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Formulation and evaluation of curcuma longa nanosponges

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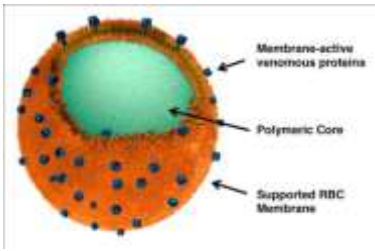
Introduction

Nano sponges are a fascinating class of nanomaterials characterized by their sponge-like structure, typically made from polymers, lipids, or other materials at the nanoscale (1-100)drugs, toxins, and other molecules. These nanostructures are gaining significant attention due to their versatile applications in fields like medicine, environmental remediation, and biotechnology.

They enhance the solubilisation capacity of both water-soluble drugs and lipid soluble drugs and also possess a spherical colloidal nature.They increase the bioavailability of drugs with prolonged drug release .Because of their internal hydrophobic chambers and exterior hydrophilic branching, Nanosponges' amphiphilic nature enables them to carry therapeutic molecules that are both hydrophilic and hydrophobic

The average diameter of a Nanosponge is below 1 micrometre but fraction below 500 nm can be selected .The Nanosponges could be either Para crystalline or in crystalline form. The loading capacity of Nanosponges depends on mainly degree of crystallization Para crystalline Nanosponges can show different loading capacities.



Advantages of Nanosponges

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1. Targeted site specific drug delivery.

2. Can be used to mask unpleasant flavours and to convert liquid substances to solid

3. Less harmful side effects (since smaller quantities of the drugs have contact with healthy tissue)

4. Nanosponge particles are soluble in water, so the Hydrophobic drugs can be encapsulated within the Nanosponge, after mixing with a chemical called an Adjuvant reagent.

5. Particles can be made smaller or larger by varying the Proportion of cross-linker to polymer.

6. Production through fairly simple chemistry called "Click chemistry" (methods for making the Nano sponge particle)

Disadvantages of Nano sponges:

1. Limited Molecular Weight Capacity:

- Nanosponges are primarily designed to encapsulate smaller molecules, with a molecular weight generally less than 500 Daltons.
- This limits their applicability for delivering larger molecules like proteins, enzymes, and antibodies, which are crucial in many therapeutic applications.

2. Dose Dumping:

- There's a risk of "dose dumping," where a large amount of the encapsulated drug is released rapidly rather than being released in a controlled manner.
- This can lead to ineffective therapy or even toxicity.
- Early dissolution of the crosslinked, which is used to create the Nano sponges, can contribute to dose dumping.

3. Drug Loading Capacity:

- The drug loading capacity of Nano sponges is affected by the degree of crosslinking.
- Higher crosslinking can reduce the void space available for drug loading.
- The degree of crystallization also affects drug loading.

4. Synthesis and Control Challenges:

- Precise control over the size and porosity of Nano sponges can be difficult, which can lead to variations in drug loading and release profiles.
- Variations in the synthesis process can influence the reliability and effectiveness of the drug delivery system.

5. Potential for Toxicity and Non-Biocompatibility:

- The materials used to create Nano sponges, such as polymers and cross linkers, could potentially be toxic or non-biocompatible.
- Undesirable by-products of degradation could also be a concern.

Why Nanosopnges?

1. Targeted Drug Delivery in Medicine

Nanosponges can be used to deliver drugs to specific parts of the body in a controlled way. They act like tiny "vehicles" that can carry medications, release them at a precise location, and help improve the effectiveness of treatments while minimizing side effects. For example, in cancer therapy, nanosponges could deliver chemotherapy drugs directly to tumor sites, reducing damage to healthy tissues.

2. Toxin Removal

In environmental science, Nanosponges can be engineered to absorb harmful toxins, chemicals, or heavy metals from water, air, or soil. This makes them useful for pollution control and cleaning up contaminated environments. They could be used to filter water or air in industrial processes or even during oil spills, absorbing pollutants before they spread.

3. Antibacterial and Antiviral Properties

Some nanosponges are designed to target bacteria or viruses, making them useful for disinfecting wounds or cleaning surfaces. Their structure allows them to "trap" microorganisms and prevent their growth or spread, providing an alternative to traditional antibiotics and helping to combat antibiotic resistance.

4. Wound Healing and Tissue Regeneration

Because nanosponges can be loaded with healing agents, they could be used in wound dressings or other medical treatments to accelerate tissue repair. They can be designed to release these agents slowly, which makes them ideal for long-term healing.

5. Versatility and Customization

Nano sponges can be tailored to perform very specific tasks, such as absorbing only certain types of molecules or interacting with particular environmental conditions. This makes them highly versatile and adaptable for different industries, from healthcare to environmental remediation.

6. Enhanced Drug Stability

Some drugs are unstable or break down too quickly in the body. Nano sponges can help encapsulate these drugs and protect them from degradation, allowing for longer shelf life and more effective treatments.

Application of Nanosponges:

1. Drug Delivery and Controlled Release

- **Cancer Treatment**: They can deliver chemotherapy drugs directly to cancer cells, reducing side effects by limiting the exposure of healthy tissue to toxic drugs.
- **Antibiotics Delivery**: Nano sponges can also be used for targeted antibiotic delivery, especially in treating bacterial infections where local, high concentrations of antibiotics are needed.
- **Insulin Delivery**: For diabetes, Nano sponges have been researched for their potential in delivering insulin in a controlled manner, mimicking the body's natural insulin release patterns.

2. Cosmetic and Skincare Product:

- **Anti-aging products**: Nano sponges help deliver anti-aging compounds (like retinol or hyaluronic acid) deeper into the skin.
- **Sunscreens**: They can also be used to encapsulate UV filters and provide more consistent protection against the sun.

3. Environmental Clean-up:

- **Oil Spill Clean-up**: Nano sponges can absorb large amounts of oil, offering a potential solution for cleaning up oil spills in water bodies.
- **Removal of Heavy Metals**: They can also adsorb heavy metals such as lead or mercury from polluted water, which could be especially valuable in areas with industrial contamination.

4. Food and Agriculture

- **Pesticide Delivery**: Nano sponges can encapsulate pesticides and herbicides, ensuring that they are released gradually, which can improve crop yield and reduce the need for frequent application.

- **Food Preservation**: Nano sponges are being explored for the controlled release of preservatives, reducing spoilage in food products.
- **Nutrient Delivery**: They could be used to deliver vitamins, minerals, or other nutrients to crops in a controlled manner, ensuring better growth.

5. Imaging and Diagnostic Application

- **Magnetic Resonance Imaging (MRI)**: Nano sponges can be used as contrast agents in MRI to improve the visibility of certain tissues or cells.
- **Fluorescent Imaging**: They can encapsulate fluorescent dyes, enabling more sensitive and precise detection in diagnostic applications.

6. Gene Therapy.

- **CRISPR-Cas9 Delivery**: Nano sponges can be used to deliver CRISPR-based gene-editing tools to targeted cells for precision medicine.

7. Textile Industry

- **Self-Cleaning Fabrics**: Nanosponges can be integrated into fabrics to impart properties like **self-cleaning** or **antimicrobial resistance**, useful for clothing, hospital uniforms, and industrial materials.
- **Waterproofing**: Nanosponges can also enhance the water-resistant properties of fabrics.

8. Antimicrobial Applications

- **Wound Healing**: Nanosponges can be designed to release antimicrobial agents in a controlled manner, providing protection from infections in wounds or burns.
- **Surface Coatings**: They can be applied to surfaces (like medical equipment or textiles) to prevent the growth of harmful bacteria or fungi.

9. Neuroprotective Drug Delivery

The brain's **blood-brain barrier (BBB)** is one of the biggest challenges in drug delivery for neurological diseases. Nano sponges are being researched as carriers that can pass through this barrier to deliver drugs directly to the brain.

- **Parkinson's and Alzheimer's Diseases**: They can potentially be used to deliver therapeutic agents directly to brain tissues, enhancing treatment for neurodegenerative conditions.

Nanosponges of Curcumin:

Curcumin is the active compound found in **turmeric**, a yellow spice that is widely used in cooking, particularly in Indian and Southeast Asian cuisines. It's known for its potential health benefits, many of which stem from its anti-inflammatory and antioxidant properties. Here are some common uses of curcumin:

1. Anti-inflammatory Benefits:

- Curcumin is often used as a natural remedy for chronic inflammation, which is linked to various health conditions like arthritis, heart disease, and even cancer.
- It may help reduce symptoms of inflammatory diseases, such as rheumatoid arthritis and osteoarthritis.

2. Antioxidant Effects:

- Curcumin acts as a powerful antioxidant, neutralizing free radicals that can cause oxidative damage to cells and tissues. This can help reduce the risk of chronic diseases and slow down the aging process.

3. Supporting Brain Health:

- Some studies suggest that curcumin may help improve brain function, including boosting levels of a brain-derived neurotrophic factor (BDNF), which plays a role in cognitive function and memory.
- It's also being studied for its potential to help in neurodegenerative diseases like Alzheimer's.

4. Digestive Health:

- Curcumin can aid in digestion and is sometimes used to relieve bloating or indigestion. It may also help reduce the symptoms of conditions like irritable bowel syndrome (IBS).

5. Cancer Prevention and Treatment:

- Some research suggests that curcumin may have anti-cancer properties by influencing the growth of cancer cells, inhibiting angiogenesis (formation of new blood vessels), and blocking the spread of tumors.
- However, these benefits are still under investigation, and more clinical trials are needed.

6. Skin Health:

- Curcumin has been used topically in skin care products for its anti-inflammatory, antioxidant, and anti-aging properties.
- It’s sometimes used in creams and masks for acne, psoriasis, or general skin irritation.

7. Pain Relief:

- Due to its anti-inflammatory properties, curcumin is often included in natural pain relief supplements or taken to alleviate joint pain.

8. Cardiovascular Health:

- Curcumin may help improve heart health by reducing cholesterol, preventing plaque buildup, and improving blood vessel function. It's being studied for its potential to reduce the risk of heart disease.

Need of Present Investigation

The **present investigation into Nanosponges** (especially in drug delivery systems, including the use of curcumin) is an evolving and highly dynamic area of research. Nanosponges are gaining attention because of their unique properties, such as **high surface area biocompatibility**,**controlled release**, and **targeted delivery**, all of which make them ideal for therapeutic applications. Here's a breakdown of the **current need and importance** for further investigation in this field:

1. Improving Drug Bioavailability

2. Targeted Drug Delivery

3. Sustained/Controlled Release of Drugs

4. Stability of Bioactive Compounds

5. Nano toxicity and Safety

6. Personalized Medicine

7. Encapsulation of Multiple Drugs

8. Wound Healing and Tissue Regeneration

9. Regulation and Standardization

10. Integration with Other Therapeutic Strategies

11. Environmental Considerations

Objective:

They are improving stability, bioavailability, and solubility of therapeutic agents or drug provide the desired pharmacokinetic effects. Realization and application of systems, structures and devices with novel function obtained via precursor nanoparticles is emphasized. Approaches may include has follow,

a. Gas
b. Liquid
c. Solid
d. Vacuum based process
e. Size reduction
f. Chemical and bio-self-assembly.

Plan of work:

1. Collection of plant material
2. Extraction From leaves
3. Preformulation Studies
a. Organoleptic Properties
b. Determination the pHc.
c. Phytochemical Test Performed
- Test for alkaloids
- Test for Glycoside
4. Fluorescence of behaviour of drug extract

5. Characterisation of extract

Determination total ash

1. Determination water soluble Ash

2. Determination Acid insoluble Ash

6. Determination of LOD [loss on drying]

7. Determination of solubility

8. Determination refractive index

9. Determination of Melting point

10. Determination of Extractive value :

❖ Alcohol Soluble Extractive Value

❖ Water Soluble Extractive value

11. Identification Test:

a) Ultra violet

b) Infrared radiation.

c) DSC (Differential Scanning Calorimetry

12. Calibrations Curve of turmeric extract in methanol. 13

13. Drug –Excipient compatibility studies:

a) Visual observation

b) Infrared spectroscopy

14. Formulation of Nano sponges.

15. Evaluation of Nano sponges

16. Formulation and Evaluation of Turmeric extract Nano sponges gel

1. Stability study

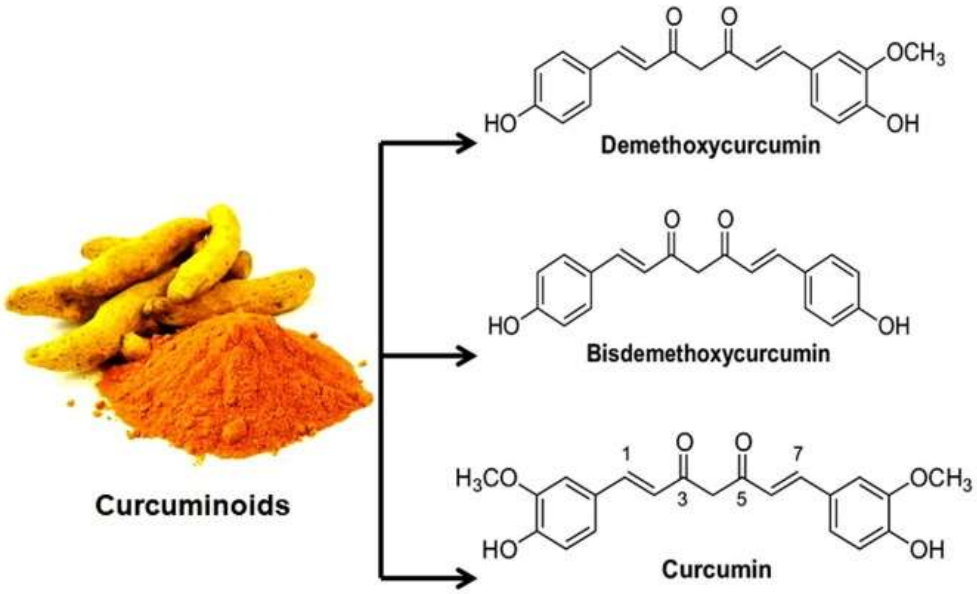
17. Result and interpretation

18. Report writing. Compilation and binding.

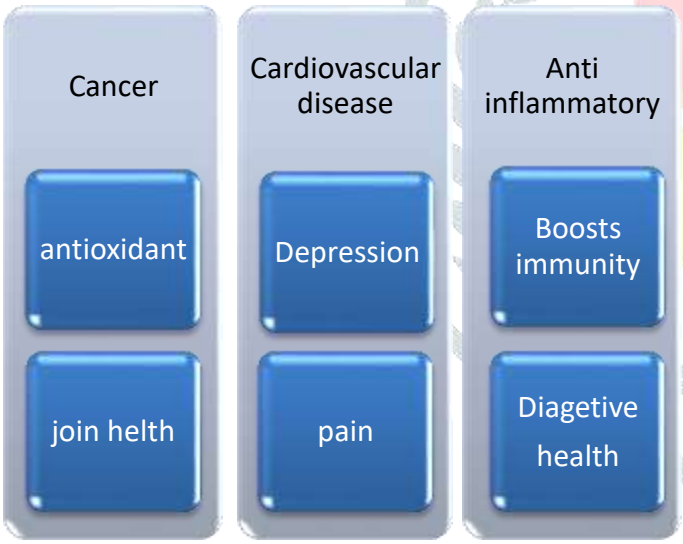
Table no.1

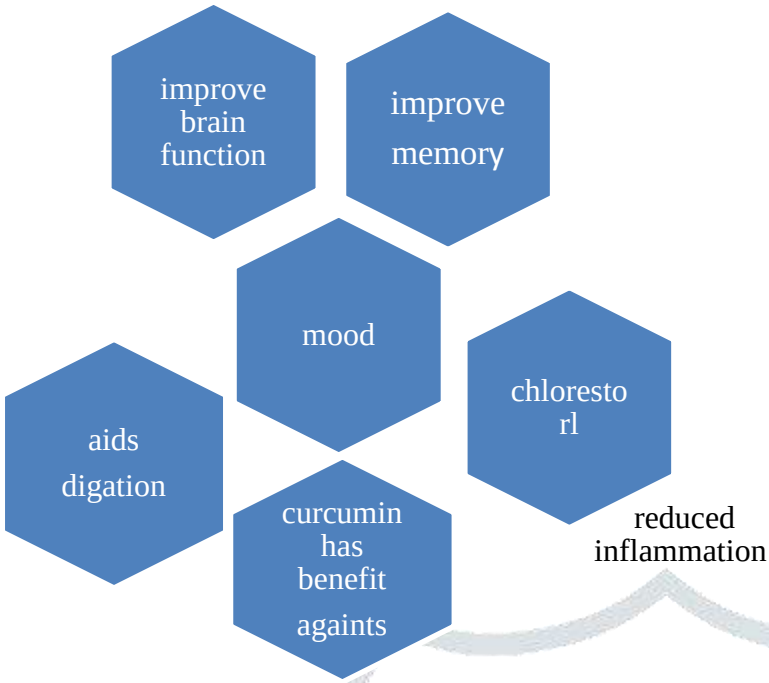
Sr.no	Activity	Periods(in days /months)
1.	Literature survey	15 days
2.	Selection of drug &excipients	15days
3.	Procurement of drug excipient	1 month
4.	Preformulation studies	1 month
5.	Formulation & evaluation of Nano sponges & suitable dosages form.	45 days
6.	Stability studies and in vivo studies	1 month
7.	Data compilation and report writing	15 days

Drug Profile



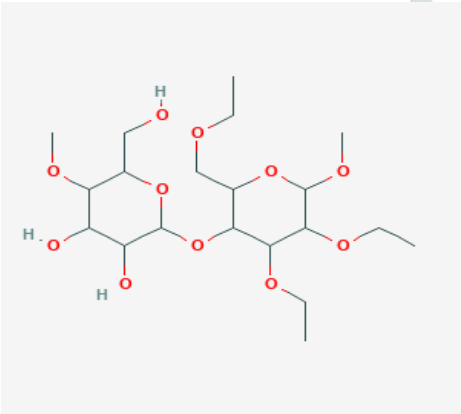
Use of Turmeric





Excipient Profile:

1. Ethyl cellulose



IUPAC Name: Ethyl cellulose

Molecular Formula: $(C6H7O2)_n(C2H5)_n$

CAS Number: 9004-57-3

Molecular Weight: Varies based on the degree of substitution, typically ranges between 50,000 and 150,000 g/mol.

Appearance: White to off-white powder or granular form

Solubility: Insoluble in water but soluble in organic solvents such as ethanol, acetone, chloroform, and ether.

Viscosity: Varies depending on the molecular weight and grade of the product.

Boiling Point: Decomposes before boiling.

Uses of ethyl cellulose:

1. Encapsulating curcumin

2. Bioactive compound in turmeric

3. Improving its stability, solubility, and bioavailability

- For example, curcumin-chitosan nanoparticles can be encapsulated in ethyl cellulose patches for managing inflammation via skin delivery.
- ethyl cellulose-based patches containing curcumin-chitosan nanoparticles for managing inflammation via skin delivery.

Pharmaceutical Applications

Agent:

Ethyl cellulose is used to coat pills and tablets, providing a protective barrier and aiding in controlled drug release.

Binder:

It acts as a binder in pharmaceutical formulations, helping to hold ingredients together.

Taste Masking:

It can mask the taste of unpleasant medications.

Film Former:

Ethyl cellulose forms films, which can be used for various purposes, including drug delivery systems.

- **Microencapsulation:**

Ethyl cellulose is used for microencapsulation, which is a process of coating small particles with a protective layer

Food Industry:

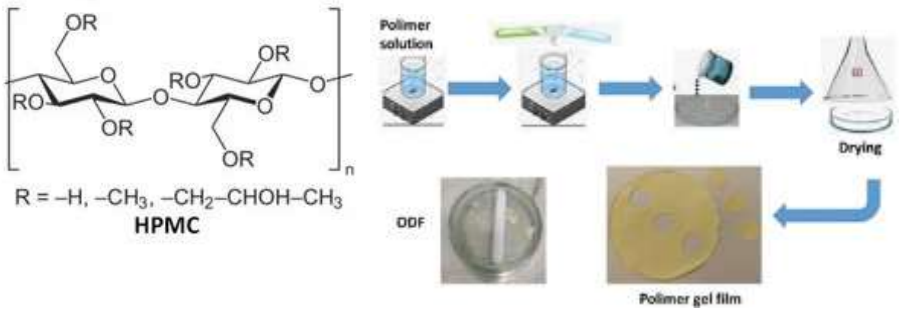
- **Thin-film coating:** Used as a thin-film coating in food packaging.
- **Emulsifier:** It acts as an emulsifier in food products.
- **Thickener:** It can be used as a thickener in certain food applications.

Other Industries:

- **Cosmetics:** Used as a thickener, fragrance stabilizer, and film former in cosmetics and personal care products.
- **Printing Inks:** Used in printing inks for its film-forming properties.
- **Paper Coating:** Used as a thin-film coating material for coating paper.
- **Textiles:** Used in textile applications, such as coatings and finishes.
- **Electronics:** Used in battery technology for electrolyte membranes.
- **Photographic Film:** Used in the production of photographic film, acting as a protective coating.

Construction: Enhances water retention and workability in cement mixtures.

2. Hydroxyethyl Cellulose



IUPAC Name: Methyl (2-hydroxypropyl) cellulose

Molecular Formula: (C6H7O2(OH) x)(C3H7O2) x

CAS Number: 9004-65-3

Molecular Weight: Varies depending on the degree of substitution (typically between 30,000 – 200,000 g/mol)

Appearance: White to off-white powder or granular form

Solubility: Soluble in cold water, but insoluble in hot water

Viscosity: The viscosity can vary depending on the grade, ranging from low to high, making it suitable for a wide variety of formulations.

pH: Neutral (typically around 6 to 8)

Boiling Point: Decomposes before boiling.

Uses of HPMC

1 . It is water soluble cellulose ether

2 .It is used as a thickener, emulsifier, stabilizer

3 .Used in turmeric powder formulation particularly curcumin based on to enhance solubility, improve bioavailability, & controlled release of the active ingredient.

E.g. Solid Depressions: HPMC is can be used to create solid dispersion of curcumin, which amorphous system that improve solubility

4. Its used for sustained or targeted drug delivery

5. Hpmc can also dissolved in water- oraganic solvent and mixed solvent

Applications of HPMC

1. Improving Solubility and Bioavailability

2 .Controlled Releases

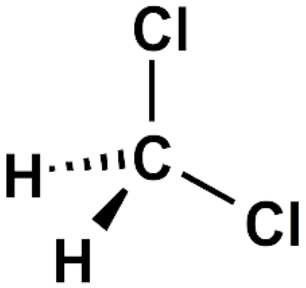
3. Solid Dispersions

4 .Pharmaceutical Formulations

5. Food Products

6 . Cosmetics

3. Dichloromethane:



- IUPAC **Name**: Dichloromethane
- Molecular **Formula**: CH_2Cl_2
- Molecular **Weight**: 84.93 g/mol
- CAS **Number**: 75-09-2

- Boiling **Point**: 39.6°C (103.3°F)
- Melting **Point**: -96.7°C (-142°F)
- Solubility: Slightly soluble in water, but highly soluble in organic solvents like ethanol, ether, and chloroform.
- Vapour **Pressure**: 350 mmHg at 20°C

Uses of Dichloromethane in Turmeric

1. Dicholromethane used as the solvent to dissolve and extact curcumin from turmeic rhizomes.

2. Curcumin is not soluble in water or ether.

3.It can be dissolved in organic solvent like dichloromethane.

4. Besides dichloromethane, other solvents like ethanol, acetone, and methanol are also used in the extraction of curcumin and other turmeric components.

5. In Thin Layer Chromatography dichloromethane can be used with methanol as a mobile phase to separate and identify curcuminoids.

6. The yellow pigment responsible for the color of turmeric, from turmeric rhizomes.

Applications DCM:

1. Solvent in Industrial Processes

- **Paint Remover and Strippers**: DCM is widely used in paint removers and strippers, as it effectively dissolves a variety of coatings, resins, and paints, making it a go-to solution for stripping surfaces.
- **Cleaning Agent**: It is used for cleaning and degreasing equipment, especially in industries like electronics, automotive, and manufacturing, due to its ability to dissolve oils, greases, and fats.
- **Solvent in Chemical Synthesis**: DCM serves as a solvent in various chemical reactions, such as in the synthesis of pharmaceuticals, plastics, and agrochemicals.

2. Pharmaceutical and Biotech Industry

- **Extraction Solvent**: In pharmaceutical industries, DCM is used in **extraction** processes, particularly for isolating compounds from natural sources, like extracting alkaloids from plants or separating active pharmaceutical ingredients.
- **Drug Formulation**: DCM is used in the preparation of certain drug formulations and as a solvent for **lipid-based drug delivery systems**, like liposomes, due to its ability to dissolve both hydrophobic and hydrophilic substances.

3. Laboratory and Research

- **Chromatography**: DCM is used in **liquid chromatography** (LC) as a mobile phase solvent for separating compounds, due to its excellent solvating properties for organic compounds.
- **Sample Preparation**: It's commonly used to prepare samples for **spectroscopic** or **analytical testing**, particularly in gas chromatography (GC) and mass spectrometry (MS).

4. Aerosol and Propellants

- DCM is sometimes used as a **propellant** in aerosol products, such as spray paints, deodorants, and insecticides, due to its low boiling point and ability to evaporate quickly.

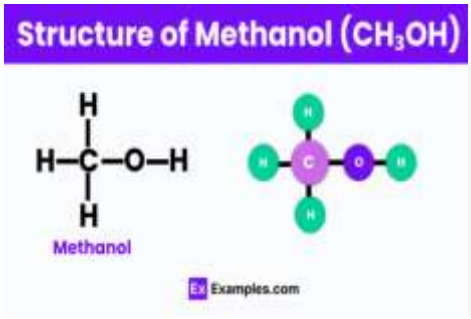
5. Foam Blowing Agent

- DCM is used in the production of **foam materials**, like polystyrene and polyurethane foams, where it acts as a **blowing agent**. It is also used in the production of insulating materials and packaging.

6. Extraction of Essential Oils

- In the food and beverage industry, DCM is used for **decaffeination of coffee** and **tea**, as well as in the extraction of essential oils from plants. It is preferred in decaffeination because it selectively removes caffeine without significantly affecting the flavor of the beverage.

4. Methanol :



Generic Name: Methyl Paraben
Chemical Name: Methyl 4-hydroxybenzoate
CAS Number: 99-76-3
Molecular Formula: C8H8O3
Molecular Weight: 152.15 g/mol

- **Uses of methanol:**

1. Methanol can be used as a solvent to extract curcumin from turmeric powder

2. it's a source of the bioactive compound curcumin, and methanol can be used to extract curcumin from turmeric powder.

- **Applications of methanol:**

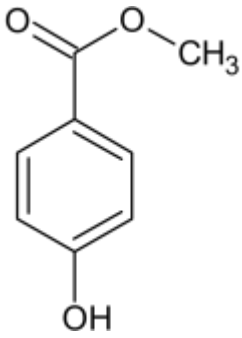
1. Antioxidant activity

2. antibacterial activity

3. Other biological activity

4. HPLC analysis

5. Methyl Paraben:



Generic Name: Methyl Paraben

Chemical Name: Methyl 4-hydroxybenzoate

CAS Number: 99-76-3

Molecular Formula: C8H8O3

Molecular Weight: 152.15 g/mol

- **Uses of Methyl Paraben:**

1. Methyl Paraben is widely used as the antimicrobial activity.

2. It's used as the turmeric gel formulation.

3. Methyl paraben is an anti-fungal agent often used in a variety of cosmetic & personal care product.

4. It's also used as food preservative.

- **Applications of methyl paraben:**

1. Often mixed with propyl paraben and dissolved in propylene glycol before being added to the aqueous phase of the gel.

2. Cosmetics and Personal Care Products: Methyl paraben is frequently used in shampoos, lotions, creams, deodorants, and makeup products to prevent the growth of mold, bacteria, and yeast, which can spoil the product. It helps extend shelf life and maintain the safety of these products.

3. Pharmaceuticals: In pharmaceutical formulations, methyl paraben acts as a preservative to prevent contamination of liquid medications, eye drops, and other formulations.

4. Food and Beverages: It is sometimes used as a preservative in processed foods and beverages, though it is less common compared to other preservatives. It inhibits microbial growth, which helps prevent spoilage and extends the shelf life of the products.

5. Household Products: Methyl paraben can also be found in cleaning products, air fresheners, and other household items, where it helps to prevent microbial contamination.

6. Industrial Uses: Methyl paraben is used in some industrial applications, such as in the production of plastics, as a stabilizer to prevent degradation of the material over time.

7. Biocides and Pesticides: It has been used as a component in certain biocidal products due to its antimicrobial properties.

6. Propyl Paraben:

Generic Name: Propyl Paraben

Chemical Name: Propyl 4-hydroxybenzoate

CAS Number: 94-13-3

Molecular Formula: C10H12O3

Molecular Weight: 180.21 g/mol

- **Uses of Propyl Paraben:**

1. Proyl paraben is commonly used as a preservative.

2. Its main function is to prevent the growth of harmful bacteria, mold, and yeast, extending the shelf life of these products.

3. **Cosmetics and Personal Care**: Propyl paraben is often found in products such as lotions, shampoos, deodorants, and makeup. It helps prevent microbial contamination and maintain the stability of the product.

4. **Pharmaceuticals**: It is used in medications, especially in topical treatments like creams and ointments, to prevent bacterial and fungal growth.

5. **Food**: In the food industry, propyl paraben can be used as a preservative, though it's more commonly replaced by other substances in food products.

6. **Household Products**: It can be found in some cleaning products and detergents to prolong shelf life.

- **Applications of Propyl Paraben:**

• **Shampoos and Conditioners**: Prevents microbial contamination, extending the shelf life of the product.

• **Lotions and Creams**: Ensures the stability and longevity of these products by preventing the growth of harmful microorganisms.

• **Deodorants and Antiperspirants**: Used to prevent bacterial growth that can cause odor.

• **Makeup**: Keeps products like foundation, mascara, and lipstick safe from contamination and degradation.

• **Sunscreens**: Helps preserve the active ingredients in sunscreens, ensuring their effectiveness over time.

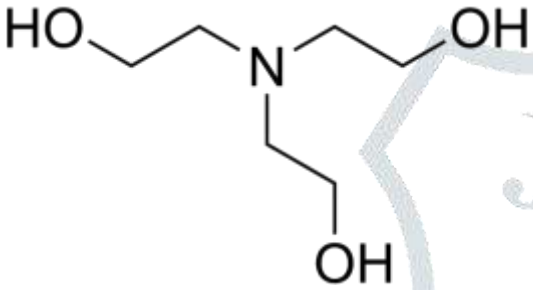
• **Topical Medications**: Often included in creams, ointments, and gels to prevent microbial growth, ensuring the product remains safe and effective throughout its use.

- **Liquid Medications**: Sometimes added to liquid formulations to avoid microbial contamination, especially in multi-dose containers.

- **Cleaning Products**: Propyl paraben may be added to detergents, disinfectants, and surface cleaners to prolong the shelf life by preventing microbial contamination.

- **Air Fresheners**: Used to prevent bacterial growth in aerosol sprays and other air-freshening products.

7. Triethanolamine:



Chemical Name: Triethanolamine

Other Names: TEA, Trihydroxyethylamine

Chemical Formula: $C_6H_{15}NO_3$

Molecular Weight: 149.19 g/mol

CAS Number: 102-71-6

- **Uses of tea:**

Emulsifying Agent: Triethanolamine is used in topical pharmaceutical formulations to help stabilize emulsions, such as in creams, ointments, and lotions. It keeps oil and water phases together, preventing separation.

- **pH Adjuster**: It is commonly used to adjust the pH of formulations, especially in skin care products, to ensure the product remains at an ideal pH for skin compatibility.

- **Solubilizing Agent**: TEA can be used to improve the solubility of certain active ingredients, ensuring better bioavailability in topical formulations.

• **Toxicity**: Ingesting large amounts of triethanolamine can be toxic. Ingested TEA may cause gastrointestinal irritation and other systemic effects. However, as a topical agent, it is generally regarded as safe at low concentrations (typically less than 5% in cosmetics and pharmaceutical products).

• **Skin Irritation**: TEA can cause skin irritation or allergic reactions in sensitive individuals, especially at higher concentrations. Prolonged exposure may lead to dermatitis in some people.

• **Eye Irritation**: It can cause moderate to severe eye irritation if it comes into direct contact with the eyes.

• **Carcinogenicity**: There is no strong evidence to suggest that triethanolamine is carcinogenic. However, it can react with certain ingredients to form potentially harmful substances like nitrosamines, which have been associated with cancer in animal studies.

Pregnancy Category: Generally considered safe for topical use, but caution is advised during pregnancy, especially if absorbed in significant amounts.

- **Applications tea:**

• Emulsifier: TEA helps blend oil and water-based ingredients in creams, lotions, and ointments, preventing separation.

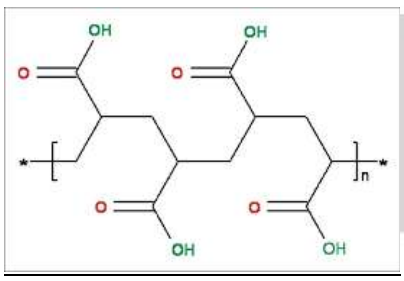
• pH **Adjuster**: It is used to adjust the pH of cosmetic formulations to ensure the product is gentle and effective on the skin.

• Surfactant: In shampoos, conditioners, and body washes, TEA acts as a surfactant that helps remove dirt and oils from the skin and hair.

• Hair **Care Products**: TEA is used to formulate shampoos, conditioners, and hair gels, as it helps in stabilizing formulas and enhancing texture.

• Skin **Care Products**: In face creams, body lotions, and sunscreens, TEA helps stabilize emulsions and ensures the smooth application of the product.

7 . Carbopol 934:



• **Name**: Polyacrylic acid (Carbopol 934)

• **Molecular Formula**: $(C_3H_4O_2)n$

- **Molecular Weight**: High molecular weight, typically ranging from 1 million to 5 million Daltons.

- **Appearance**: White to off-white powder.

- **Solubility:** It is insoluble in water, but forms gels when mixed with water, especially in an alkaline pH range.

Uses of Carbopol:

1. Used as an exicipient in drug formulations.

2. Main function of carbopol is soak the water.

3. **Suspensions and emulsions**: Carbopol 934 is often used in the preparation of topical formulations like gels, creams, and ointments. It helps in stabilizing suspensions, improving the viscosity of liquids, and ensuring uniform distribution of active ingredients.

4. **Controlled-release formulations**: Due to its ability to form gels, it is used in the preparation of **controlled-release oral dosage forms**. The polymer can slow the release of

active pharmaceutical ingredients.

5. **Topical products**: Carbopol 934 is used in gels for topical drug delivery systems, such as for **anti-inflammatory creams, antiseptic gels, and other dermatological formulations**.

Applications of Carbopol 934:

- Topical pharmaceuticals (gels, creams, ointments)

- Controlled-release oral formulations

- Suspension formulations

- Hydrogels for wound care

- Cosmetic products (lotions, creams, shampoos, etc.)

- Food thickener and stabilizer

- Industrial applications (paints, coatings, cleaning products)

- Lubricating gels in medical devices

Review of Literature:

1. Kumar L. et. (2010): concluded that topical gel prepared from natural polymer having good spread ability extrudability and bio adhesive strength. From the vivo drug diffusion study they concluded that the gel prepared from the natural polymer, controls the release of drug for longer period of time which would be helpful to avoid the more fluctuation and also might easily in reduction of the cost therapy.

2. B. Dinesh kumar et. al.(2011): Concluded that Mahanimbinepossess anti- hyperglycaemic, anti-lipid emic and beneficial effect in the management of diabetes associated with abnormal lipid profile and related cardio vascular complications.

3. Manvi M. et. al (2013): Carried out work on antimicrobial efficacy of Murray aKoenig (Linn) spring root extracts. They have concluded that the root extract in organic solvent (hexane,methanol,chloroform) showed good antimicrobial activity. However, aq. Extracts could not exhibit any activity.

4. Sharma R. et. al. (2015): have developed sustained released topical drug delivery system of econaozole nitrate as a Nano sponges hydrogel which offered solubilizing matrix and served as depot for sustained drug release and in turn provided rate limiting matrix barrier for release of drug .

5. Harishet. al.(2016): reviewedMurrayakuenigii following the traditional and folk claims very little efforts have been made by researchers to explore the therapeutic potential of this plant.

6. ThilahgavaniNagappan et.al. (2018) : revealedthe bioactive potentials of Carbazolealkaloids from Murray konini where, machine and mahanimbicineinhibited antibiotic resistant bacteria and Mahanimbine was found to significantly suppress the proliferation of MCF -7 cells.

7. Ansari K. A. et. al. (2022) :carried out the work to increase the solubility and stability permeation of resveratrol by cyclodextrin based Nano sponges. This study was aimed at formulating complexes of resveratrol with β- cyclodextrinNano sponges in different Wight ratios.

8. Salem HF. et. al. (2022) : This work suggests the silver nanoparticle particle of the size ranging from 5-50 nm & their solution are stable over a wide range pH. The nanoparticles show high anti-bacterial and antifungal effect.

9. Manoj .K. M. et. al. (2023): It can be concluded that methyl substitution at terminal hydroxyl group and methyl at R6 position are have better binding interactions with enzyme Neuraminidase when compared to Zanamivir. Even by considering the ADME & T profile, respective analogs are have better profilewhen compared to other analogs.

10. Satish et.al. (2024) : has concluded that crude powder of clurry leaves are dark in colour with chaeracteristic odour and tasteless. The crude powder and extracts of curry leaves are free from heavy metal and microbial contamination. The alkaloids are present with varying degree in clurry leaves.

11. Raja C. N. et. al (2024) : formulated Nano sponges loaded with ciprofloxacin antibiotic resulted in sustained drug release. Between all the batches from F1 to F9 ; the F6 batch was considered as the best batch

.Materials and Methods:

Materials and Equipment:

Materials use like drug, polymers, excipients and chemical required for the present work from different sources. Following materials were used for the formulation and evaluation off nanosponges and gel.

Table No 2 : List of drug , Excipients , Polymers and solvent

Sr. no	Drug/ Polymer/Excipients/solvent	Manufacturer
1.	Dichloromethane	S .D. Lab Chem. Mumbai
2.	Ethanol	S. D. Lab Chem. Mumbai
3.	Carbopol 934	Research –lab Fine Chem. Industries, Mumbai
4.	Methyl Paraben	LobaChemiePvt. Ltd, Mumbai
5.	Propyl Paraben	LobaChemiePvt. Ltd, Mumbai
6.	Triethanolamine	Research –lab Fine Chem. Industries, Mumbai

Equipment Uses:

Table No. 3: List of Equipment with model/ company name.

Sr. No	Name of Equipments	Model/ Company name
1.	Electronic Balance	Contech Instrument Ltd, Navi, Mumbai
2.	U.V. Visible Spectrophotometer	Jasco V-730 Spectrophotometer
3.	IR Spectrophotometer	Jasco FTIR - 4600
4.	Magnetic Stirrer	Remi Electronic Ltd, instrument Vasai 401208.
5.	pH meter	Lab India SAD -5000 Labline
6 . Diffusi**o**n cell Dolphin Instrument**,** Mumbai		

Experimental Methods:

A. Collection Plant Martials: Turmeric's biological source is the dried rhizome of the plant Curcuma longa. Family- Zingiberaceae.

B. Authentication of Plant Material:

The authentication of leaves was done from Department of Botany, Ministry of Environment forest & Climate Change Botanical Survey of India Western Regional Centre / 7- Koregoan road Pune.

Extraction from leaves:

The crude leaves extract was prepared by Soxhlet extraction method. The dried powder of curcuma longa was crushed in mixer & 50 gm powder of curcuma longa was extracted with 250 ml methanol. This process of extraction was continued till the solvent in siphon tube became colourless. The excess solvent was evaporated. The extract stored in sterile container.

D. Per formulation Studies:

A) Characterization of Turmeric extract:

a. Organoleptic properties:

Turmeric extract was evaluated for its organoleptic properties such as colour, odour, &taste.

b. Determination of pH:

Turmeric powder was dissolved in distilled water and was kept in water bath for 20min, filtered & checks the pH

Phytochemical Tests performed:

Test for alkaloids

1. Hager's test: To 2-3gm extract, a 1ml Hager's reagent was added in test tube.

2. Wagner's Test: To a 1 ml of filtrate, few drops of Wagner's reagent are added by the side of the test tube.

Test of Glycoside:

1. Molish test: To 2-3 ml extract was treated with 2 drop of α naphtol solution in test tube & then conc. Sulfuric acid was added carefully along with test tube.

Proteins and amino acids:

1. Millions Test – 3ml of test solution mixed with 5ml of millions reagents was added in a test tube. White precipitate obtained precipitate was warmed.

Determination of total ash:

The total ash value of crude powder of curcuma longa was determined by incinerating 2g of accurately weighted crude powder in a silica crucible. It was incinerated in a muffle furnace at a temperature not exceeding 450 C until free from carbon, then cooled and weighed.

1. Determination of water soluble ash:

The total ash obtained was boiled with 25ml of distilled water for 5 min .The insoluble matter was collected on an ash less filter paper, washed with hot water and ignited to constant weight at allowed temperature. The weight of insoluble matter was subtracting from the weight of total ash .The difference in weight represent the water soluble ash. The percentage of water soluble ash with reference to the air dried drug was calculated.

2. Determination of acid insoluble ash:

The ash obtained in the above method was boiled with 25 ml of dilute Hydrochloric acid for 5 min. The residue was collected on ash less filter paper and washed with hot water, ignited, cooled and weighed. The percent of acid insoluble ash with reference to air dried drug was calculated.

3. Determination of loss on drying:

The loss on drying was determined by weighing 2 g of crude powder of Curcuma longa in an evaporating dish and then dried in an oven at 105°C till constant weight was obtained and loss on drying was calculated. The percent loss on drying was calculated on the basis of sample taken initially.

4. Determination of refractive index:

Refractive index of Curcuma longa extract was determined at room temperature by using Abbe's type refractometer.

5. Determination of melting point:

Determination of the melting point of Curcuma longa extract involves using a micro-controlled based melting point apparatus. The process includes inserting the sample into a capillary tube with one end closed, then placing the capillary in a silicone oil bath. The oil bath is heated in a controlled manner using an electric heating coil. The temperature at which bubble formation occurs is recorded as the melting temperature of the extract.

1. Determination of extractive values:

1. Determination of alcohol soluble extractives -

a. Weighed about 4 g of the coarsely powdered drug in a dried 250 ml conical flask.

b. Filled conical flask with the 100ml of solvent (Alcohol).

c. Cork the flask and set aside for 24 hrs, shaking frequently.

d. Filtered into a 50ml cylinder. When sufficient filtrate was collected, transferred 25ml of the filtrate to a weighed, thin porcelain dish, as used for the ash value determination.

e. Evaporated to dryness on a water bath and complete the drying in an oven at 105°C for 6 hrs.

f. Cooled in a desiccator for 30 min and weighed immediately.

g. Calculated the percentage w/w of extractive with reference to the air dried drug.

2. Determination of water soluble extractives -

a. Weighed accurately 4gm of the coarsely powdered drug in a dried 250ml conical flask.

b. Filled conical flask with the 100ml of solvent (Water).

c. Cork the flask and set aside for 24 hrs, shaking frequently.

d. Filtered into a 50ml cylinder. When sufficient filtrate was collected, transferred 25ml of the filtrate to a weighed, thin porcelain dish, as used for the ash value determination

e. Evaporated to dryness on a water bath and complete the drying in an oven at 105°C for 6 hrs.

f. Cooled in a desiccator for 30 min and weighed immediately.

g. Calculated the percentage w/w of extractive with reference to the air dried drug.

B) Identification of Curcuma longa extract

a. Ultraviolet spectroscopy:

The UV spectrum of Curcuma longa extract in phosphate buffer was obtained using Shimadzu UV spectrophotometer (Pharma spec 1700, Schimadzu, Japan). Scanning was carried over a wavelength region of 200-700 nm.

b. differential scanning calorimetry (DSC):

DSC performed in order to access the thermal properties and thermal behaviour of the drug and the extract. It measures the heat flow in and out of both sample and reference during a controlled temperature program. The nature of the pure drug and its thermal behaviour was studied by differential scanning calorimetry (DSC). About 5mg of the sample was sealed in the aluminium pan and heated at the rate of 10°C/min, covering a temperature range of 40°C to 300°C under nitrogen atmosphere of flow rate 10ml/min and DSC Thermogram (Mettle-Toledo DSC821e, Switzerland) for pure drug and extract was obtained.

c. Calibration curve of Curcuma longa extract in Phosphate buffer pH 5.5.

Accurately weighed 100 mg (0.1 gm) Curcuma longa extract was taken and transferred to 100 ml volumetric flask and volume was made to 100 ml with petroleum ether (Stock I). The 10ml solution from above stock I solution was again diluted with methanol and volume was made to 100 ml (Stock II). The final solutions of stock II were then prepared in methanol. From Stock II solution aliquots of 1, 2, 3, 4, 5, 6, 7, 8, 9 and 10 ml were transferred to 10 ml volumetric flasks and final volume was made to 10ml with methanol in the concentration range of 10-100 µg/ml. The absorbance values of these solutions were measured at 239.5 nm using double beam UV spectrophotometer (Shimadzu, PharmaspecUV-1700, Japan) against blank of methanol.

D. drug-excipient compatibility studies:

Prior to formulation, to study the physical and chemical compatibility of curcuma longa l extract with the proposed excipient to be used, the following studies were conducted on the physical mixtures of drug and each excipient in the ratio 1:1. The physical mixtures were stored in the humidity chamber for 14 days at 37°C and 75% RH, before analysis. The results were compared with that obtained with individual drug and excipients. The following samples were subjected to analysis.

Table No.4: Samples used in drug-excipient compatibility studies

Pure sample	Drug +Excipient
Curcuma longa	---------
Polyvinyl alcohol	Polyvinyl alcohol + Extract
Carbopol 934	Carbopol 934 +Extract

E. Formulation of Nanosponges:

1. Preparation of Blank Nanosponges:

Blank Nanosponges were prepared by quasi emulsion solvent diffusion method. The inner phase was prepared by dissolving Ethyl cellulose in a suitable solvent i.e. dichloromethane. The inner phase was then poured into the HPMC solution in water (Outer Phase). Following 60 min of stirring (rpm 800-900), the mixture was filtered to separate the Nanosponges. The Nanosponges were dried in an air heated oven at 40°C for 12 h.

Table No 5.Composition of blank Nano sponges

Batch no	Ethyl callouses	HPMC	DCM	Water
F1	1gm	0.50	20ml	100ml
F2	1.5gm	0.75	20ml	100ml
F3	2gm	1	20ml	100ml
F4	1gm	0.50	20ml	100ml
F5	1.5gm	0.75	20ml	100ml
F6	2gm	1	20ml	100ml
F7	1gm	050	20ml	100ml
F8	1.5gm	0.75	20ml	100ml
F9	2gm	1	20ml	100ml

Preparation of drug loaded Nanosponges:

Drug loaded Nanosponges were prepared by Quasi - emulsion solvent diffusion method. The inner phase was prepared by Ethyl cellulose in a suitable solvent i.e. dichloromethane. Then drug was added to solution and dissolved under ultra-sonication at 35 °C. The inner phase was then poured into the HPMC solution in water (Outer Phase). Following 60 min of stirring (rpm 800-900), the mixture was filtered to separate the Nanosponges, The Nanosponges were dried in an air heated oven at 40°C for 12 h

Table No. 6: Composition of drug loaded Nanosponges

Batch no	Drug (mg)	Ethyl celloulse	HPMC	DCM	Water
F1	2mg	1	0.50	20ml	100ml
F2	2mg	1.5	0.75	20ml	100ml
F3	2mg	2	1	20ml	100ml
F4	2mg	1	0.50	20ml	100ml
F5	2mg	1.5	0.75	20ml	100ml
F6	2mg	2	1	20ml	100ml
F7	2mg	1	0.50	20ml	100ml
F8	2mg	1.5	0.75	20ml	100ml
F9	2mg	2	1	20ml	100ml

Evaluation of Nanosponges:

1) Visual inspection: The visual inspection of Nano sponges was determined by optical or binocular microscopy.

2) Determination of production yield:

The production yield of the Nano sponges was determined by calculating accurately the initial weight of the raw materials and the final weight of the Nano sponges obtained.

$$\text{Production Yield (PY)} = \frac{\text{Practical mass of Nano sponges}}{\text{Theoretical Mass (Polymer + Drug)}} \times 100$$

3) Actual drug content and Entrapment Efficiency: The actual drug content was determined by the amount of drug which was entrapped in Nano sponges. The weighed amount of drug loaded Nano sponges (50mg) was kept in 10ml ethanol and soaked for 3 h. The samples were filtered and analysed at 239.5nm against blank using UV spectrophotometer (Shimadzu, PharmaSpecUV-1700, Japan). Encapsulation efficiency was calculated by following formula:

$$\text{Entrapment efficiency (\%)} = \frac{\text{Total amount of drug - Free unentrapped drug}}{\text{Total amount of drug}} 100$$

5) Differential Scanning Calorimetry (DSC) :

Thermal analysis is an important evaluation technique to find any possible interaction between the drug and excipient. Such interaction can be identified by any change in thermogram. Thermogram of pure curcuma longa extract and finished Nano sponges formulations were obtained using DSC instrument (Mettle Toledo DSC 821Ce, Switzerland) equipped with an intercooler. Indium standard was used to calibrate the DSC

temperature and enthalpy scale. The powder sample of Nano sponges was kept in the aluminium pan and heated at constant rate of 5°C/min up to 300°C. Inert atmosphere was maintained by purging nitrogen at the flow rate of 10ml/min.

6) Scanning Electron microscopy: Scanning electron microscopy was used to study the microscopic aspects of the Nano sponges. The morphology of Nano sponges was carried out by using zeta sizer**.**

7) Particle size analysis: Particle size analysis of prepared Nano sponges was carried out by using zeta sizer (Particulate system Nano plus),

8) Zeta potential:

Zeta potential of optimized Nano sponges was measured by using zeta sizer at 25°C (Particulate system Nano plus).

Formulation and evaluation of curcuma longa extract Nano sponges gel

Preparation of curcuma longa extracts Nano sponges gel:

1% Carbopol 934 was allowed to soak for 24 h in distilled water. On next day accurately weighed curcuma longa extract Nano sponges were added to the gel base. Triethanolamine was added drop wise to the formulation for adjustment of required pH (5.5-5.6) and to obtain the gel in required consistency. Finally preservatives were added in the carbopol solution

Table no 7 : Formulation table for gel formulation

Batches	Nano sponges 100mg drug	Methyl paraben (g)	Propyl paraben (g)	Triethanolamine (ml)	Carbpol 934(gm)	Distilled water(ml)
F1	0.5	0.015	0.05	q.s	0.1	q.s
F2	0.5	0.020	0.010	q.s	0.1	q.s
F3	0.5	0.025	0.015	q.s	0.1	q.s
F4	0.5	0.015	0.05	q.s	0.2	q.s
F5	0.5	0.020	0.010	q.s	0.2	q.s
F6	0.5	0.025	0.015	q.s	0.2	q.s
F7	0.5	0.015	0.05	q.s	0.3	q.s
F8	0.5	0.020	0.010	q.s	0.3	q.s
F9	0.5	0.025	0.015	q.s	0.3	q.s

1. Physical appearance: The physical appearance of the formulation was checked visually**.**

2. Colour: The colour of the formulation was checked out against white and black background**.**

4. Odour:

The odour of gel was checked by mixing the gel in water and taking the smell.

2) Determination of pH:

The pH of gel was determined using digital pH meter by dipping the glass electrode completely into the gel system.

3) Determination of Spread ability:

Spread ability was determined by modified wooden block and glass slide apparatus. The apparatus consisted of a wooden block with fixed glass and a pulley. A pan was attached to another glass slide (movable) with the help of a string. For the determination of Spread ability measured amount of gel was placed on the fixed glass slide. The movable glass slide with a pan attached to it, was placed on other fixed glass slide such that the gel was sandwiched between the two slides for 5 min. About 50gm of weight was added to the pan. Time taken for the slides to separate was noted. Spread ability was determined using formula**:**

4) Determination of drug content:

The drug content of gel formulation was determined by dissolving an accurately weighed quantity (1g) of gel in 100 ml of solvent (pH 5.5-5.6). The solutions were kept for stirring up to complete dissolution of the formulations. Solutions were filtered and were subjected to spectrophotometric analysis. The drug content was calculated from calibration data.

$$\text{Drug Content} = \frac{Actual\ Conc}{Therotical\ yield} \times 100$$

Results and Discussion:

1. Collection of plant material:

Fig no.1 curcuma longa (plant)

2.Extraction of curcuma longa

Extract was obtained in sufficient quantity from the curcumin powder by soxhelt extraction method

Fig.no.2 Soxhlet extraction of powder of curcumin

3. Prefomulation study :

A) Characterization of curcuma longa extract:

a. Organoleptic Properties :

Colour: colour of the powder was found to be dark yellow

Odour: odour of the powder was found to be aromatic in nature

4. Determination of pH:

pH of the extract was found to be 5.7, while as per literature standard it is reported to be 5.3-6.4. As experimental values were in good agreement with official values, it could be concluded that procured extract was in pure form.

5. Phytochemical tests performed:

Table no 8: phytochemical test

Sr.no	consituents	Test	Observations
1	Alkaloids	1.Hager test 2.Wagners test	Present Present
2	Glycoside	Molischs test	Present
3	Proteins and amino acid	Millons test	Present

Test for alkaloids:

1. Wagner's test - This test was performed which showed formation of orange brown precipitate that indicated the presence of alkaloids.

2. Hager's test: This test was performed which showed formation of yellow precipitate that indicated the presence of alkaloids.

Test for glycoside:

1. Molisch's test- This test was performed which showed formation of violet ring at the junction of 2 liquids that indicated the presence of glycosides.

Test for proteins and amino acids:

1. Millions test- This test was performed which showed formation of white precipitate. Warm the obtained precipitate which converted it in into brick red colour that indicated the presence of proteins and amino acids.

6. Determination of total ash: The total ash value of curcuma longa was found to be 6.06.%, while as per literature standard it is 11.69%.

1. Determination of water soluble ash: The water soluble ash value was found to be 4.05%.

while as per literature standard is 5.08%

2. Determination of acid insoluble ash: The acid insoluble ash value was found to be 0.55%, while as per literature standard it is 1.24%.

7.Determination of loss on drying: The loss on drying was found to be 5.43 gm, while as per literature standard it is 10.06±0.15gm.

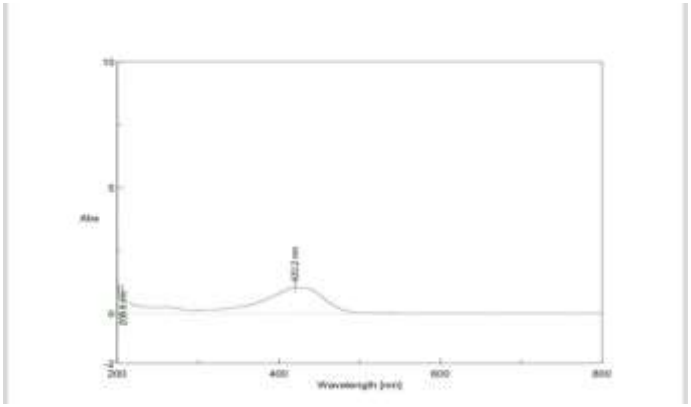
.8. Determination of refractive index: The refractive index was found to be 1.44, while as per literature standard it is 1.52**.**

9**. Determination of melting point**: The melting point of curcuma longa was found to be 97°C-100 °C, while as per literature standard it is 96°C-100°C

Identification of curcuma longa:

1.UV Spectroscopy –

UV-Vis spectroscopy is an analytical technique that measures the absorption or reflection of ultraviolet (UV) and visible light by a sample. It's primarily used for quantitative analysis, determining the concentration of substances in solution, though it can also provide qualitative information about the presence and nature of molecules. The technique relies on the principle that certain molecules absorb specific wavelengths of UV or visible light, causing electronic transitions within the molecule.



[Measurement Information]	
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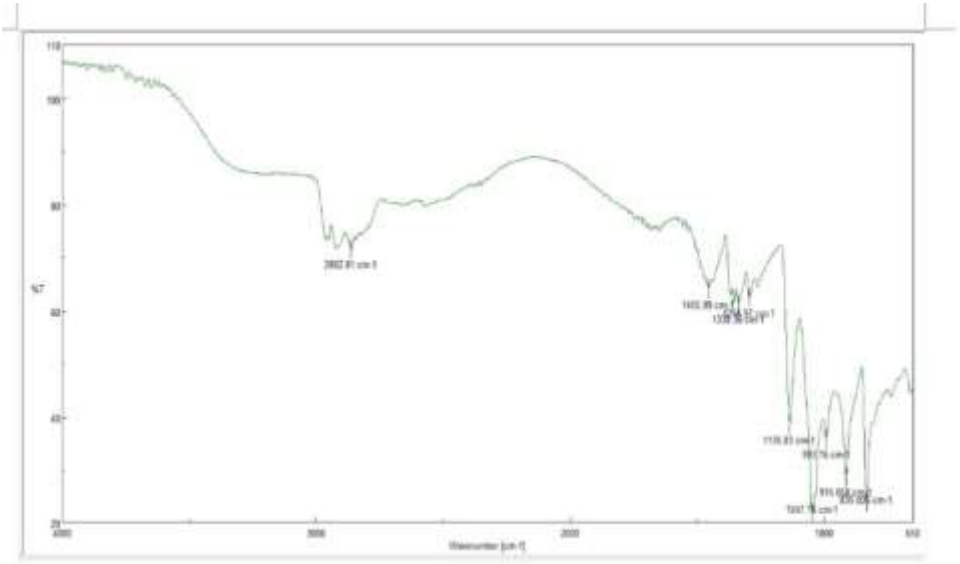
Serial No.	D381761798
Measurement date	12-12-2024 11:36
Photometric mode	Abs
Measurement range	800 - 200 nm
Data interval	0.2 nm
Bandwidth	1.0 nm
Response	0.24 sec
Scan mode	Continuous
Scan speed	100 nm/min
Change source at	340 nm
Light source	D2/WI
Filter exchange	Step
Correction	Baseline
No. of cycles	1

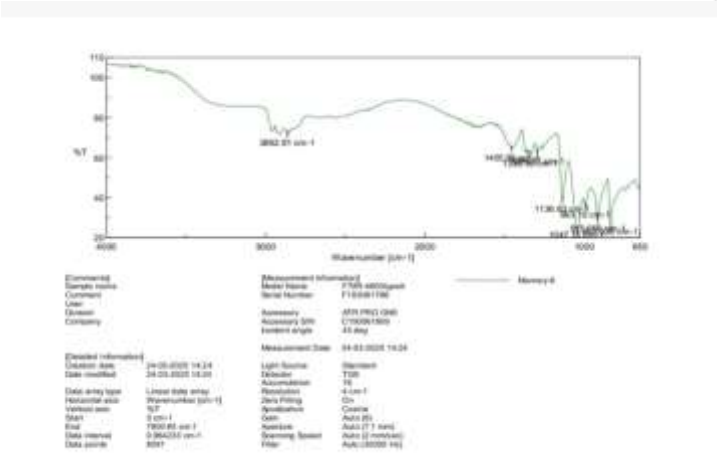
[Detailed Information]	
Creation date	12-12-2024 11:36
Date modified	12-12-2024 11:47
Data array type	Linear data array
Horizontal axis	Wavelength [nm]
Vertical axis	Abs
Start	800 nm
End	200 nm
Data interval	0.2 nm
Data points	3001

Discussion- According to this standard curve it shows that the highest concentration lowest concentration is a 0.122. The value of R^2 is obtained from the 0.9967 was near useful to calculate the concentration of the unknown sample. So, they are slightly equ reference standard

2.Infrared Spectroscopy :

Infrared (IR) spectroscopy is a technique that measures the interaction between infrared radiation and a substance, revealing information about its molecular structure and bonding. It's used to identify chemical substances or functional groups within solid, liquid, or gaseous forms. By analysing the absorption or emission of infrared light by a molecule, IR spectroscopy helps determine the types of bonds present and their vibrational frequencies.





3. Calibration curve of curcuma longa extract in phosphate buffer ph. 5.5:

The calibration curve for curcuma longa extract in phosphate buffer pH 5.5 was plotted by using following results of absorbance at various concentrations.

4. A. Drug-excipient compatibility studies.

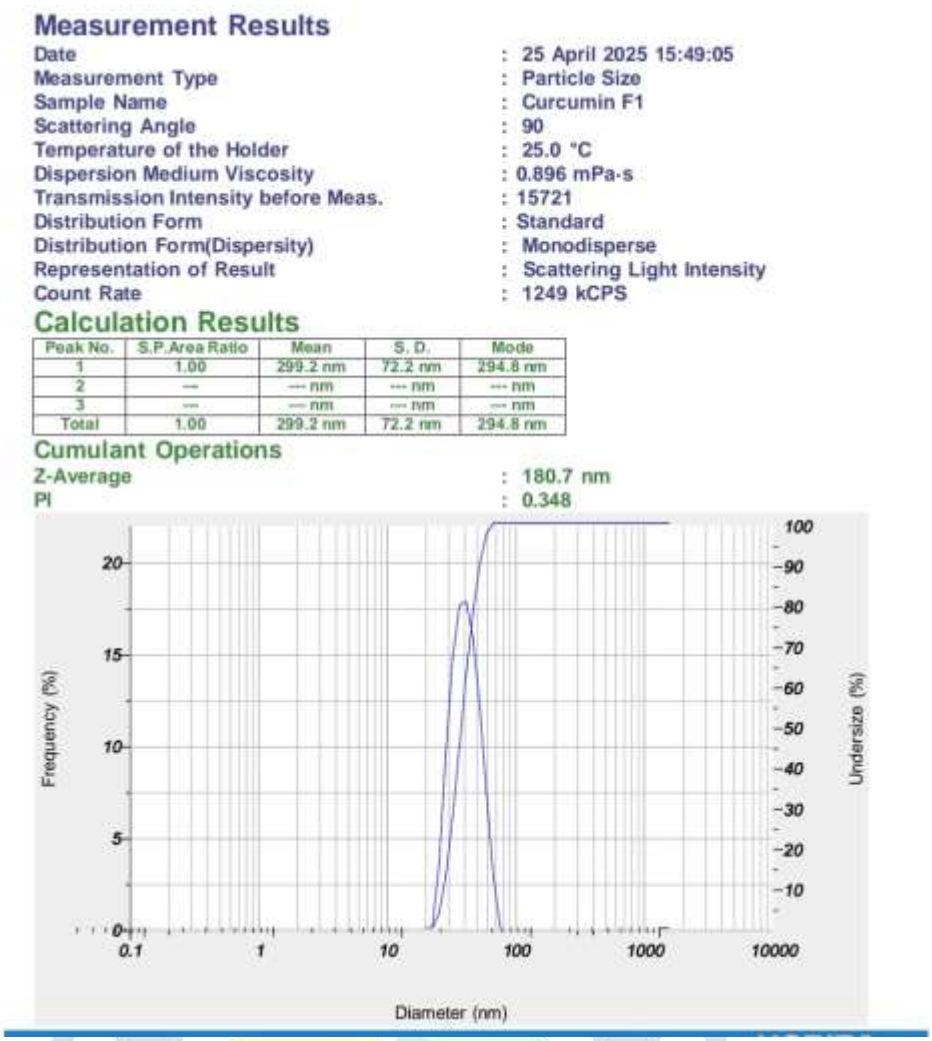
1. Visual observations:

No notable change was observed in the sample on visual observation. There was no observable colour change.

2. Particle size analysis:

Particle size of Nano sponges should be in the range of 5 - 500 nm. The visual inspection of all batches for particle size using optical and binocular microscope revealed that the particle size was increased with the increase in the ethyl cellulose. This might be due to increasing polymer wall thickness which led to the larger size of Nano sponges. The F6 batch possessed more percent of intact, uniform, spherical particles in optical

microscopy; so the batch F6 was chosen for further analysis. A mean particle size of formulation F6 was found to be 55.2 nm



4. Stability studies:

Table no: 9 Stability Studies of the curcumin

Duration Time	Test sample (t1% t2%t3%)	Colour And Ph
7 Days	No Chance	No Change
15Days	No Chance	No Change
21 Days	No Chance	No Change

Discussion – The duration of stability study of the sample 1% 2% 3% there was no changes in a concentration, solubility, stability, ph and colour

7. Spreadability –

S=M*L/T

Table no: 10 Spreadability of curcumin loaded Nano gel

Test sample	Spread-ability (g.cm/s)
T1%	20.01
T2%	18.44
T3%	10.09

Discussion – According to this data spread ability is also as to variations with the test sample 1% 2% 3% so as to compare with the reference standard.

Summary and conclusion:

Conclusion:

The integration of turmeric extract into Nano sponge-based gel formulations presents a promising advancement in the realm of topical drug delivery and anti-inflammatory applications. Nano sponge technology not only facilitates the sustained and controlled release of turmeric bioactive compounds but also enhances their stability and skin compatibility. This targeted delivery system can significantly reduce the adverse effects commonly associated with direct turmeric application, such as irritation or hypersensitivity, thereby improving patient compliance and therapeutic outcomes.

Looking forward, turmeric-loaded Nano sponge gels hold immense potential in the treatment of various dermatological disorders, including acne vulgaris, eczema, and fungal infections. Additionally, their incorporation into cosmetic formulations aligns with the increasing global demand for natural, sustainable, and efficacious skincare solutions. Future research should focus on optimizing the Nano sponge matrix for improved drug loading, evaluating long-term stability, and conducting comprehensive clinical trials to validate efficacy and safety.

With ongoing innovation and scientific validation, Nano sponge-containing turmeric gels are poised to emerge as a significant development in both pharmaceutical and cosmeceutical industries, bridging traditional herbal medicine with modern delivery technologies.

Future Perspective:

A Nanosponge consists of a myriad of interconnecting voids with in non-collapsible structure that can accept a wide variety of substance. The outer surface is typically porous allowing the flow of substance into and out of the sphere, scientist are more concentrating on delivery of anti- acne, sunscreen, antidandruff, agents which can also use in delivery of thermos labile substance such as vaccines, proteins, peptides, and DNA based therapeutics, now-a-days, it is also used in tissue engineering and in controlled drug delivery for therapeutic agents, which requires long duration of therapy Optimization techniques are carried out in these studies to get best out come from various formulation. Hence it requires lot of skills for developing novel formulation for the tropical diseases. Some Nanosponges based products are already approved; several others are currently under development and clinical assessment.

References:-

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