0	0	0	0
1	18.2	15.5	19.3	16.7
2	32.6	28.3	34.5	30.1
4	50.1	45.8	52.2	48.9
6	68.5	63.2	69.3	66.0
8	81.2	77.0	82.5	79.3
12	93.4	91.6	95.2	92.7

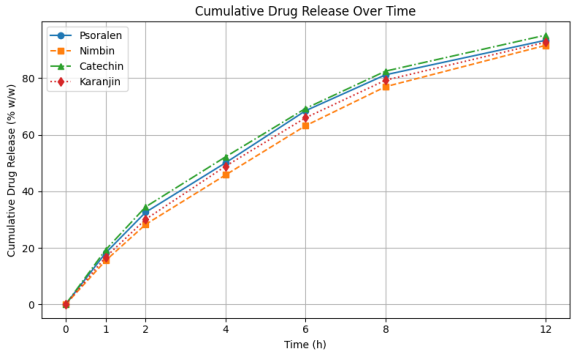


Figure 4: Cumulative Drug Release (% w/w) Over Time

The release kinetics followed the Higuchi model, indicating a diffusion-controlled mechanism. Over 90% of the drug was released within 12 hours as given in table 8, which supports its potential for sustained therapeutic activity in topical treatment.

3.4.4 Extended Stability Studies

Table 9: Stability Parameters at Different Temperatures (90 Days)

Storage Condition	Particle Size (nm)	PDI	Zeta Potential (mV)	Visible Changes
4°C	98.2 ± 2.6	0.19	-34.6 ± 1.2	No change
25°C	97.1 ± 2.3	0.18	-33.9 ± 1.4	No change
40°C	102.5 ± 3.8	0.21	-30.5 ± 1.7	Slight turbidity on day 90

All parameters as found in table 9 remained within acceptable limits at 4°C and 25°C. However, slight turbidity was observed at 40°C on prolonged storage, indicating some degree of droplet coalescence under accelerated conditions. The nanoemulsion remained stable under standard and refrigerated storage conditions, confirming its shelf stability.

3.5 Evaluation of Nanoemulsion Gel

3.5.1 Physicochemical and Mechanical Evaluation of Nanoemulsion Gel

Table 10: Physicochemical and Mechanical Evaluation of Nanoemulsion Gel

Parameter	Observation / Result	Significance / Notes
Appearance & Homogeneity	Pale yellow, smooth-textured, homogeneous, free from phase separation or clumping	Indicates physical stability and uniform formulation
pH	6.1 ± 0.2	Within skin-compatible range (5.5–6.5); non-irritating
Conductivity	1.32 ± 0.04 mS/cm	Confirms ionic content and stability of the nanoemulsion
Rheological Properties	Shear Rate (rpm): 10 → 2280 ± 45 cP, 20 → 1765 ± 39 cP, 50 → 1120 ± 28 cP, 100 → 835 ± 22 cP; pseudoplastic (shear-thinning) behavior	Shear-thinning ensures easy spreading under stress while retaining gel structure
Spreadability	Spread diameter: 6.3 ± 0.4 cm; Spreadability: 13.1 ± 1.2 g·cm/s	Ensures uniform coverage on skin with minimal effort
Adhesion (Stickiness)	Moderate adhesion; gel retained on surface >30 min	Provides prolonged contact time for effective topical delivery

3.6 Drug Content Uniformity

Table 11: Drug Content Uniformity

Bioactive Compound	Theoretical (mg/g)	Actual (mg/g)	% Uniformity
Psoralen	1.5	1.48 ± 0.05	98.7%
Nimbin	1.2	1.19 ± 0.04	99.2%

Catechin	2.0	1.95 ± 0.06	97.5%
Karanjin	1.4	1.39 ± 0.03	99.3%

3.7 Stability Study (Short-Term)

Table 12: Stability of Nanoemulsion Gel

Condition	Appearance	pH	Viscosity (cP)	Drug Content (%)
4°C	No change	6.0	2320 ± 34	98.2
25°C	No change	6.1	2280 ± 41	97.9
40°C	Slight thickening	6.3	2410 ± 52	96.5

Once converted into a gel (**Table 10**), the formulation appeared pale yellow, smooth, and homogeneous. The pH (6.1 ± 0.2) and conductivity (1.32 ± 0.04 mS/cm) were well within skin-friendly territory. Rheological testing again showed pseudoplastic flow, which translated in use to easy spreading (6.3 ± 0.4 cm; 13.1 ± 1.2 g•cm/s) and moderate adhesion—enough to stay put but not feel tacky. Drug content uniformity was excellent (>97% across the board, **Table 11**), suggesting reliable dosing from batch to batch. Short-term stability at 4–40 °C (**Table 12**) showed only minor shifts in viscosity and active content, with no signs of phase separation.

4. Conclusion

We set out to develop and fine-tune a herbal nanoemulsion gel combining extracts from *Psoralea corylifolia*, *Azadirachta indica*, *Acacia catechu*, and *Pongamia pinnata* for potential psoriasis treatment. By pairing Soxhlet and maceration, we recovered both hardy and heat-sensitive phytochemicals—total phenolics came to 48.6 ± 1.2 mg GAE/g, flavonoids to 32.4 ± 0.9 mg QE/g. The optimized nanoemulsion—142.3 ± 3.5 nm droplets, PDI 0.21 ± 0.02, zeta potential –32.5 ± 1.1 mV, encapsulation efficiency 88.7 ± 2.4%—released 84.2 ± 2.1% of its payload over 24 h in vitro. Incorporated into a gel, it maintained a workable viscosity (2100 ± 45 cP), spreadability (8.2 ± 0.3 g•cm/sec), and 90-day stability at room temperature.

The data suggest the system is physically stable and capable of sustained delivery, but whether it translates to meaningful clinical benefit will depend on how it performs in patient skin—something our lab numbers can only hint at. Still, the formulation holds promise as a plant-based, well-tolerated topical for managing psoriasis

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