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## Exploring The Versatility Of Topical Gels: - An Overview


**Rohit Keshav Dimote[1*] , Avesh Aslam Tamboli[2], Shendge Roasaheb S[3]**

*[1*]Research Scholar, Department Of Pharmaceutics, Sanjivani College of Pharmaceutical Education and Research, Kopargaon (Autonomous) , Maharashtra, India 423603*
*ORCID:-(https://orcid.org/0009-0008-8286-4457)*
*[2]Research Scholar, Department Of Pharmaceutics, Sanjivani College of Pharmaceutical Education and Research, Kopargaon, (Autonomous) Maharashtra, India 423603*
*[3]Professor, Department Of Pharmaceutics, Sanjivani College of Pharmaceutical Education and Research, Kopargaon, (Autonomous) Maharashtra, India 423603*

***Corresponding Author**: Rohit Keshav Dimote*
**Research Scholar, Department Of Pharmaceutics, Sanjivani College of Pharmaceutical Education and Research, Kopargaon (Autonomous) , Maharashtra, India 423603, ORCID:- (https://orcid.org/0009-0008-8286-4457)*



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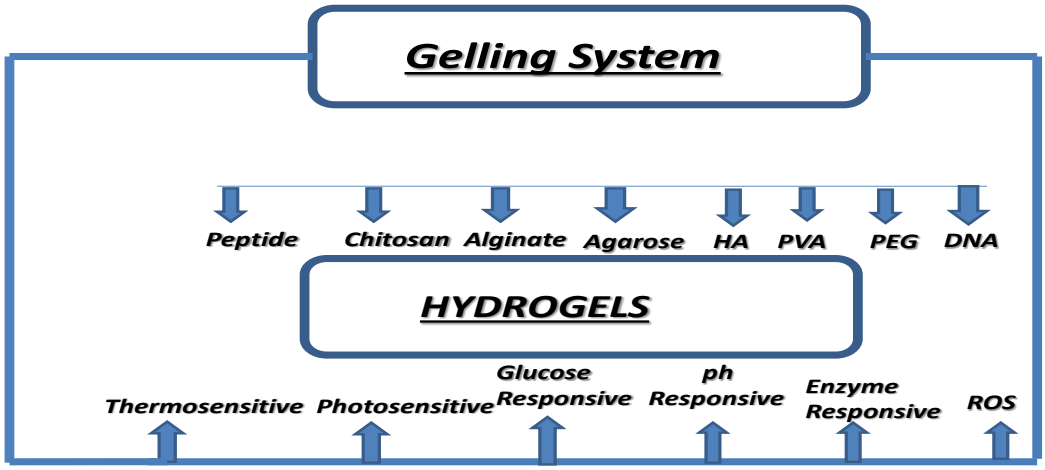
***Abstract***

Topical gels represent semi-solid formulations characterized by a phase of matter existence that is fluid encased within A three-dimensional structure made of polymers, typically consisting of synthetic or natural gums with substantial cross-linking, achieved either chemically or physically. Their unique composition enables diverse applications owing to their intermediate state between liquid and solid phases. In recent times, topical gels have garnered significant interest across various sectors, including industry, research, education, drug regulation, and professional fields. Special emphasis is placed on the utilization of gels in drug delivery systems; the discussion serves to provide insights into the versatility and involving landscape of topical gels, catering to the interests and needs of professionals and researchers in diverse domains.



***Keywords: Gelling agent, Pharmaceutical gel, HPMC, Thickening agents.***

**Graphical Abstract:-**




## 1. Introduction:-

Stabilizers, also Gelatinizing chemicals, often these materials are used as gelling agents to thicken or solidify solutions. Help to form gel-like structures bind Mix with oil to create solid Rubber is a material that is flexible; another way to put it is "elastic substance."-like materials.[1] These agents able to applied manually and given permission to naturally combine to deal with minor spills. In the case of larger Accidents can happen in situations involving intense, highly pressurized water jets utilized to combine the substances and petroleum post-application. On occasion, the gelled oil, once mixed with fuel after being extracted from the ocean, oil is repurposed using techniques like suction and netting devices, or those who skim.[2] The strength that came from wave action enhances the interaction between the chemicals and the petroleum, facilitating the course of solidification, making substances that lead to gelling suitable for use In waters that are calm to slightly disturbed. However, a drawback of gelling agents is the need for large quantities The material has the ability to hold up to three times as much as it did initially volume of the excess to be applied, making handling, transporting, and applying such quantities impractical for oil spills involving millions of gallons.[3]

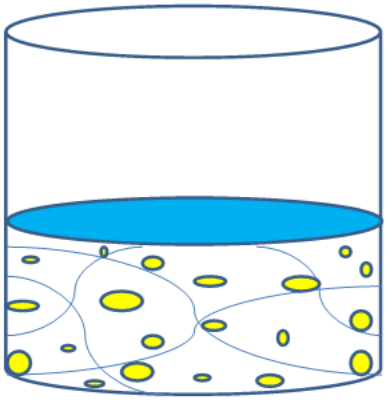


***Fig 1:- Gelling System***

Gelling agents are primarily composed of polysaccharides, large molecules derived from simple sugars like glucose, forming Three-dimensional structural net that results in a surface that is partly or completely solid. Examples of microorganisms capable of producing gelling agents include seaweeds and the bacterium Xanthomonas campestris.[4] The varied sources of gelling agents contribute to variations in their gelling characteristics. Apart from their use Gelling is a technique used to create thick or creamy textures in both food and cosmetics agents find applications in tissue culture, microbiology, and molecular biology.[5,6] In microbiology, solid media containing gelling agents are employed to cultivate and isolate bacteria and cells. In plant tissue culture, gelling agents offer support to plants and facilitate direct physical contact with nutrients, promoting growth. Additionally, gelling agents aid in plant transformation, facilitating the separation of successfully transformed plants. Various gelling agents are available in the market, such as agar, xanthan gum,

carrageenan, isabgol, GelRite (gellan gum) , and guar gum, each differing in composition, origin, and purity level.[7–10]

A table with the most often used gelling agents is shown below.

| Sr. No. | Types of Gelling Agent | Origin | Properties | Application |
|---|---|---|---|---|
| 1 | Agar | Rhodophyta<br>Nori (Porphyra spp.)<br>Dulse (Palmaria palmata)<br>Irish moss (Chondrus crispus)<br>Carrageenan (various species)<br>Gracilaria spp. | Gel-forming, vegetarian, stable, versatile, solidifying, microbiological, culture media, thickener, clarifying. | Microbiological culture media, food thickener, gel capsules, scientific research. |
| 2 | Xanthan Gum | E415<br>Pharmaceuticals (as a thickening agent in liquid medications) .<br>Oil drilling fluids.<br>Textile printing and dyeing.<br>Paints and coatings.<br>Adhesives and sealants. | Thickening, stabilizing, emulsifying, gluten-free, versatile, texture-enhancing, and pseudoplastic, suspending, binding. | Food thickener, stabilizer, emulsifier, gluten-free baking, industrial applications, cosmetics. |
| 3 | Gellan Gum (Gelrite) | E418<br>Microbiological media for culturing bacteria and other microorganisms in laboratories.<br>Pharmaceutical formulations to control viscosity and improve stability. | Gelling, stabilizing, thickening, versatile, vegan, texture-enhancing, clear formulations. | Gelling agent, stabilizer, thickener, in food, pharmaceuticals, and cosmetics. |
| 4 | Carrageenan | Irish moss<br>Pharmaceuticals as an ingredient in cough syrups and lozenges for its soothing properties.<br>Medical formulations such as wound dressings and gels for their ability to promote healing and provide moisture. | Gelling, stabilizing, thickening, plant-derived, versatile, food additive, binding. | Food stabilizer, thickener, gelling agent, vegan gelatin substitute, emulsifier. |
| 5 | Isabgol | Psyllium husk<br>Fiber Supplements.<br>Baked Goods.<br>Breakfast Cereals.<br>Gluten-Free Baking.<br>Thickening Agent. | Soluble fiber, laxative, absorbs water, relieves constipation, and promotes regularity. | Laxative, dietary fiber supplement, relieves constipation, promotes bowel regularity. |
| 6 | Guar gum | Guaran<br>Dairy Products.<br>Baked Goods.<br>Sauces and Dressings.<br>Beverages.<br>Gluten-Free Products.<br>Dietary Supplements. | Thickening, stabilizing, binding, emulsifying, gluten-free, versatile, soluble, hydrating. | Food industry, dairy, baking, sauces, beverages, pharmaceuticals, cosmetics, textiles. |

**Table 1:-** Materials that generate gels: their origins, properties, and applications

## 2. Pharmaceutical Gel:-

Gels are typically created by adjusting the viscosity of a liquid phase using various ingredients, often in addition to assistance from experienced Materials with a gel-like consistency are called gelling agents, like HPMC, Carbopol, carboxymethyl cellulose, among others. Alongside these gelling agents, stabilizers, antimicrobial

agents, and substances with anticancer properties are incorporated into gel formulations. The term "gel" originates from the Latin roots "gelatinous," meaning "icy and jelly,"signifying" firmly establish," reflecting the idea liquid transitioning into a solid yet pliable texture while retaining certain fluid properties. [11]

Described as semi-rigid structures, gels are characterized by a three-layered structure made of solvated particles dispersed phase it is possible for macromolecules to entwine debris that restricts an increase of dispersing automobile. In contrast to jams, gels are typically considered to be more rigid due to thicker physical bonds, increased covalent crosslinks, or decreased fluidity.[12] Polymers that form gels create materials with varying degrees of stiffness, ranging from sols to adhesives, jams, gels, and hydrogels as stiffness increases. [13] The transparency of gel structures can vary widely, ranging from almost complete transparency to turbidity, depending on the solubility or insolubility of internal chemicals, or the presence of aggregates that scatter light. [14–16]Gelling agents typically make up a small proportion of the overall formulation, usually falling within the range of 0.5% to 2.5%.[17,18]

**3. Benefits of gel compositions:**

Unlike traditional semisolid formulations, gel preparations offer several notable advantages.
1. The production of gels is simpler compared to other formulations.[19]
2. Gels feature an elegant texture that is non-greasy.
3. They demonstrate excellent adherence to the intended application site.
4. Gels are known for their biocompatibility and eco-friendly nature.
5. They exhibit impressive resilience even in demanding conditions.

**4. Disadvantages of gel formulation:**
While gel formulations offer various advantages, There are certain disadvantages to this strategy.[20]
1. Gelatinous materials often feature an increased steady additionally gradual mode of action.
2. Some individuals might experience irritation due to the gelators or additives present.
3. The inclusion of water in gels increases the susceptibility to microbial or fungal contamination.
4. The evaporation of solvent from the formulation can cause the gel to dry out.
5. Specific compositions may experience instability due to flocculation, leading to unstable gels.

Gelling agents, when scattered a suitable systems that are semisolid are created by means of mediums forming Three-dimensional structural net characterized by a significant level of bodily and which molecules bond with one another through chemical reactions.

**These agents encompass** [21]
1. Polyacrylic acid: Marketed as Synthalen (3V Sigma) and Carbopol (Lubrizol) .
2. Irish moss: Available as Viscarin by DuPont.
3. Chitosan: Sold under the brand Chitopharm by Chitinor.
4. Hydrolysed collagen: Marketed as Byco and Instagel.
5. E418: Offered as Kelcogel CG by CP Kelco.
6. Knee ligament: Available from CP Kelco.
7. Pluronic: Marketed as Kolliphor P (BASF) and Antarox F (Solvay) .
8. Oxide of polyethylene: Consists of poly (ethylene) oxide.
9. Polymer acrylic: Polyacrylic acid.
10. Polysaccharide: Sold under the brand Hayashibara Pullulan.
11. Supplementry components may include hydrocolloids, tragacanth, Ethyl hydroxyethyl cellulose, methyl-hydroxypropyl cellulose, cellulose methyl ether, salts of alginic acid, and carmellose sodium.

Skin gels are widely utilized as a preferred medication delivery system in both cosmetic and skin disease treatments due to their superior advantages over creams and ointments.[22] Organogels and hydrogels, the two common types, are formulated by mixing an active drug, solvent, gelator, and extra excipients.[23] Characteristics in these thickening agents, soluble agents, drugs, as well as supplements play a pivotal role in drug formulation and preparation.

Pharmaceutical gels are synthesized by blending a solvent and active ingredient Moreover, using a gelator referred to as a thickening agent. Gelators can range from Materials originating from natural sources, partially

derived from natural sources, and wholly synthetic materials are all included in the broad category of polymers to small molecules with a little molecular mass. These gels capable to employ Natural, inorganic, water-soluble, or a mix of these categories used to classify solvents as a dispersion medium.

Topical gels are administered onto the skin to serve as a vehicle for delivering active pharmaceuticals, either through direct contact or transport. pharmacological compounds that are now useful are conveyed in the direction of intended area via becoming entangled within The dimension of space structure of the gel.[24]

Gels exhibit distinctive properties such as swelling, syneresis, aging, stiffness, and rheology compared to other dosage forms. Essential parameters including appearance, odor, distribution, simplicity in extrusion, fluidity, degree of acidity, steadiness, susceptibility contamination by microbes, and potentials for absorption significantly Influence how topical gel compositions are developed. The components in reference to gel should enhance the mediacations capability to enter through the skin's surface. [25]
The formulation of the gel influences properties such as viscosity and consistency, which subsequently impact adhesion, retention, and distribution of the medication at the application site. [26] Components of topical gel formulations are typically four categories are used for categorization: solvents, gelators, excipients, and pharmaceuticals. [27]

**5. Varying gelling agent concentrations:-**

| Sr. no. | Thickening Agent | Dose used | Pharmaceutical Flexibility | Essential therapeutic component |
|---|---|---|---|---|
| 1 | Sodium Carboxymethylcellulose | 3-4 % | Sodium CMC enhances pharmaceutical formulations by serving as a versatile binder, stabilizer, and thickener. | Tantum |
| 2 | Carbopol 934 | 1% | Carbopol 934 exhibits excellent pharmaceutical adaptability due to its high viscosity, controlled release, and mucoadhesive properties in various dosage forms. | Adermykon |
| 3 | Carbopol 940 | 1% | Carbopol 940 offers pharmaceutical versatility as a widely used thickening, suspending, and stabilizing agent in various formulations. | Ponstel |
| 4 | HPMC | 2.5% | HPMC (Hydroxypropyl methylcellulose) exhibits versatile pharmaceutical adaptability due to its role as a controlled-release agent, binder, and viscosity modifier in various formulations. | Adermykon |
| 5 | Pluronic® F127 | 1-3 % | Pluronic® F127 exhibits pharmaceutical adaptability due to its thermoreversible gelation properties, making it suitable for controlled drug release and tissue engineering applications. | Feldene |
| 6 | Pemulen | 0.1-0.4 % | Pemulen is a pharmaceutical ingredient known for its versatility in formulating various topical and oral dosage forms, including gels, creams, and suspensions, due to its thickening and stabilizing properties. | Flurbiprofene |

**Table 2:- Different Concentrations of gelling agents.**

**6. Gelling and setting agents:-**

A variety of ingredients are employed to impart amplify the depth of savory and sweet tastes dishes, with various agents or combinations selected based on the intended function and usage of the dish. Different agents are utilized The selection changes for different types of confections, ice creams, soups, sauces, and desserts depending on the desired result.[28]

**7. Natural thickening agents:-**

These thickening agents were derived from natural sources and undergo minimal processing.

7.1. Egg Yolks: In terms of egg yolks, gently cooked using drinks that are dairy- or non-dairy-based, act Thickening happens in a similar way to how starch acts sauces alternatively custards additionally yielding a smooth, silk. Tempering is essential to prevent curdling, achieved by gradually incorporating hot liquid into egg yolks. [29]
7.2. Fruit juice: naturally includes pectin fruit The peels have a velvety feel, similar to citrus and guava fruit peels, and cherries, which helps naturally thickening fruit sauces or tart fillings.[30]
7.3. Pulses & Beans: The skin of most Pulses & Beans contains starch and thickening properties. Aquafaba, derived from chickpeas, serves as a popular vegan egg substitute. Slow heating of dal enables the skin to function in thickening being a part of the mixture. [31]
7.4. Cheese and Cream: Lipids in dairy products like cheese and cream contribute to the thickening of both savory and sweet dishes. Care should be taken to avoid overheating these ingredients to maintain their thickness.[32]

**8. Derived/Extracted Gelling Agents:-**

8.1. Fruit Pectin: Extracted from Peels from citrus and other fruits, fruit pectin activates in combination with a liquid at ambient temperature, commonly used in making fruit jams and jellies.[33]
8.2. Agar-Agar: Derived from seaweed, agar-agar exhibits excellent gelling abilities. It requires intense heating to activate and is available in various forms such as strips, flakes, or powder.
8.3. Carrageenan: Also derived from seaweed, carrageenan sets more slowly than agar-agar and is suitable for softer sets in dairy products like yogurts and ice creams.[34]

8.4. Gelatin: Extracted from animal skin and bones, gelatin sets at low temperatures and is widely used in setting jellies and desserts. It is available in sheet or powder forms.[35]

**9. Derived/Extracted Thickeners:-**

9.1. All-Purpose Flour: Commonly used to thicken sauces, flour is first combined with fat and then added to liquid, particularly in French and Italian cuisine.

9.2. Corn Flour/Corn Starch: This starch is frequently employed to thicken both sweet and savory dishes and activates when heated. However, it may not be suitable for highly sugary or citrusy liquids.

9.3. Starch Tapioca: Extracted from cassava root, tapioca starch has high thickening power and does not split when frozen, providing a superior mouth feel compared to corn starch.

9.4. Potato Starch: Purified potato starch activates when heated and is suitable for thickening soups, fruit sauces, or caramel without further cooking.[36]

9.5. Other Types of Gums and Chemical Thickeners/Gelling Agents:
Various gums and thickeners like alginates, Arabic resin, guar flour, E415, and gum made of cellulose are utilized in food for their thickening properties.

10. Utilization of Gel Products:
Gelatinous materials find application within both the healthcare and cosmetics sectors, serving various functions such as local action on skin or mucous membranes, long-acting drug implants, intramuscular injections, and as binders, thickeners, colloid protectors, and bases for pharmaceutical and cosmetic products.

**11. Applications of Gel Documentation Systems**:-

Methods for gel visualization indispensable tools within various areas of scientific research as well as application.

11.1. DNA and RNA Electrophoresis: These systems are vital for examining nucleic acids such as DNA and RNA. Through electrophoresis, DNA or RNA fragments are separated based on size. Researchers rely on these systems to validate PCR reactions, assess DNA sample quality and quantity, and identify genetic variations.

11.2. Electrophoresis of Proteins: Methods for gel imaging crucial involvement in proteomics by visualizing as well as quantifying proteins separated via SDS-PAGE. This allows researchers to analyze molar mass, excellence, as well as efficacy techniques for separating and purifying proteins

11.3. Western Blotting: Essential for protein analysis, Gel Documentation Systems capture images of western blots. Researchers utilize these images to study Interactome, verify immunoglobulin accuracy as well as to evaluate synthesis of proteins levels in fields like immunology and studies on cancer.

11.4. Molecular Profiling: methods for gel imaging are indispensable in genomics research for genotyping and DNA sequencing. They facilitate gene mapping, documentation, and analysis of DNA sequences, aiding in identifying genetic variants associated with traits or disorders.

11.5. Microbial Research: Microbiologists use Gel Documentation Systems to explore microbial diversity and ecology. By visualizing DNA fragments from environmental samples, researchers gain insights into microbial communities in various habitats, contributing to understanding microbial interactions and biogeochemical cycles.

11.6. Observation of Quality and Food Safety: methods for gel imaging are contribute to food hygiene and assurance by detecting foodborne pathogens, ensuring compliance with safety regulations, and investigating food composition and allergens.

11.7. Drug Development and Pharmaceutical Research: Pharmaceutical research relies heavily on Gel Documentation Systems for guaranteeing the purity and uniformity of pharmaceuticals, studying drug-protein interactions, and validating gene editing techniques.

11.8. Environmental Research: Environmental scientists utilize Gel Documentation Systems to monitor environmental changes, investigate biodiversity, and study microbial communities in extreme environments.

11.9. Medical Diagnostics: In medical laboratories, Gel Documentation Systems are used for clinical diagnostics, aiding in identifying cancer biomarkers, infectious diseases, and genetic abnormalities.

11.10. Education and Research: Gel Documentation Systems serve as essential educational tools in research institutes and educational settings, helping researchers and students learn molecular biology techniques and understand genetic principles and experimental procedures.

**12. Gel Electrophoresis Applications:-**

Recent research has placed significant emphasis on innovative gel-based drug delivery systems, highlighting their recent advancements and diverse applications. These cutting-edge systems have illustrated their efficacy in delivering medicinal substances with desirable attributes and functionalities, notably targeted selection. When compared to conventional drug delivery methods, they present a myriad of advantages, including enhanced drug loading, controlled release kinetics, biocompatibility, and enhanced patient adherence.[3]

Of particular interest is the responsive gel technology, especially within intelligent delivery systems, which has exhibited promising capabilities in responding to various stimuli such as pH, temperature, and enzymatic activity. This capability facilitates the precise and localized release of medicinal compounds at designated sites within the body. Despite the proven effectiveness of these systems in drug transportation, there remains untapped potential in exploring novel polymers to formulate distinctive gels, potentially reshaping the current landscape of drug delivery.

Furthermore, recent investigations have delved into the integration of plant extracts into the development of innovative delivery methodologies, resulting in the emergence of non-toxic medication delivery platforms. By incorporating natural compounds into formulations, these approaches offer a spectrum of environmental

benefits, aligning with the principles of green chemistry. The evolution of green synthesis techniques has led to the development of environmentally sustainable processes with minimal ecological footprint.[37]

Empirical evidence suggests that formulations synthesized through green technology outperform conventional systems in terms of efficacy and safety.[38,39] By circumventing the use of common hazardous chemicals and instead harnessing biocompatible and biological reagents, these approaches mitigate concerns related to toxicity inherent in traditional delivery systems. Nonetheless, further research is warranted to comprehensively elucidate the advancement and integration of green technology within drug delivery systems.[40]

**13. List of latest marketed Emulgels:-**

| Sr.no | Name of the Brand | Essential therapeutic component | Manufactured by | Year | Reference |
|---|---|---|---|---|---|
| 1 | Voltarel Emulgel | Diclofenac Diethyl ammonium | Novartis | 2007 | [41] |
| 2 | Diclomax Emulgel | Diclofenac Sodium | Torrent Pharma | 2007 | [42] |
| 3 | Miconaz-H-Emulgel | Miconazole nitrate, Hydrocortisone | Medical union pharmaceuticals | 1971 | [43] |
| 4 | Dermafeet emulgel | Urea | Herbitas | 2010 | [44] |
| 5 | Isofen Emulgel | Ibuprofen | Beit jala Pharmaceuticals | 2012 | [45] |
| 6 | Diclona Emulgel | Diclofenac Diethyl amine | Kuwait Saudi Pharmaceuticals | 2022 | [46] |
| 7 | Dosanac emulsion gel | Diclofenac diethyl ammonium | Siam Pharma | 2006 | [47] |
| 8 | Diclon Emulgel | Diclofenac diethyl amine | Med Pharma | 2021 | [48] |
| 9 | Denacin Emulgel | Clindamycin phosphate | Beit jala pharmaceuticals | 2015 | [49] |
| 10 | Avindo Gel | Azithromycin | Cosme pharmaceuticals | 2012 | [50] |

**Conclusion:-**

The review investigates the structural efficacy of medication gels, which serve as intricate frameworks where large natural particles disperse within a continuous phase, intermingling with flexible chains, while inorganic particles remain distributed throughout. Additional constituents are frequently incorporated to densify the fluid phase and form drug gels, with common gelling agents encompassing HPMC, Carbopol, and Sodium CMC. Key attributes of these gels encompass their ease of spreadability, crucial for effective skin treatment. Various physicochemical attributes of advanced gels, such as pH, consistency, spreadability, and drug content, are scrutinized, highlighting their promising potential as substitutes for cutaneous or transdermal therapies, notably in wound healing and mitigation.

The study chiefly accentuates recent strides Novel drug delivery methods based on gel compositions, underscoring its efficient conveyance of medicinal substances and advantageous traits like targeted delivery. In contrast to conventional methods, these systems offer benefits For instance heightened medication encapsulation, controlled discharge, biological compatibility, aas well as enhanced person comfort. Responsive gel technology, particularly in smart delivery systems, facilitates precise drug release triggered by stimuli like pH and temperature, augmenting their site-specific efficacy.

Furthermore, there lies potential in exploring novel polymers to fashion distinctive gels, thereby modifying existing compositions. Recent investigations also indicate the utilization of plant extracts in crafting non-toxic medication delivery methods, aligning with the tenets of green chemistry. Green technology obviates the necessity for harmful chemicals, yielding stable and biocompatible formulations. Further research is warranted

to comprehensively comprehend the evolution and application of green technology in pioneering drug delivery methodologies.

**Discussion:-**

Topical gels resemble jelly-like substances that contain liquid medicine within a solid framework. They are composed of special materials known as polymers, which act like small building blocks. These gels are valuable due to their unique intermediate state between liquid and solid. Think of them as a pudding that can hold medication!

In recent times, there has been growing interest in utilizing these gels across various sectors such as industry, research, and medicine. One significant advantage is their effectiveness in delivering drugs to specific areas of the body. Because they are neither entirely liquid nor solid, they can transport medication precisely where it's needed, much like applying cream to a sore spot on the skin. Understanding the versatility of topical gels is crucial for students and professionals as it showcases their diverse applications in different fields. It's akin to realizing how a single tool can serve multiple purposes. By familiarizing themselves with topical gels, individuals can innovate and devise novel solutions for various challenges.

**Conflict of interest:** - We affirm that we do not have any competing interests.

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