

DEVELOPMENT OF PHYCO-COLLOID BASED BIODEGRADABLE MEMBRANE

Submitted in partial fulfillment of the requirements for the award of

Bachelor of Technology degree in Chemical Engineering

by

KOWDHAM C (39190012)

VIJAYAGANESH K (39190037)



**DEPARTMENT OF CHEMICAL ENGINEERING
SCHOOL OF BIO AND CHEMICAL ENGINEERING**

SATHYABAMA

**INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)**

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JEPPIAAR NAGAR, RAJIV GANDHI SALAI CHENNAI - 600 119

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This is to certify that this Project Report is the bonafide work of Kowdham C (39190012), Vijayaganesh K (39190037), who carried out the project entitled "DEVELOPMENT OF PHYCO-COLLOID BASED BIODEGRADABLE MEMBRANE" under our supervision from November 2022 to April 2023.

Internal Guide
Dr. A. ANNAM RENITA
MTech, Ph D.

External Guide
Dr. L. STANLEY ABRAHAM
M.Sc, Ph D.

Head of the Department

Dr. S. SATHISH ME., Ph D.

HEAD OF THE DEPARTMENT
DEPARTMENT OF CHEMICAL ENGINEERING
SATHYABAMA
INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)
Jeppiaar Nagar, Ramo-Gandhi Salai
Chennai - 600 119

Submitted for Viva voce Examination held on _____

Internal Examiner

External Examiner

DECLARATION

We, Vijayaganesh K (39190037) and Kowdham C (39190012) hereby declare that the Project Report entitled **"Development of phyco-colloid based biodegradable membrane"** done by us under the guidance of Dr. A. Annam Renita and Dr. L. Stanley Abraham, **Sathyabama Institute of Science and Technology** is submitted in partial fulfillment of the requirements for the award of Bachelor of Technology degree in Chemical Engineering.

DATE:

PLACE: CHENNAI

A handwritten signature in black ink, appearing to read 'Kowdham C', with a stylized flourish above it.

SIGNATURE OF THE CANDIDATES

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ABSTRACT

The widespread use of plastic in industries including packaging, electronics, building and construction, healthcare, transportation, has become a global problem. This has resulted in an ever-increasing strain on the environment, which has drawn many scientists and environmentalists to developing new strategies to deal with this threat. Due to their widespread use in consumer products, construction, building, agriculture, defense materials, sanitary ware, tiles, plastic bottles, artificial leather, and other home items, they serve as the foundation of numerous enterprises. Additionally, plastic is utilized in the packaging of foodstuffs, medications, detergents, and cosmetics. Consequently, employing seaweed as biomass material is a viable way to replace traditional plastic that is both economical and environmentally benign. Compared to traditional extraction techniques, green production methods are more practical for producing seaweed films because they are more cost- and eco-efficient.

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LIST OF ABBREVIATIONS

OA	Oxidized Alginate
ISO	International Standard Organization
ASTM	American Society for Testing and Materials
CMC	Carboxymethyl Cellulose
MNP	Melanin Nanoparticles
PEG	Poly Ethylene Glycol
PEO	Poly Ethylene Oxide
POE	Poly Oxy Ethylene
PVA	Polyvinyl Alcohol
FESEM	Field Emission Scanning Electron Microscopy
FTIR	Fourier Transform Infrared Spectroscopy
EDX	Energy Dispersive X-Ray Analysis
CHT	Cross Head Travel
TGA	Thermo-Gravimetric Analysis

CHAPTER 1

INTRODUCTION

Plastic materials are ideal for many applications, such as in wrapping, construction supplies, goods and services, in addition to personal hygiene products, can also cause waste-disposal problems because these components are not degradable as well as their rigidity to biodegradation, they build up in the environment. In the 1980s, the primary bioplastics and polymers were introduced. Plastics, the foundation of many businesses, are utilized to produce many objects we use daily, including defense supplies, sanitary items, tiles, plastic bottles, faux leather, and other domestic items. Additionally, packaging for food, drugs, detergents, and cosmetics uses plastic [1].

Although synthetic polymers are made from non-renewable resources, natural polymers can be found in extremely larger amounts from renewable sources. The Greek term "Plastikos," which meaning that may be molded into multiple shapes, is where the English word "plastic" originates. Plastics were identified as polymers which begin to melt when heated, allowing them to be cast into molds.

Unfortunately, their barrier and mechanical properties still do not match the synthetic reference polymers, and its cost of production are too high for them to be competitive on the market. In this regard, cellulose-rich aquatic plants and seaweeds are being investigated as an effective substitute for terrestrial biomass for the synthesis of bio-based polymers. Plastics present distinct fracture property from elastomers due to different dissipation mechanisms. It is urgent to ascertain whether similar crack growth takes place in degradable plastics [2].

The usage of seaweed waste materials stream, such as those produced during alginate manufacture, may be of particular relevance. Sea weed is widely available in many nations, including India. In order to create a sustainable bioplastic, the current work's goal is to extract sodium alginate from sea weed. Alginate is the sodium salt type of alginic acid infused with gum predominantly derived from the cellular membranes of brown algae and has chelating activities.

1.1 BIO DEGRADABLE POLYMER:

Enzymes and/or chemical breakdown linked to live organisms are responsible for biodegradation. The steps involved are pretty much simple. The first is the breakdown of polymers into lower molar mass, either through biotic/abiotic events. In the next step, assimilation and mineralization of biopolymers takes effect, which is done by bacteria. In addition to the polymer's place of origin, biodegradability also depends on the polymer's chemical make-up and the environment's parameters for environmental degradation. The mechanisms of polymer biodegradation and estimate methods have been examined. The chemical composition, production, storage, and processing features, ageing, and application condition influence the mechanical characteristics of biopolymers. Biodegradation is the mineralization of organic material done by microorganisms (such as fungus and bacteria) ultimately producing both H_2O and CO_2 as the final products in an aerobic environment. Biotransformation occurs when mineralization is incomplete which produces organic and inorganic metabolites, often known as transformation products.

Extracellular enzymes secreted by microorganisms carry out the most necessary biodegradation processes for bio plastics, including the breakdown of ester linkages for releasing monomers. Since the substrates are mostly at larger sizes, biodegradation of relatively smaller molecules mostly happens outside the microbe. A portion of the substrate is cut off by the active sites of extracellular enzyme, creating a complex due to interaction.

The majority of bacteria utilize a system of many enzymes to completely biodegrade a substrate. These biological activities lead to compound's whole breakdown when abiotic processes take place which degrade the material chemically and physically, such as photodegradation and biochemical hydrolysis under hot, acidic/basic conditions. Both the abiotic and biotic properties can interact with one another. Mechanical degradation makes a polymer more susceptible to enzymatic breakdown, hence boosting biotic degradation. Mechanical deterioration might result through micro faunal activity, like earthworms breaking down excretes and incorporating it into the mineralized soil. Both the abiotic and biotic processes contribute to the overall breakdown.

1.2 ADVANTAGES OF BIO DEGRADABLE POLYMER

Recycling of bio-based polymers is done mostly using organic methods. Degradation time is much lower and these polymers tend to have no toxic properties. They also tend to serve as source material for biogas. Considering cost and land space, biopolymers seem to be an optimal solution. Recycling process reduces landfill requirements and high production cost gets compensated by low disposal costs. Production of these plastics focuses primarily on environmental effects. These plastics has low energy requirements for production. Location access and transportation are not major factors influencing the production of bio plastics unlike conventional polymers. This will result in less pollution because less fossil fuels will be used. Also, it significantly benefits the environment because during manufacturing it creates 68% less greenhouse gases. On the basis of the ingredient used for preparation the bio - plastic and the disposing technique, biodegradable polymers only degrade over a few months. 13 % of the waste product stream, or thirty-two million tons of rubbish every twelve months, is made up of other classic plastic types, of which only 9% can be recycled. The usage of biodegradable plastics is preferable due to their quick degradable properties while consumed by the soil, and their conversion into compost feed. Moreover, even if a complete breakdown doesn't take place, it is easier to decrease the quantity of land needed to dispose of the entire plastic waste produced. When compared to terrestrial plants, seaweeds are macroscopic, multicellular, benthic algae that are more effective at photosynthesis, leading to a rapid accumulation of biomass because of a quicker growth rate. It contributes significantly to aquatic biomass and accounts for around 50% of the planet's primary productivity [4]. Brown seaweed appears in a wide range of sizes, species, and general morphologies, but they typically have a brown color because of a pigment produced during photosynthetic processes. *Laminaria pallida*, *Fucus* species, and *Zonaria* species are common varieties of brown seaweed. Brown seaweed contains the polysaccharides alginate, laminarins, and fucoidans (FUC) [5]. Over time, there has been a tremendous increase in the production of plastics. According to estimates made by scientists, there may be more polymers in the ocean than aquatic organisms by the year of 2050. At that point, 80 percent of the water

supply will be contaminated with micro plastic. With the development of biodegradable polymers, the world can expect forward to a time when plastics can break down and release only the energy required to create them.

Emissions of carbon dioxide are also reduced because fossil fuels are not needed to make such environmentally beneficial, biodegradable plastic products. They only release as much CO₂ during their breakdown as was used up during their production.

Traditional plastics can release methane, hazardous substances, and other forms of contaminants into the environment when they are discarded. These substances are potentially harmful as they degrade because they can easily harm both terrestrial and aquatic ecosystems as well as general human health. Natural decomposition is a frequent occurrence in which living things, particularly bacteria, convert complex organic matter into a simple organic component. The enzymatic breakdown of the plastic provides nutrients to the bacterium. The energy and carbon needed for their growth and development are sourced from plastic garbage [6].

1.2 COMPONENTS OF BIO DEGRADABLE POLYMER

Bio degradable polymer components like polysaccharides, polynucleotides and polypeptides are discussed below

1.3.1 *Polysaccharides*

The most common type of carbs in diet are polysaccharides, also known as polycarbohydrates. These are polymer carbohydrate of longer chains made up of monosaccharide linked by glycosidic bonds. Using amylase enzymes as a catalyst, these carbohydrates can react with H₂O (hydrolysis), releasing carbohydrates (monosaccharide, or oligosaccharides). They come in a various shape, from straight to heavy branching. Examples are structural polysaccharides like cellulose, chitin, starch, glycogen, and galactogen.

Often quite diverse, recurring unit variations can be seen in polysaccharides. These macromolecules' characteristics can differ from those of their monosaccharide building units depending on the structure. They might even be water insoluble or amorphous. Homopolysaccharides, also known as homoglycans, are polysaccharides that contain only one kind of monosaccharide;

meanwhile, heteropolysaccharides, also known as heteroglycans, are polysaccharides that contain many types of monosaccharides.

Natural saccharides consist of monosaccharides and are simple carbohydrates with the formula $(\text{CH}_2\text{O})_n$, where n is two or higher. Monosaccharides include sugars including glucose, fructose, and glyceraldehyde. The standard formulae for polysaccharides are $\text{C}_x(\text{H}_2\text{O})_y$, where x is often a big value from 200 and 2500. The generic formula becomes $(\text{C}_6\text{H}_{10}\text{O}_5)_n$ when the two subunits in the polymeric matrix are six-carbon monosaccharides, which is frequently the case. Typically, n is 3000.

The M/G ratio, as well as the structure and distribution of acid blocks in the polysaccharide backbone, determine the biological and physicochemical characteristics of alginates. These factors vary depending on the species, type of tissues, age, or harvesting seasons. In this respect, elastic and flexible gels are known to have high M/G ratios, whereas stiff and brittle alginate gels are known to have low M/G ratios. Because of their stabilizing, thickening, and gelling qualities, they are particularly popular additives in the food business.[3]

1.3.2 Polynucleotides

The ester bonds between the phosphoryl and the hydroxyl of the carbohydrate of the following nucleotide provide the basis of a biopolymer that is made up of a continuous, linear chain of nucleotides.

A polynucleotide is a mixture of several nucleotide (as opposed to oligosaccharides comprised of only a few, i.e., about three to twenty). Each isomeric component is made up of a phosphate group, a 5-phosphate moiety, and a nucleobase. The phosphate group of one nucleotide and the hydroxyl of the glucose of the following nucleotide form ester bonds binding the monomers together in a chain. One of the main biopolymers, along with polysaccharides and polypeptides, is polynucleotides.

A pentose, a nitrogen base, and a phosphate molecule are the three components that make up each monomer. A phosphodiester connection connects the phosphate groups and pentose sugar. Adenine, Cytosine, Guanine, and Thymine or Uridine are the four nitrogenous bases.

1.3.3 Polypeptides

A polypeptide is a peptide chain that is longer, continuous, and Unbranched. Proteins are polypeptides with a molecular weight of 1 million Da or higher. Oligopeptides, which comprise dipeptides, tripeptides, and tetrapeptides, are chains containing less than twenty amino acids.

Peptides, along with nucleic, disaccharides, polysaccharides belonging to the vast chemical like biological polymers with oligomers.

Enzymes are biocatalysts that take part in reactions, act on certain substrates, and hasten the transformation of those substrates into useful products. The potential for microorganisms to break down the plastic that pollutes our environment has raised interest in the fundamental process by which microbes can break down this extremely durable polymer [4]

1.4 PHYCO-COLLOID

The phyco-colloids that are extracted from diverse red and brown seaweeds include agar, alginate, and carrageenan. They are an extremely large-molecular, non- crystalline material that dissolve in water to produce a viscous solution. These are water-soluble carbohydrates that are used to stabilize some goods, such as ice cream, thicken aqueous solutions, make gels (jellies) of varied degrees of stiffness, and form water-soluble films. These phyco-colloids are used in a variety of industries.

1.4.1 Agar

Agar makes up the majority of the cell wall of red seaweed from the families Gracilariaceae, Gelidiellaceae, and Gelidiaceae. *Gelidium* sp, *Gelidiellaacerosa*, *Pterocladia* sp, and *Ahenfeltia* sp. are all used to make agar. A chain of 9-B galacto pyranose units connected by 1, 4 bonds to a sulphated L-galactose makes up agar.

Agar's propensity to gel and the special qualities of these gels make them frequently used in a variety of applications. A little portion of the agar produced is used in bacteriology and other biotechnological applications, while the majority of it is used for food applications. Agar has been designated as Safe by the USFDA. Agar is utilized in the baking industry as a stabilizer and thickener in pie fills, icings, and meringues since it can resist higher temperatures. Pies, buns, and are

frequently pre-packaged in a variety of contemporary wrapping materials and frequently adhere to them, particularly when it is hot, but by lowering the amount of water and adding some agar, this issue can be solved.

Agar for bioplastic has primarily been produced via the extrusion method and is still in the early stages of development. The melting point, thermal decomposition, and chemical qualities must be understood for the optimal extrusion. Water addition during the extrusion process for producing agar-based bioplastic was noted [5]

It won't melt while being sterilized and canned. Because of its stronger gel and greater melting temperature than gelatin, agar is also utilized in the production of gelled meat and fish items.

Agar has been utilized to stabilize ices when combined with other gums. Agar is not easy to digest, therefore it adds less calorific value to meals, improving the quality of dairy like cream, cheese, and yoghurt. It serves as a meat alternative in vegetarian cuisine. Agar is used in canned fish and meat products as a protective covering against the impact of metal cans and also against shaking while these products are being transported. Wines, beers, and liquors can all benefit from the clarifying properties of agar. It serves as a laxative for those with chronic constipation, a medication delivery system in the pharmaceutical sector, and an ion exchanger in the production of ion exchange resins.

Agar is used as a cleaning and sizing agent in the paper and textile industries as well as a component of skin lotions and ointments in the cosmetic sector. As a growth medium, nutrient-supplemented agar gels can be used to produce clones or duplicates of specific plants. Meristems, or the portion of the plants with continuously dividing cells, are often the stem tips that are cultivated in gel until they are large enough to be transplanted and have developed enough roots. This technique has the benefit of allowing for sterile cultivation of the plants. In order to test for microorganisms, we utilize purified bacteriological agar.

1.4.2 Alginate

Alginate has been extensively employed in a variety of biomedical applications, including drug administration, regenerative medicine, and wound dressing.

The phyco-colloids that are extracted from diverse red and brown seaweeds include agar, alginate, and carrageenan. They are an extremely large-molecular, non- crystalline material that dissolve in water to produce a viscous solution. These are water-soluble carbohydrates that are used to stabilize some goods, such as ice cream, thicken aqueous solutions, make gels (jellies) of varied degrees of stiffness, and form water-soluble films. These phycocolloids are used in a variety of industries.

Alternative methods were employed to create covalent cross-linked alginate hydrogels in order to increase the stable and ion cross-linked alginate hydrogels, which can dissolve under physiological conditions via the interchange of divalent with monovalent cations.

Therefore, the study explains to valorize the waste production following a standard alginate extraction from brown seaweed species in order to extract less pure cellulose-based fractions using more straight forward extraction procedures. Additionally, the effectiveness of these fractions in producing bio-polymeric films for use in edibles packaging is assessed, looking over the impact of the various fractions' compositions on the functioning of the films.

Alginate was modified a decade ago to allow for hydrolysis in physiological settings, permitting the utilization of alginate-based hydrogels for purposes where hydrogel breakdown was necessary. Alginate's backbone can be functionalized with hydroxyls to produce oxidized alginate (OA), also known as alginate di-aldehyde. However, the application of bioplastics made from alginates is restricted due to their high stiffness, high brittleness, low deformability, and moisture sensitivity when compared to synthetic polymers used in everyday life. However, these issues can be solved by using composite technology in combination with additional natural polymers, plasticizers, and reinforcement elements [6]

Algin is used as a filler in the production of tablets, pills, and as the base of any topical application. It is also employed as an emulsifier in watery emulsification with fats, oils, and waxes. A blood-stopping plaster is made of alginate gauze. Alginate is regarded as a slimming agent since it transforms into a gel in the abdomen and causes a sated feeling. Laminar flow hoods employ ammonium

alginate wool as a microorganism filter.

Due to their capacity to form films, alginates are used in the cosmetic, detergent, and soap-making industries as thicken and dispersion agents in the manufacture of ointments, cream, liquid emulsions, lotions, and toothbrush as well as an addition in hair dye and shampoos. Shaving creams' consistency is improved by alginates. Alginates are used to create fixatives for denture moldings.

Alginates are a component of baking emulsions and enhance the baking qualities in the food sector. They are utilized to create fruit imitations and sugar glazes. Products created from jelly are made from insoluble alginates and water (calcium alginates). Alginates are frequently recommended as a gelation ingredient in jams and marmalades in many different nations. Alginates are frequently found in dairy goods including soft cheese, custard, custard powder, milkshake combined with chocolate, and cheese. Alginates provide milk mixtures a uniform viscosity and high whipping ability when employed as stabilizers. Alginates are used in beverages as foam stabilizers in beer, a clarifying agent for wines, and a raw spirit of sugar and molasses.

Products containing meat and sausage are given a longer shelf life using alginate film. Especially for vegetarians, artificial casing with an alginate basis have been created for tiny sausages. For the deep cooling of fish, meat, and poultry products, alginate gel is used. Because they are biodegradable and biocompatible, alginate chitosan polyelectrolyte complexes are extensively researched [[7]. Chitosan alginate polyelectrolyte complexes outperform polymers alone when employed as coated membranes or controlled release delivery systems because they are more resilient to pH changes and more effective at safeguarding enclosed components.[8]

1.4.3 Carrageenan

Carrageenan actually is a sulphated galactan polymer which is derived from a variety of red seaweeds that belong to the groups Gigartinaceae, Solieriaceae, and Hypneaceae. Its larger sulphated fraction and higher ash content are its key differences from agar. The 1, 3, and 1, 4 connected D-galactopyranose units that make up the carrageenan polymer's backbone differ in their level and location of sulphated esterification. There are two fractions of carrageenan that may be

distinguished: kappa carrageenan, which has a branched polymer chain, and iota carrageenan, which has a linear polymer chain. Carrageenan typically has a high molecular weight, ranging from 100 to 1000 kDa on average. Other polysaccharide residues and substituents such as glucose, xylose, uronic acids, methyl ethers, and pyruvate groups are also present in addition to the ester sulphate and galactose groups as the major backbone in its structure.[9]

Dairy products are the principal application for carrageenan. Whey separation is avoided by adding 0.01–0.04% of Kappa carrageenan to cream cheese and ice cream. Comparable numbers of kappa can be added to keep the cocoa in hot chocolate suspended; this creates a weak highly viscous liquidated gel that's firm when vigorously Shaked. By avoiding the separation of fat, lambda or a combination can also enhance liquid coffee whiteners. Kappa may have been added to the tiny bottles of ultra-high temperature sterilized milk seen in the fridge of some hotels to stop the separation of the fat and protein.

Carrageenan is used in the culinary industry to clarify beer, fruit juices, and other beverages, as well as to prepare condiment goods, syrups, whipped creams, ice desserts, and cheese. Making spaghetti and parottas with wheat flour now has better quality. The majority of their customers' needs can be met by carrageenan producers by combining different carrageenan with locust bean gum, konjac flour, and starch to produce an array of warming and non-melting gels and gel textures.

Significant inventive breakthroughs are required throughout the entire production chain, from seaweed cultivation and harvesting, transportation, carrageenan extraction, through to the manufacture and marketing of products, to successfully commercialize carrageenan films in a manner like PLA, bio-PBS, and other commercial bio-based polymers. The fact that carrageenan-based plastics can provide consumers with significant overall environmental benefits when compared to some other materials makes them another crucial factor that partially offsets the higher production costs. Historically, such perspectives have been linked to rising market demands.[10]

The demand from consumers for pre-cooked poultry items like chicken and turkey parts is rising. The loss of freshwater during cooking as well as the resulting decrease in texture and feeding quality worried poultry processors. The meat's

texture and softness were increased by infusing a brine containing salt into the muscle. Carrageenan absorbs water in the muscle and enhances texture.

Fresh ground beef can be combined with iota carrageenan, which when cooked gives the product qualities similar to those of fat and moisture retention. The optimal method for producing it has been found to be precipitation in alcohol solution since the gelling strength of κ -carrageenan is not as great as that of λ -carrageenan, making the filtrate of κ -carrageenan unsuitable for dehydration using the gel-pressing process. After heat extraction, the liquor extract is passed through a fine filter, allowed to evaporate, and then isopropanol is added to precipitate the liquid to produce a fibrous carrageenan coagulum.

1.5APPLICATIONS OF BIO POLYMER

- To improve the intended features and usefulness of these biopolymers, they are mixed with other materials to strengthen their inherent qualities.
- They also possess barrier qualities that are not found in other polymers, such as water resistance.
- The automotive industry uses biopolymers to create interior and exterior components, electrical parts, engine, exhaust, steering wheels, etc.
- Used to produce nanomaterial. Biopolymers are advantageous in particular scientific fields, such as green chemistry, due to their distinctive features.

CHAPTER 2

LITERATURE SURVEY

M. Martínez-Sanz al. (2021) published an article under the title “**Valorization of alginate-extracted seaweed biomass for the development of cellulose- films**”.

0.25 g of the extracted fractions (dry weight) were dispersed in 50 mL of distilled water to create cellulosic films. It took about a minute of ultra turrax homogenizer churning to homogenize the mixture. After that, water was removed from the dispersions using vacuum filtration with PTFE filters having 0.2 m pore sizes. The remaining solid material in the filter was then dried at room temperature over the following day. Peeling the produced films off the filters allowed them to be kept in a desiccator at 0% RH. Using a Palmer electronic digital micrometer, the film's thickness was determined to be between 25 and 60 m[11]

Guodong Feng al. (2019) wrote a journal named “**Synthesis of Bio-base Plasticizer Using Waste Cooking Oil and Its Performance Testing in Soft Poly (vinyl chloride) Films**”.

Following the addition of 50 mL of THF, the PVC resin powder (3 g) was combined with 1.2 g of various plasticizers (40 phr, a, b, c, and DOP). At 40°C, the mixes were vigorously stirred to create a transparent, uniform solution. The solutions were then poured into various glass petri dishes with a diameter of 22 cm, dried for 7 days at room temperature, followed by 7 days of vacuum drying at 50°C to remove any remaining THF and produce various plasticized PVC films (a/PVC, b/PVC, c/PVC, and DOP/PVC). Arifa Shafqat al. (2020) published a scientific journal called “A review on environmental significance carbon foot prints of starch-based bio - plastic: A substitute of conventional plastics”. Starch-based bioplastics are the most promising alternative because of the abundance of starch in nature. Bioplastics can be made from natural organic components such as polysaccharides, proteins, and lipids. A variety of starch-based biodegradable bioplastics made from banana peels, rice starch, corn starch, cassava starch, tapioca starch, sago starch, and potato starch, and other sources, have been successfully fully created by many researchers. However, the development of bioplastics is not enough due to the high cost of manufacture, which has some limits. To effectively green-synthesis bioplastics, new studies on producing biodegradable bioplastics as effective, affordable, and environmentally

friendly as feasible are required[12]

R. Scalenghe (2018) wrote a paper on the topic of **“Resource or waste? A perspective of plastics degradation in soil with a focus on end-of-life options”**. Renewable resources are used to make bio-based polymers. Polylactic acid (PLA) is a bio-based polymer made from lactic acid monomers obtained from biomass. At 25 °C for 4, 12, 20, or 24 months (about 2 years), PLA buried in (unknown) soils exhibits no weight change and no discernible physical changes. The test results are highly ambiguous; in fact, after 4 months, an open burial trial conducted at 20 °C in (mystery) soil exhibited evidence of disintegration. However, it takes high temperatures (>50 °C) for PLA to decompose in the soil environment, which takes a few months. After 20 months (about 1 and a half years) of soil burial, there may be a degradation of 20% to 75%. Understanding which soils speed up or slow down the phenomenon of degradation is not possible based on the current body of information. Instead, it seems like the characteristics of soil matter; for instance, adding PLA to soil drastically reduces pH[13]

Abdul Rehman et al. (2021) published a paper under the title **“Plastics degradation by microbes: A sustainable approach”**. The biodegradability of polymeric materials can currently be measured using a wide range of techniques. International Standard Organization (ISO) and American Society for Testing and Materials (ASTM) have created several test procedures to evaluate the potential biodegradability of plastics, including gas chromatography, stereomicroscopy, micro- Fourier transform infrared spectroscopy, and mass spectrometry (GC-MS) (m-FTIR). Loss is a sign of decay in biological material due to changes in molecular weight distribution, weight, tensile strength, dimensions, chemical and physical qualities, carbon dioxide production, soil bacterial activity, and weight.

Natalie Stephanie Sawada Nunes et al. (2022) wrote a journal with the topic **“Optimal conditions for alkaline treatment of alginate extraction from the brown seaweed *Sargassum cymosum* C. Agardh by response surface methodology”**. Alginate extraction required ethanol pretreatment of the seaweed to remove phenolic compounds, an acid treatment followed by an alkaline treatment, which was assessed using BBD with various temperature, duration, and pH values. The dried algae (6 g) were subjected to two treatments with ethanol (200 mL) while being stirred for three hours in an orbital shaker (Model TE141,

Tecnal, Piracicaba SP, Brazil), and they were then allowed to dry for an entire night at 40 °C in a convection oven (Model 420-1D, EthikTechnology). In an orbital shaking incubator (Model Q816M22, Quimis, Diadema, SP, Brazil), the resulting residue was dispersed in 0.1 M HCl (Impex, Diadema, SP, Brazil), the pH was adjusted to 2.0, and stirring (250 rpm) at 45 °C for 110 min was maintained. The acquired residual biomass was cleaned with distilled water, then subjected to an alkaline treatment using 2 percent (w/v) Na₂CO₃ (Synth, Diadema, SP, Brazil) to modify the pH (8, 9, and 10), while altering the temperature (50, 65, and 80 °C) and duration of the process (90, 195, and 300 mins). Alginate was subsequently removed from the liquid phase using a 1:2 ethanol solution, and it was dried for 15 hours at 45 °C in a convection oven.

Equation used to compute the SA yield (%) is: Yield % = (Dry weight of alginate / Dry weight of seaweed) x100[14]

Keeran Ward al. (2022) wrote a paper titled “**Sargassum inspired, optimized calcium alginate bioplastic composites for food packaging**”. A mixture of sodium alginate was employed, including Manugel DMB and Sargassum natans seaweed that was extracted for the alginate in local East Trinidad bays (donated by FMC Biopolymer). To create the casting solutions, various plasticizer concentrations and reinforcing materials were added. Carboxymethyl cellulose (CMC) (Sigma Aldrich, Mw 700,000), potato starch (SDFCL, purity >90%), sorbitol (Sigma Aldrich, purity >98%), and polyethylene glycol (PEG200) were all used in varied amounts in casting solutions (Sigma Aldrich). The crosslinking agent was calcium chloride dihydrate (Sigma Aldrich, purity >99 percent). Magnesium nitrate hexahydrate, Mg (NO₃)₂·6H₂O (Sigma Aldrich, purity > 99 percent), was used to manage humidity.

The RSM design with DoE was used to optimize the alginate composite, resulting in the ideal film composition of 6 weight percent alginate, 0.263 weight percent starch, 0.35 weight percent CMC, 0.065 grammes per gramme of sorbitol, and 0.025 grammes per gramme of PEG 200. The composite films have a high E of 3.93 GPa, a decent WVP of 2.18 10⁻¹² g m/m², and a very low OP of 0.2 cm³ mmmd kPa⁻¹. Additionally, it was discovered that alginate composite films had equivalent material qualities to commercial HDPE, PET, and PLA and had superior OP and higher WVP.

L. P´erez-Alvarez al. (2022) wrote a paper titled “**Electro and magnetoactive printed bi-functional actuators based on alginate hybrid hydrogels**”. In 20 mL of deionized water, various concentrations of iron zerovalent NPs (1, 2, 3, 5, 10 percent w/w) were mechanically distributed. After that, sodium alginate was added to create a 10 percent weight-to-weight solution while keeping a moderate stir and avoiding magnetization for 24 hours. The prepared solutions were then put into the printer cartridges and various shapes were printed onto a petri dish that had previously been treated with a 1 M calcium chloride solution using an extrusion 3D printer (Cellink+, InkRedible+). The hybrid hydrogel strands were printed in three dimensions using an extrusion 3D printer (Cellink+, InkRedible+). To carry out the optimization of the printing settings, strands of a 10 percent w/w alginate solution with a viscosity of 7048 cP were printed at different speeds (300, 600, and 800 mm/min), with variable injection pressures (25, 30, 35, and 40 kPa). Adhesive Dispensing Ltd. Employed two distinct imprint tips with internal diameters of 0.41 and 0.254 mm (about 0.01 in). Finally, using Fiji software, the diameters of the impressions were determined from a total of three strands for each condition. The hybrid hydrogels deflect in the direction of the magnetic field when they are near a magnet or towards the cathode when subjected to an electric field (15 V). It has been demonstrated that the material’s electromechanical and magnetic response is favorably influenced by an increase in nanoparticle content (from 0% to 10%). These alginate hybrids, in contrast to previous comparable systems, have high mechanical stability and can be printed as three-dimensional actuators that can be controlled remotely[15]

Jyoti Prasad Saikia al. (2011) published article titled as “**Bioplastic (P-3HB-co3HV) from Bacillus circulans (MTCC 8167) and its biodegradation**”. The biomass of the B. circulans (MTCC 8167) was removed from the culture broth by centrifugation at 8000 g) to extract PHA. After being lyophilized, the cell pellet underwent two washes in sterile distilled water. Using Soxhlet extraction with chloroform for 24 hours, PHA was recovered from the dry biomass. The PHA was then concentrated using a rotary vacuum evaporator, and 10 vol. of ice-cold methanol was used to precipitate it. The procedure was carried out three times, and the precipitate polymer was collected by air drying and gravimetrically quantified[16]

Creation of anisotropic aligned micron-size fibrous structures and macroscale filament bundles". For 30 minutes, a 1 weight percent agar solution (aq) was heated at 90 °C to promote disintegration. The heated agar solution was run through a lab-scale colloid mill (IKA magic LAB®, IKA Staufen, Germany) with circulating cooling water at 5 C to produce agar fluid gels. With a rotational speed of 20,000 rpm, the gap width was fixed to 0.159 mm. The agar fluid gel was repeatedly sheared and cooled until it reached a temperature of 15 C. Agar fluid gel was given CaCl₂ to crosslink printed SC/SA blend. CaCl₂ was either combined directly into the created agar fluid gel or added to a heated agar solution prior to the shear-cooling process to evaluate the effect of CaCl₂ on the rheological properties of the agar fluid gel. Agar fluid gel or heated agar solution was treated with CaCl₂ at varying concentrations (0.12, 0.25, 0.33, 0.55, and 1.1 wt.%) [17]

Alessandro F. Martins al. (2020) wrote a journal on **"Biodegradable films based on commercial κ-carrageenan and cassava starch to achieve low production costs"**. The casting procedure, as previously described elsewhere with changes, was used to generate films based on -carrageenan, cassava starch, PVA, and glycerol [24]. Under magnetic stirring, distilled water was used to dissolve glycerol and PVA. The aqueous glycerol and PVA solution were then gradually supplemented with the desired amounts of –carrageenan and cassava starch while magnetically stirred for 20 minutes. For creating polymer blends and promoting starch gelatinization, the mixture was heated to 90 °C for 30 min while being magnetically stirred. To eliminate air bubbles, the mixtures were introduced to an ultrasonic bath at 25 °C for 10 min. The mixtures were then transferred to Petri dishes, which are 150 mm diameter polystyrene plates. The solvent evaporated at 40 °C for 16 hours. The casting method is effective for creating films with various carrageenan: starch concentrations of cassava starch, PVA, glycerol, and carrageenan. The mechanical, physical, and chemical characteristics of the films were significantly influenced by the weight ratio of -carrageenan to starch. When the weight ratio of carrageenan to starch was equal to 1, the WVP was lowest. A film can be chosen for the desired application based on its features[18]

Ramon Moreira al. (2022) wrote an article named **"Effect of the addition of different sodium alginates on viscoelastic, structural features and hydrolysis kinetics of corn starch gels."**

Alginates were hydrated overnight after being dissolved in distilled water. The alginate solutions were then given a weighted addition of corn starch. To aid in the homogenization of these mixes, they were physically shaken for 60 s. Following that, mixtures were heated at 100 °C for 20 min while being gently stirred by hand every 5 min for the final 10 s before gel formation. For a subsequent study, the starch gels were cooled (for 20 min) to 37 °C. The gels were made using a fixed ratio of maize starch to water (1:4) and three different amounts of alginate (w/w, starch base, 0, 1, and 2%). The appearance of elongated and uneven voids and the creation of linear partition walls that structured a spatial anisotropic network were significant effects of the addition of sodium alginates to the viscoelastic properties and structural features of the corn starch gels. Regardless of the tested alginate content, these structures remained intact. The rheological properties were dramatically altered by the addition of alginates with various origins and production processes. With the addition of alginates, weaker gels (with lower elastic modulus) were produced, and viscosity rose. When the hydrophilic character of the alginates was high, stronger gels were produced by increasing the alginate content.[19]

Jong-Whan Rhim al. (2021) wrote a journal “**Gelatin/agar-based functional film integrated with Pickering emulsion of clove essential oil stabilized with nanocellulose for active packaging applications**”. To completely dissolve the polymers, 2 g of gelatin and 2 g of agar were added to 200 mL of distilled water that also contained 1.2 g of glycerol (30 wt. percent based on polymer) as a plasticizer. This mixture was rapidly stirred at 90 °C for 1 hour. A variety of amounts of PEC (0, 1, 5, and 10 wt. percent based on the polymer) were added to the solution and stirred at 50 °C for one hour after the mixture was cooled to 50 °C. A flat Teflon film-coated glass plate was used to cast the film-forming solution onto, and it was allowed to dry for 48 hours at room temperature (22 ± 2 °C). The dry film was removed from the glass plate and treated for at least 72 hours at 25 °C and 50% RH. By adding a Pickering emulsion of clove bud essential oil stabilized with nanocellulose fiber, gelatin/agar-based functional films were created. The gelatin/agar-based films with PEC added were clear, had a strong UV light barrier, and had improved water resistance. The PEC addition had a minor impact on the mechanical and water vapor barrier qualities of the composite films. Bioactive film also shows high antioxidant activity. The gelatin/agar-films with PEC added are likely to be used in active food packaging applications, because they have better

physical and functional characteristics.[20]

Jong-Whan Rhim al. (2019) wrote an article titled **“Preparation of carrageenan-based functional nanocomposite films incorporated with melanin nanoparticles”**. Using a solution casting technique, MNP (0, 0.25, 0.5, 1 and 2 wt. percent based on carrageenan) were created. For the creation of the film solution, a predetermined quantity of MNP was dissolved in 200 mL of 0.1 M KOH while being stirred vigorously with a magnetic stirrer (Model VCX 750, Sonics & Materials Inc., Newtown, CT, USA) [19]. Next, 4 g of carrageenan was dissolved into the MNP solution while being stirred vigorously with a magnetic stirrer at 90 °C for 30 min. The film solutions were applied to a glass plate with a coated Cole-Parmer Instrument Teflon film that was levelled and allowed to dry at room temperature. Films were removed from the glass plate after drying and conditioning for 48 hours at 25 °C and 50% RH. Melanin nanoparticles (MNP) with a zeta potential of - 30.83 0.61 mV and a polydispersity index of 0.196 0.01 were monodisperse spheres with an average diameter of 98 22 nm. [21]

CHAPTER 3

AIM AND SCOPE

3.1 AIM:

The primary goal of this work is to obtain a biopolymer film with sodium alginate as the source material. Glycerol is used as a plasticizer despite other options due to its better compatibility with sodium alginate. These biopolymer films are created with one main goal in mind which is to overthrow the usage of non-bio degradable plastics which has been continuously affecting the ecosystem in worst way possible. This is the starting step towards a huge revolution and the focus is set on perfecting the film properties to compete with commercial polymer films used to make bags.

3.2 SCOPE:

The scope of this project describes about the degradable films which has several positive outcomes. The price of the film matters just next to the way of investing on it. A large-scale production of these bags makes disposing easier, making huge savings for money spent on disposal of commercial and industrial wastes every year. Easier processing and creation of film further makes it an efficient alternative to polymer bags that consumes more space and investments for production.

Choosing phycocolloids, specifically alginate derived from brown algae is chosen due to its specific binding and film forming properties which is discussed further.

Biodegradable polymers used for commercial bags sold at shops, supermarkets, malls etc., do not withstand high temperature and becomes sticky. The proposed biodegradable polymer has scope for high temperature applications

CHAPTER 4

MATERIALS AND METHODOLOGY

4.1 MATERIALS REQUIRED

The materials required for the synthesis of an alginate-based film are as follows:

- Sodium Alginate (powdered)
- Polyethylene glycol
- Glycerol
- Carboxy-methyl cellulose
- Starch
- Polyvinyl alcohol
- Distilled water

4.1.1 Apparatus Required

- Beaker (200-400 ml capacity)
- Spatula
- Measuring tube
- Petri Plate
- Magnetic stirrer heater
- Weighing machine
- Vacuum oven

4.1.2 Sodium alginate

Alginic acid along with gum are primarily taken from the cell wall of brown algae to create sodium alginate, which has chelating action. Sodium alginate binds to and prevents the intestinal absorption of several radioactive isotopes. Its molecular formula is $(C_6H_7NaO_6)_n$. It is available in the form of dry powder. The color of this substance is described as 'cream-colored' or 'yellowish brown'. Sodium alginate is almost odorless and tasteless. It is insoluble in alcohol, chloroform, ether, aqueous acid solution below pH 3, and in hydro-alcoholic solution greater than 30% wt/wt but soluble in water forming viscous, colloidal solution. A polyuronide with 1,4 linked d-mannuronic acid and l-guluronic acid units and possible additional linkage. It does not swell in a medium that is acidic. The viscosity of the solution is based on the temperature, concentration, mole weight, and the presence of

polyvalent metal cations; commercial molecular weights range between 32,000 and 200,000, with a “degree of polymerization” ranging from 180 to 930.

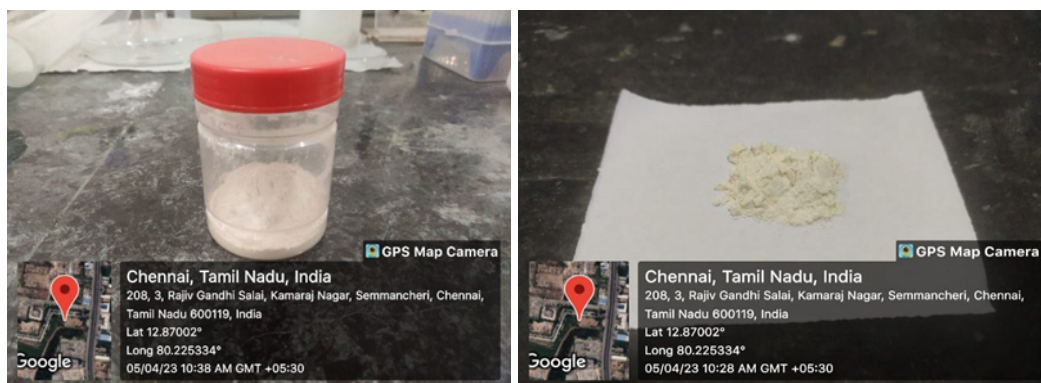


Fig.4.1: sodium alginate

4.1.3 Polyethylene Glycol

Being a polyether chemical produced from petroleum, polyethylene glycol has numerous uses in both industrial and medicinal processes. Based upon its molecular weight, PEG is also known as polyethylene oxide (PEO) or polyoxymethylene (POE). The structure of PEG is commonly expressed as $\text{H}-(\text{O}-\text{CH}_2-\text{CH}_2)_n-\text{OH}$. PEG is insoluble in diethyl ether and hexane but soluble in water, methanol, ethanol, acetonitrile, benzene, and dichloromethane. To create non-ionic surfactants, it is linked with hydrophobic compounds. PEG, a hydrophilic polymer, has been used to passivate microscope glass slides to prevent proteins from clinging to the slides in a non-specific manner when performing single-molecule fluorescence experiments. Low toxicity polyethylene glycol is utilized in several goods.

The polymer is used to cover various surfaces with a lubricant in both aqueous and non-aqueous settings. PEG is a water-soluble, flexible polymer that can be used to produce extremely high osmotic pressures. Additionally, it is unlikely to interact specifically with molecules found in living things. PEG, when using the osmotic stress technique, is one of the most helpful compounds for providing osmotic pressure in biochemistry and bio membranes investigations. PEG is considered biologically inert and safe by the FDA.

Table 4.1 Properties of Polyethylene Glycol

Appearance (Color)	White
Appearance (Form)	Fakes/powder
Solubility (Turbidity) 50% aq. Solution	Clear
Solubility (Color) 50% aq. Solution	Colorless
Molecular Weight	~8000
pH (5% aq. solution)	5.5 - 7.0
Chloride (Cl)	max. 0.001%
Sulphate (SO ₄)	max. 0.002%
Iron (Fe)	max. 0.0002%
Heavy Metals (Pb)	max. 0.0005%
Sodium (Na)	max. 0.02%
Potassium (K)	max. 0.02%
Water (KF)	max. 1.0 %



Fig.4.2: Polyethylene Glycol

4.1.4 Carboxy Methyl Cellulose

Carboxymethyl cellulose (CMC), often known as cellulose gum, is a cellulose derivative in which part of the hydroxyl groups of the glucopyranose monomers that make up the cellulose backbone are linked to carboxymethyl groups ($-\text{CH}_2-$

COOH). It is frequently used as sodium carboxymethyl cellulose, which is its sodium salt.

Available in White solid or Powdered form and is hygroscopic. It is nearly odorless. CMC is utilized in a variety of goods, both food- and non-food-related, to stabilize emulsions and modify viscosity. Since the primary source fiber is either softwood pulp or cotton linter, it is utilized largely because it has a high viscosity, is Nontoxic, and is generally thought to be hypoallergenic Sodium CMC has the chemical formula of $C_8H_{15}NaO_8$ and its molecular weight is 262.19.

Table 4.2 Properties of Carboxy Methyl Cellulose

Appearance (Color)	White to off - white
Appearance (Form)	powder
pH (1% aq. suspension)	6.5 - 8.0
Loss on drying	max.10%
Viscosity (2% aq. suspension, at 25°C)	1100 - 1900 CPS

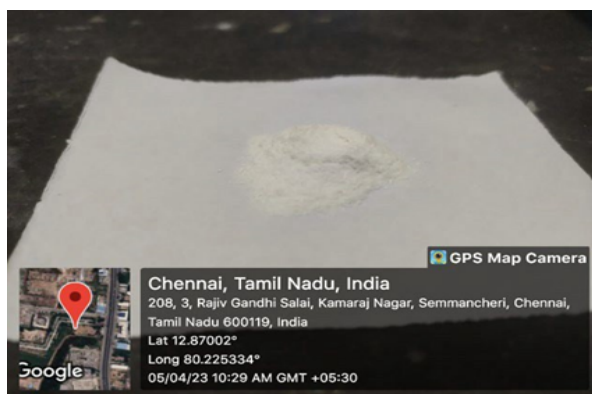


Fig.4.3: Carboxy Methyl Cellulose

4.1.5 Starch

A polymeric carbohydrate known as starch is made up of many glucose units connected by α -(1→4)- glycosidic linkages. Most green plants synthesize this

polysaccharide as a means of storing energy. It is the most prevalent carbohydrate in human diets worldwide and is present in significant levels in common foods like wheat, potatoes, *maize* (corn), rice, and *cassava* (manioc). A white, flavorless, and odorless powder known as pure starch is insoluble in both cold water and alcohol. It is made up of two different kinds of molecules: branched amylopectin and linear and helical amylose. Glycogen is a more intricately branched form of amylopectin, which serves as an animal's energy reserve.

The experimental gelatinization of the starch may partially account for the observed differences, but one cannot completely rule out the influence of SA properties.

A complicated molecule (such as starch) must be broken down into its most basic form throughout the digestive process (i.e., glucose). In vitro techniques are frequently used to examine how food behaves in the gut while replicating digestion processes[22]

Table 4.3 Properties of starch

Appearance (Color)	White
Appearance (Form)	Fine powder
Solubility (Turbidity) 2% aq. hot solution	Slight opalescent
Solubility (Color) 2% aq. hot solution	Colourless
Loss on drying	max. 15%
Sulphated Ash	max. 1%
Reducing sugars (maltose)	max. 0.5%
Chloride (Cl)	max. 0.04%
Heavy Metals (Pb)	max. 0.001%
Acidity	max. 4ml N%

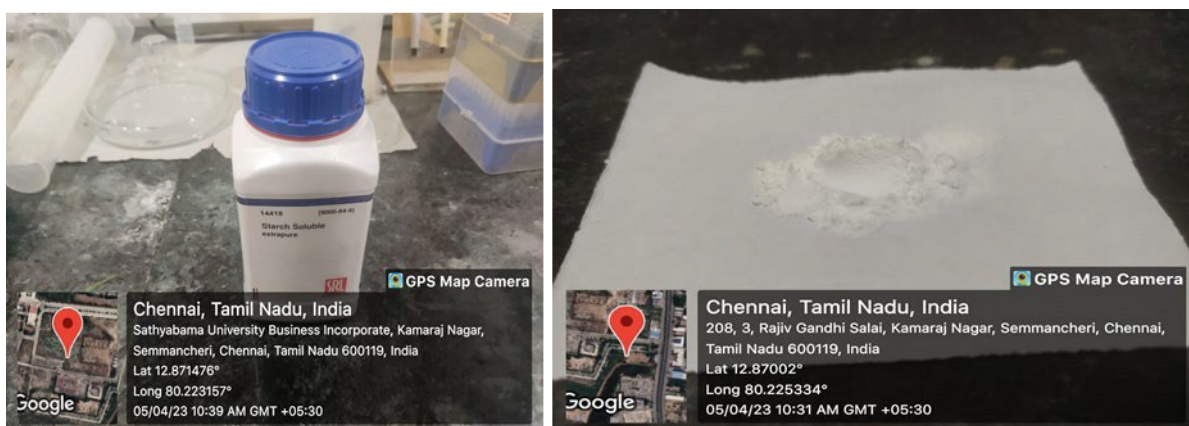


Fig.4.4: Starch

4.1.6 Glycerol

Glycerol is a triol with hydroxy groups substituting at positions 1, 2, and 3 in the propane molecule's structure. It functions as a human metabolite, an algal metabolite, a solvent, a detergent, a Gero protector, and other things. It's a triol and an alditol. Triglycerides (also known as fats and oils) and phospholipids both include a significant amount of glycerol.

Molecular Formula $C_3H_8O_3$ or $CH_2OH-CHOH-CH_2OH$ Its molecular weight is 92.09. It is a clear, colorless, odorless, syrupy liquid or solid (below 64 °F). [Note: The solid form melts above 64°F but the liquid form freezes at a much lower temperature. It has mild to no odor and a sweet, warm taste. The boiling point is around 290°C and the melting point is 18°C. Insoluble in petroleum ether, benzene, carbon tetrachloride, chloroform, carbon disulfide, and mildly soluble in ethyl ether.

Table 4.4 Properties of glycerol

Appearance (Clarity)	Clear
Appearance (Color)	Colorless
Appearance (Form)	Liquid
Colour (APHA)	max. 10
Assay (NaOH titration)	min. 99.5%
Refractive Index (20°C)	1.474 - 1.475
Density (g/ml) @ 20°C	1.257 - 1.260 g/ml
pH (10% aq. solution)	6.0 - 7.0
Residue after ignition	max. 0.01%
Chloride (Cl)	max. 0.0001%
Sulphate (SO ₄)	max. 0.001%
Iron (Fe)	max. 0.0001%
Heavy Metals (Pb)	max. 0.0001%
Fatty Acid Esters	max. 0.08%
Sugars (Glucose)	max. 0.004%
Reducing Substances	Passes

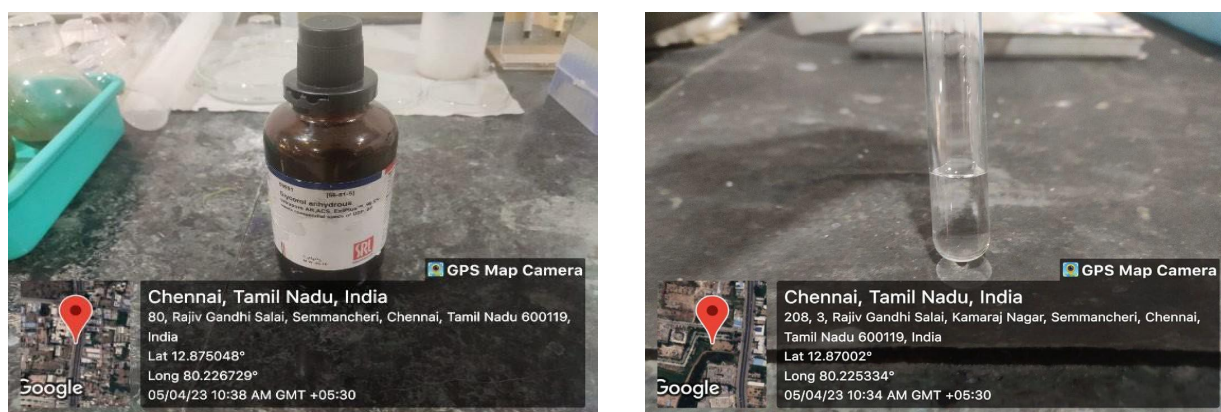


Fig.4.5: Glycerol

4.1.7 Polyvinyl Alcohol

Vinyl alcohol and vinyl acetate can be copolymerized to create polyvinyl alcohol (PVOH), a hydrophilic linear polymer. As a result, the degree of polymerization and hydrolysis determines the structural characteristics of polymers made of polyvinyl alcohol. These modifications include esterification, etherification, crystallization, and ion-polymer complexation in the polymer, among other chemical and physical processes. PVOH structures that have been modified can be used in biomedical applications. To create a mixed-matrix membrane, NaA zeolite particles were combined with a poly (vinyl alcohol) matrix. This membrane will be used to research the pervaporate separation of water-butanol mixtures. Biocompatible polymeric scaffolds made of gelatin and poly (vinyl alcohol) have been utilized to build 3D cancer models. Its Linear Formula is $[-CH_2CHOH-]_n$.

For usage in food, polyvinyl alcohol comes in the form of a translucent, tasteless, and white or cream-colored granular powder. While it is insoluble in other organic solvents, it is soluble in water and just marginally soluble in ethanol. A typical pH range for a 5 percent solution of polyvinyl alcohol is 5.0 to 6.5. The melting point of polyvinyl alcohol is between 180 and 190°C.

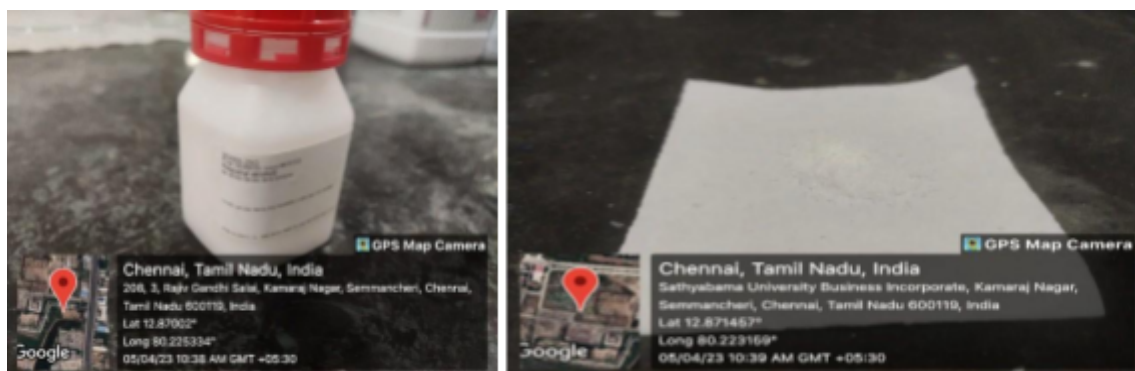


Fig.4.6 Polyvinyl Alcohol.

4.2 METHODOLOGY

4.2.1 *Experimental Procedure for Film Preparation*

- Sodium alginate is an extract from brown seaweed (sargassum) and is collected in fine powdered form.
- Polyethylene glycol (PEG), glycerol, carboxymethyl cellulose (CMC) and starch are purchased from Sisco Research Laboratories Pvt Ltd. Polyvinyl alcohol is purchased from Sigma Aldrich Co.



Fig.4.7: Samples of the chemicals



Fig.4.8: Measuring the weight of chemicals.

- The obtained chemicals are weighed in desired quantities and kept ready for mixing.
- A beaker containing 100 milliliters of distilled water is taken. The beaker is kept in a magnetic and stirring heater.

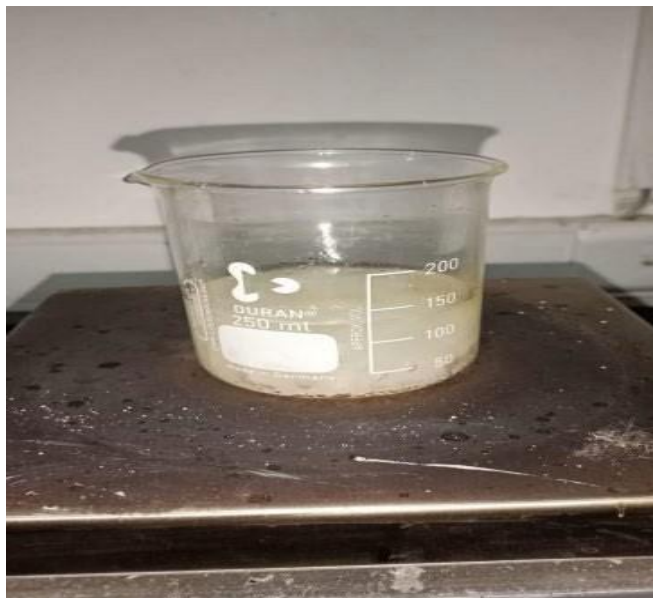


Fig.4.9: Mixture of components

- The chemicals are added one after one when the stirrer activates. The sample is prepared at 80°C for 2 hours at continuous stirring.
- The sample turns to gel consistency after the timeline. The processed sample is then transferred to a petri plate.



Fig.4.10: Mixture being placed in a magnetic stirrer heater and processed.

- The petri plate is kept at room temperature for 12 hours to allow the sample to cool and settle.
- Then the plate is further placed in a vacuum pressure oven under 60°C for 24 hours.
- Finally, the film is formed on the surface of the plate which is removed carefully.
- The obtained sample shows properties like that of a polymer film.
- The obtained sample undergoes characterization tests.



Fig.4.11: The sample obtained as a result

4.2.2 Chemical composition

Each chemical is weighed respectively at same ratio per sample. A total of twelve samples are prepared out of which one sample is chosen to undergo further tests.

The more the sample shows the properties of the film, the more likely it is chosen as the expected product result. The list of samples prepared are shown in the table as follows:

Table 4.5 Chemical composition of samples

SAMPLE	PEG (g)	ALGINATE (g)	GLYCEROL (ml)	CMC (g)	STARCH (g)	PVA (g)
A	5	5	5	5	x	x
B	1	1	1	1	x	1
C	2	2	2	2	x	2
D	2.5	2.5	2.5	2.5	x	2.5
E	4	4	4	4	x	4
F	3	3	3	3	3	x
G	1	1	1	x	1	x
H	2	2	2	x	2	x
I	2.5	2.5	2.5	x	2.5	x
J	3	3	3	x	3	x
K	2.5	2.5	2.5	x	2.5	x
L	1	1	1	x	1	1

4.2.3 Mixing and Heating

100 ml is the standard amount of water for every sample that is prepared. The film-forming solution was prepared by a casting process.[23]

A 200ml/400ml beaker is taken and filled with 100 ml of distilled water. A magnetic pellet is dropped inside it and placed in a magnetic stirrer heater. The stirrer is set at 500 rpm (rotations per minute). As the water begins to stir, the chemicals are added one by one, alginate being the last. The chemicals should be added very slowly to ensure that they mix well and do not form clumps. Formation of clumps makes dissolving of alginate difficult and disturbs even distribution while obtaining film. Then 80°C is set and stirrer is left undisturbed for 2 hours.

4.2.4 Cooling and Drying

The obtained sample from the stirrer is transferred from the beaker to a petri plate. It is left unclosed for a few minutes. The petri plate is then closed and left undisturbed overnight. Then the sample is placed in a vacuum oven under 60°C for 24 hours. The residual moisture content from the sample is removed by the oven and the plate is then taken out.



Fig.4.12: Dried Sample

4.2.5 Extraction of Prepared Film

The film formed on the surface of the Petri plate is carefully removed using forceps.

An aluminum foil can also be used as a base to obtain the fragile sample without tear. The extracted film is transferred to an airtight cover.



Fig.4.13: obtained film

4.3 SAMPLE OVERVIEW

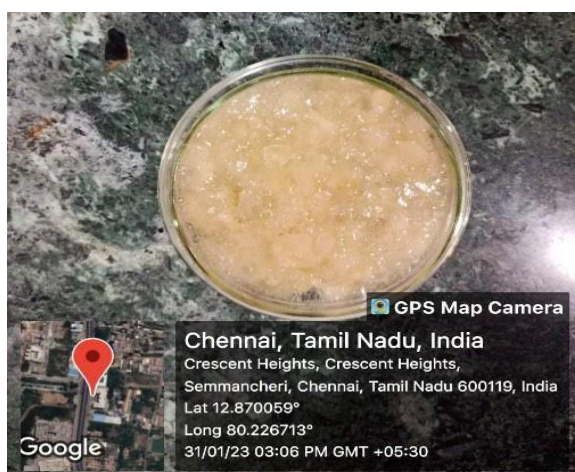


Fig.4.14: Sample A containing 5g of PEG,5g of Alginate,5g of Glycerol and 5g of CMC.



Fig.4.15: Sample B containing 1g of PEG,1g of Alginate,1g of Glycerol,1g of CMC and 1g of PVA.



Fig.4.16: Sample C containing 2g of PEG,2g of Alginate, 2g of Glycerol,2g of CMC and 2g of PVA.



Fig.4.17: Sample D containing 2.5g of PEG,2.5g of Alginate,2.5g of Glycerol,2.5g of CMC and 2.5g of PVA.



Fig.4.18: Sample E containing 4g of PEG,4g of Alginate,4g of Glycerol,4g of CMC and 4g of PVA.



Fig.4.19: Sample F containing 3g of PEG, 3g of Alginate, 3 ml of Glycerol, 3g of CMC and 3g of Starch.



Fig.4.20: Sample G containing 1g of PEG, 1g of Alginate, 1 ml of Glycerol, and 1g of Starch.



Fig.4.21: Sample H containing 2g of PEG, 2g of Alginate, 2 ml of Glycerol, and 2g of Starch.



Fig.4.22: Sample I containing 2.5g of PEG, 2.5g of Alginate, 2.5 ml of Glycerol, and 2.5g of Starch.

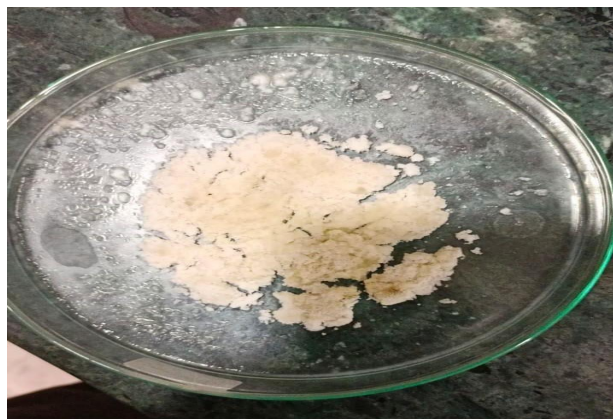


Fig.4.23: Sample J containing 3g of PEG, 3g of Alginate, 3ml of Glycerol and 3g of Starch



Fig.4.24: Sample K containing 2.5g of PEG, 2.5g of Alginate, 2.5 ml of Glycerol, and 2.5g of Starch.



Fig.4.25: Sample L containing 1g of PEG, 1g of Alginate, 1 ml of Glycerol, 1g of Starch, 1 ml of PVA.

CHAPTER 5

RESULTS AND DISCUSSION

5.1 CHARACTERISATION RESULTS

5.1.1 FTIR Analysis

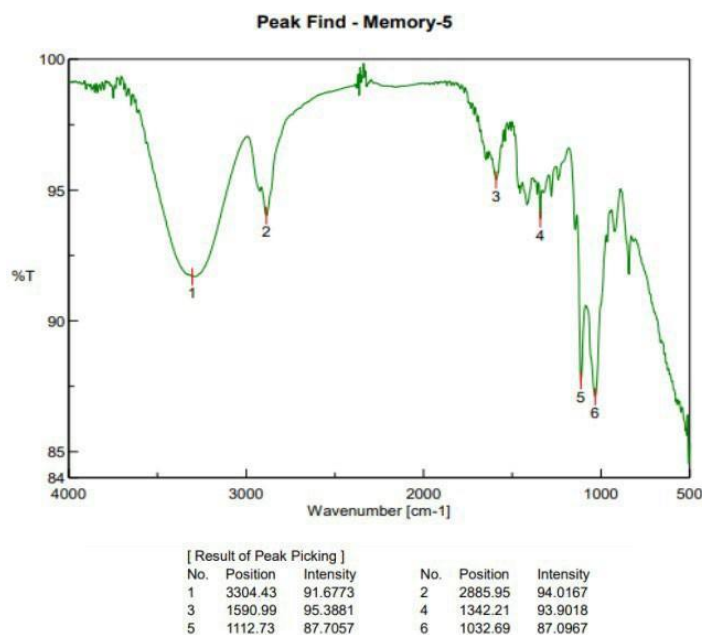


Fig.5.1: FTIR analysis

Because of the O-H group's stretching frequency, the alginate film's absorption band at 3304.43 cm^{-1} is clearly visible. Upon combining all of the ingredients with the alginate film, the O-H band in the alginate powder was moved. Alginate's absorption in the COO- band was boosted when carboxylate-containing groups in CMC at (1590 cm^{-1}) were combined with it. According to this, the polymer matrix's intermolecular hydrogen bonds were broken, which caused vibrations of the C-O and C = O to be amplified. Shifts at 1342 cm^{-1} observed in the alginate film were attributed to the C-O stretch in the ester bonds formed between the hydroxyl groups in glycerol and PEG and the carboxylic acids found in CMC and alginate. This established a stable structure and demonstrated compatibility.

5.1.2 Energy Dispersive X-Ray (EDX Analysis)

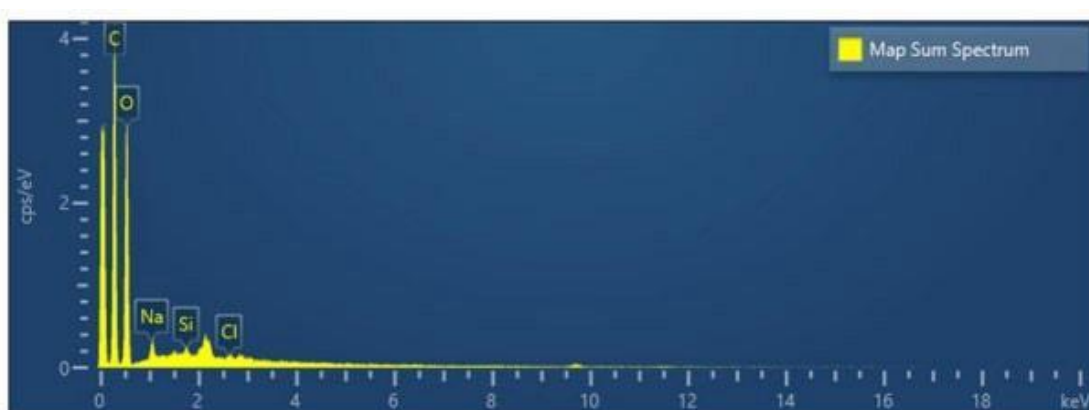


Fig.5.2: EDX analysis

Table 5.1 Map sum spectrum

Map Sum Spectrum				
Element	Line Type	Weight %	Weight % Sigma	Atomic %
C	K series	55.74	0.53	62.91
O	K series	42.87	0.52	36.33
Na	K series	1.00	0.09	0.59
Si	K series	0.22	0.04	0.10
Cl	K series	0.18	0.04	0.07
Total		100.00		100.00

The EDX pattern with weight percentage of alginate film. The elemental composition of the film sample was studied using EDX analysis pattern confirms that the prepared alginate sample primarily contains carbon (55.74%), oxygen (42.87%) and sodium (1%).

5.1.3 FESEM Analysis

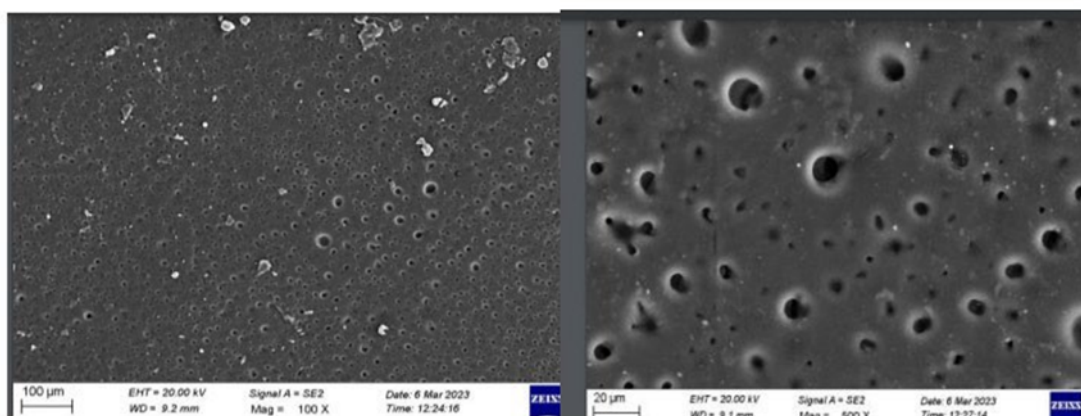


Fig.5.3: FESEM Analysis

The morphology of the prepared Alginate sample was analyzed using SEM studies. SEM images of the sample show a rough and porous surface without certain geometry.

5.1.4 Tensile Strength Test

The prepared biopolymer film undergoes tensile strength test. The test is done by machine model M-50. The specimen is given as 6 samples with the dimensions of (15mm x 2mm). the specimen thickness is specified as 2 mm.

The initial G.L for percentage of elongation is 45mm. the output data shows load at yield to be 0.86N. Elongation at yield is 1.210 mm and elongation at peak is 10.006 mm. Elongation at 10.006 mm. The load at peak and break are both 2.120 N. Yield stress is 0.029 N/mm². The tensile strength of the film is shown as 0.071 N/mm².

Three graphs depicting the tensile properties of the polymer film are as follows:

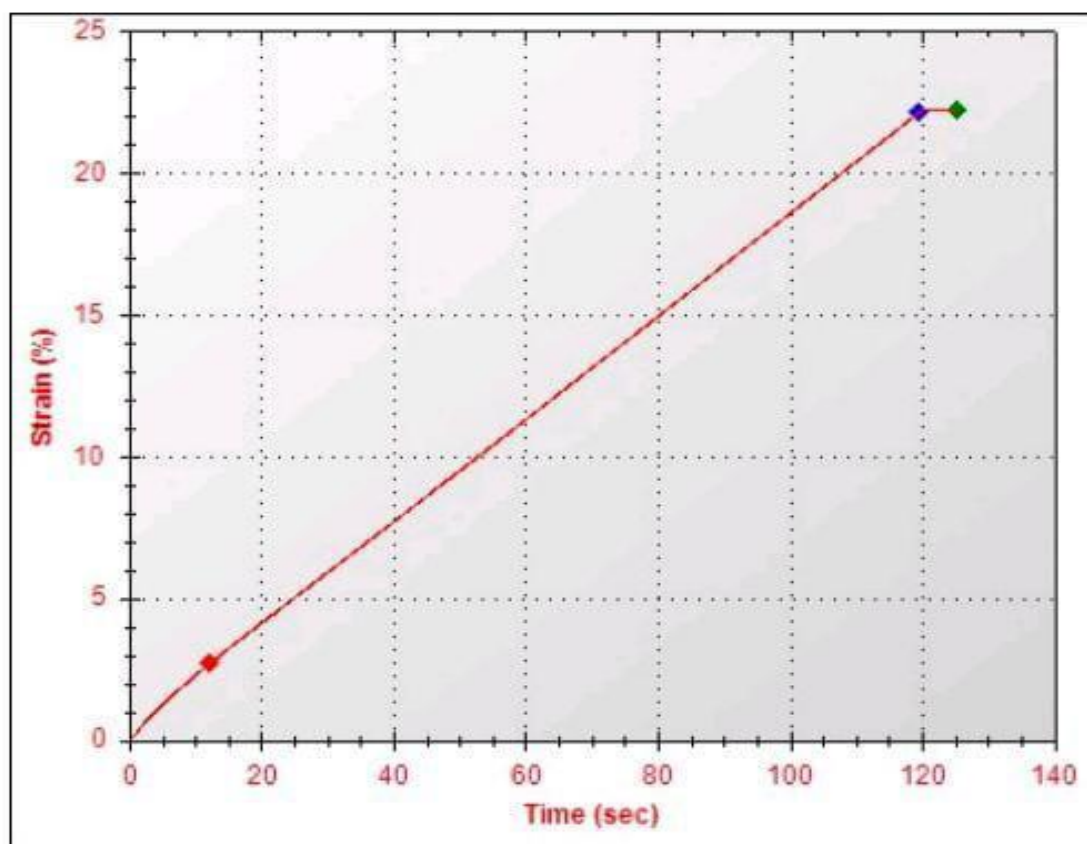


Fig.5.4: Strain vs Time

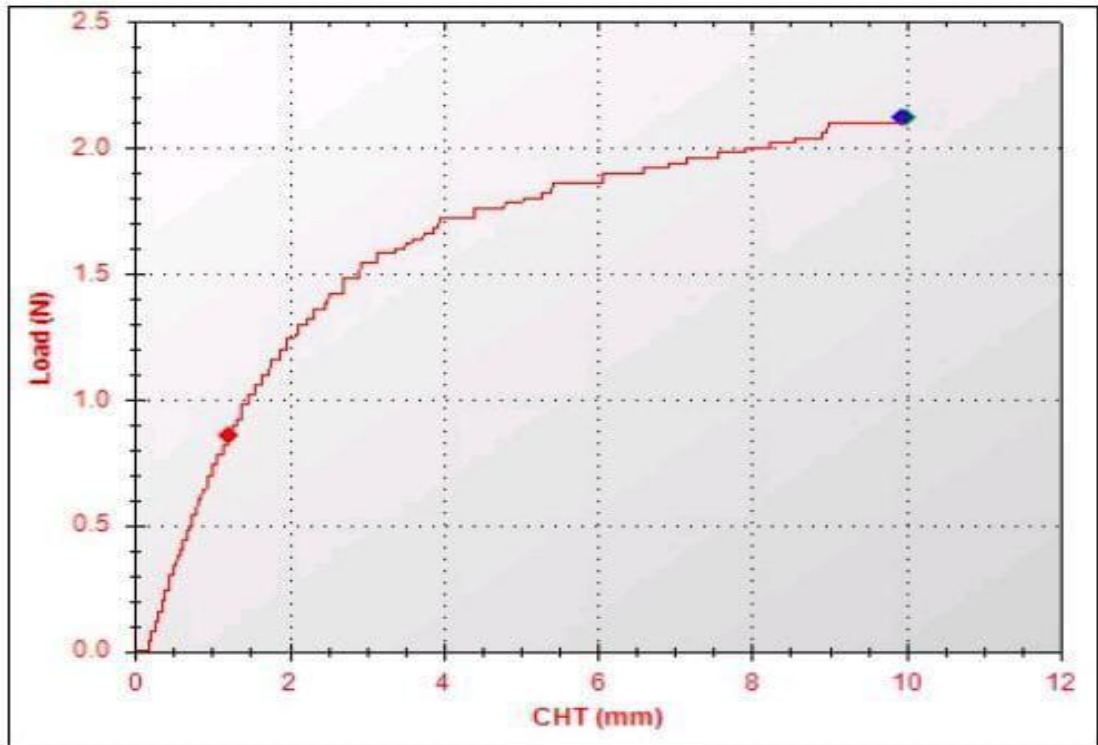


Fig.5.5: Load vs Cross Head Travel

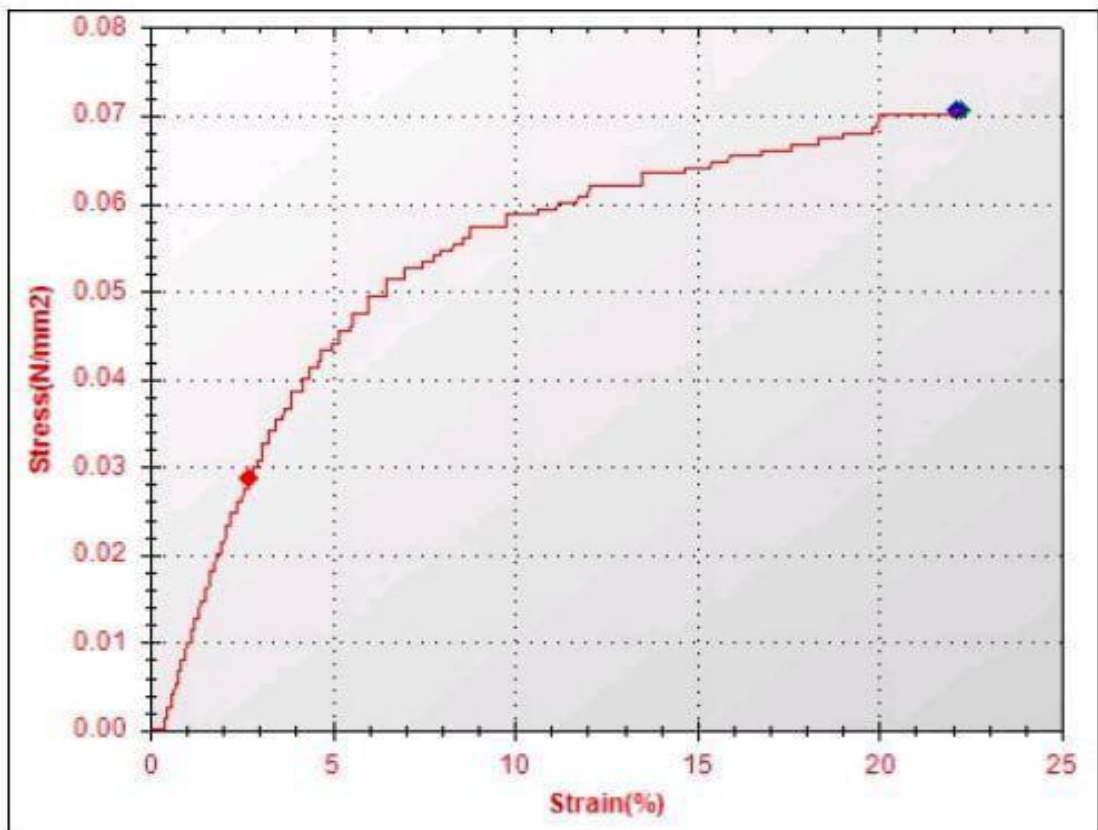


Fig.5.6: Stress vs Strain

5.1.5 Thermo-Gravimetric analysis (TGA)

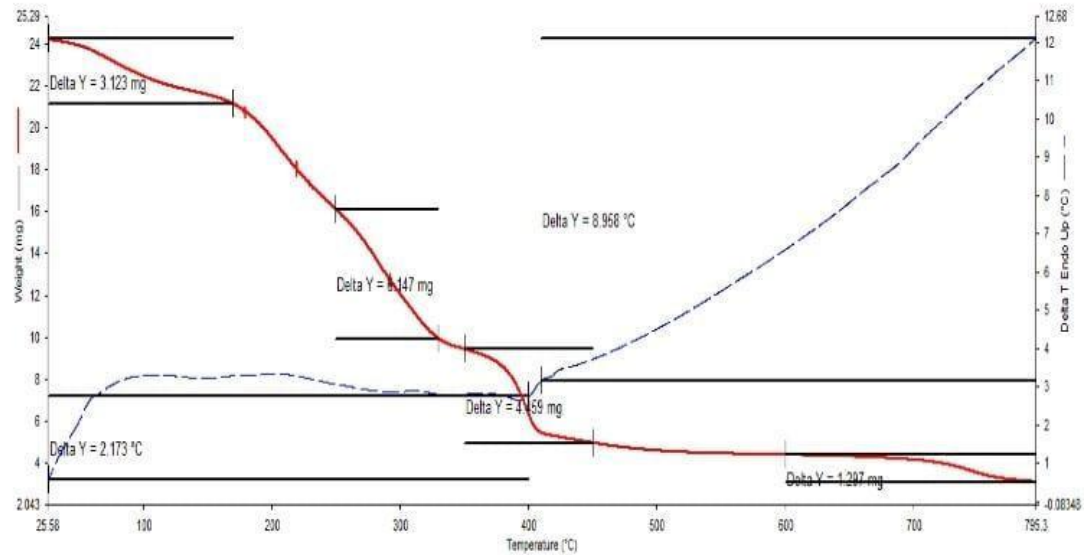


Fig.5.7: Thermo-Gravimetric analysis

5.1.6 Bio degradation test for the film



Fig.5.8: Observation-Day 1

- Sample is placed in a beaker containing agricultural soil
- No changes are observed



Fig. 5.9: Observation-Day 6

- Sample shows slight changes in texture and appearance.
- Water is added regularly to maintain the moisture in soil.



Fig. 5.10: Observation-Day 10

- Reduction of thickness is observed
- Pore formation is observed
- Tear across the film is observed.

5.2 BIOPOLYMER BAG PRODUCTION

The obtained film is made into a long rectangular film. This film is then heat pressed on parallel sides to be converted into usable bags.





Fig.5.11: Biopolymer Bag

CHAPTER 6

SUMMARY AND CONCLUSION

Polysaccharides from seaweed proves to be one of the best alternative sources for production of bio based plastic films. Alginate is made strong and flexible by the copolymers. Alginate is a crucial industrial polysaccharide due to qualities including high viscosity, gelling abilities, and high stability. Alginate has shown exceptional compatibility with the chosen materials for reinforcement and plasticizers. Binding affinity of glycerol has made it an obvious choice as a plasticizer. Additionally, carboxy methyl cellulose and polyvinyl alcohol slightly enhances the mechanical properties of the obtained alginate films. This paper follows the process of thermal mixing and casting to obtain the alginate films. Mixing alginate along with plasticizer and reinforcement materials under a controlled process environment with stable temperature and fixed time gives better films. The heated sample is then allowed to cool for extracting films easily. Vacuum oven is used to dry the sample under stable conditioning. Under previous studies this process has proved to be effective and shows promising results. Moreover, the requirement of low amount of equipment and low energy consumption compared to other techniques for extraction makes this process a more optimal choice and solution.

Several combinations of samples were prepared and the combination showing a more positive and expected result is chosen. Collection of experimental data from every sample proved to be effective to obtain a result easily. Based on physical appearance and resemblance to an actual polymer film, the sample is chosen for further analysis. Therefore, choosing the right models and creating an effective experiment are essential for getting accurate results. Overall, the application of alginate as a source of this alternative film production and using thermal mixing and cooling presents a viable strategy for process improvement, cost reduction, and the creation of a productive and scalable process

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Vijay report

by Rishikiran A

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CHAPTER 1 - INTRODUCTION

Plastic materials are an ideal for many applications, such as in wrapping, construction supplies and goods and services, in addition to personal hygiene products, can also cause waste-disposal problems because these components are not degradable as well as their rigidity to biodegradation, they build up in the environment. The interest in biodegradable polymers, and specifically biodegradable biopolymers, has been sparked by these facts. In the 1980s, the primary bio plastics and polymers were introduced. The production of many items we use on a daily basis, including defence goods, sanitary items, tiles, bottles made of plastic, faux leather, and other household items, uses plastics, the backbone of many industries. Plastic is also used for packaging in the food, drug, detergent, and cosmetic companies. [1].

Although synthetic polymers are made from non-renewable resources, natural polymers can be found in extremely larger amounts from renewable sources. The Greek term "Plastikos," which meaning that may be molded into multiple shapes, is where the English word "plastic" originates. Plastics were discovered to be polymers that shift when heated and can be cast into moulds. [[2]

Unfortunately, their barrier and mechanical properties still do not match the synthetic reference polymers, and its cost of production are too high for them to be competitive on the market. In this regard, cellulose-rich aquatic plants and seaweeds are being investigated as an effective substitute for terrestrial biomass for the synthesis of bio-based polymers. Due to different dispersion mechanisms, plastics have different fracture properties than elastomers. Finding out whether identical crack growth occurs in degradable plastics is urgent.. [3]

The usage of seaweed waste materials stream, such as those produced during alginate manufacture, may be of particular relevance. Sea weed is widely available in many nations, including India. In order to create a sustainable bioplastic, the current work's goal is to extract sodium alginate from sea weed. Alginate is the sodium salt type of alginic acid infused with gum predominantly derived from the cellular membranes of brown algae and has chelating activities.

1.1 BIO DEGRADABLE POLYMER:

Enzymes and/or chemical breakdown linked to live organisms are responsible for biodegradation. The steps involved are pretty much simple. The first is the breakdown of polymers into lower molar mass, either through biotic/abiotic events. In the next step, assimilation and mineralization of biopolymers takes effect, which is done by bacteria. In addition to the polymer's place of origin, biodegradability also depends on the polymer's chemical make-up and the environment's parameters for environmental degradation.

The mechanisms of polymer biodegradation and estimate methods have been examined. The chemical composition, production, storage, and processing features, ageing, and application condition influence the mechanical characteristics of biopolymers. Biodegradation is the mineralization of organic material done by microorganisms (such as fungus and bacteria) ultimately producing both H₂O and CO₂ as the final products in an aerobic environment. Biotransformation occurs when mineralization is incomplete produces organic and inorganic metabolites, often known as transformation products.

Extracellular enzymes secreted by microorganisms carry out the most necessary biodegradation processes for bio plastics, including the breakdown of ester linkages for releasing monomers. Since the substrates are mostly at larger sizes, biodegradation of relatively smaller molecules mostly happens outside the microbe. A portion of the substrates is cut off by the active sites of extracellular enzyme, creating a complex due to interaction.

The majority of bacteria utilize a system of many enzymes to completely biodegrade a substrate. These biological activities make up a compound's whole breakdown. When abiotic processes take place which degrade the material chemically and physically, such as photo - degradation and biochemical hydrolysis under hot, acidic/basic conditions.

Both the abiotic and biotic properties can interact with one another. Mechanical degradation makes a polymer more susceptible to enzymatic breakdown, hence boosting biotic degradation. Mechanical deterioration might result through micro faunal activity, like earthworms breaking down excretes and incorporating it into the

mineralized soil. Both the abiotic and biotic processes contribute to the overall breakdown.

1.2 ADVANTAGES OF BIO DEGRADABLE POLYMER:

Recycling of bio-based polymers is done mostly using organic methods. Degradation time is much lower and these polymers tend to have no toxic properties. They also tend to serve as source material for biogas.

Considering cost and land space, biopolymers seem to be an optimal solution. Recycling process reduces landfill requirements and high production cost gets compensated by low disposal costs.

Production of these plastics focuses primarily on environmental effects. These plastics has low energy requirements for production. Location access and transportation are not major factors influencing the production of bio plastics unlike conventional polymers. This will result in less pollution because less fossil fuels will be used. Also, it significantly benefits the environment because during manufacturing it creates 68% less greenhouse gases.

On the basis of the ingredient used for preparation the bio - plastic and the disposing technique, biodegradable polymers only degrade over a few months. 13 % of the waste product stream, or thirty-two million tons of rubbish every twelve months, is made up of other classic plastic types, of which only 9% can be recycled.

The usage of biodegradable plastics is preferable due to their quick degradable properties while consumed by the soil, and their conversion into compost feed. Moreover, even if a complete breakdown doesn't take place, it is easier to decrease the quantity of land needed to dispose of the entire plastic waste produced.

Seaweeds are multicellular, macroscopic benthic algae that grow more quickly than terrestrial plants and are more efficient at photosynthesis, resulting in a rapid buildup of biomass. It makes a sizable contribution to aquatic plant matter and is responsible for approximately fifty percent of the world's primary productivity. [[4].

Brown seaweed appears in a wide range of sizes, species, and general

morphologies, but they typically have a brown color because of a pigment produced during photosynthetic processes. *Laminaria pallida*, *Fucus* species, and *Zonaria* species are common varieties of brown seaweed. Brown seaweed contains the polysaccharides alginate, laminarins, and fucoidans (FUC) [5].

Over time, there has been a tremendous increase in the production of plastics. According to estimates made by scientists, there may be more polymers in the ocean than aquatic organisms by the year of 2050. At that point, 80 percent of the water supply will be contaminated with micro plastic. With the development of biodegradable polymers, the world can expect forward to a time when plastics can break down and release only the energy required to create them.

Emissions of carbon dioxide are also reduced because fossil fuels are not needed to make such environmentally beneficial, biodegradable plastic products. They only release as much CO₂ during their breakdown as was used up during their production, not more.

Traditional plastics can release methane, hazardous substances, and other forms of contaminants into the environment when they are discarded. These substances are potentially harmful as they degrade because they can easily harm both terrestrial and aquatic ecosystems as well as general human health. Natural decomposition is a frequent occurrence in which living things, particularly bacteria, convert complex organic matter into a simple organic component. The enzymatic breakdown of the plastic provides nutrients to the bacterium. The energy and carbon needed for their growth and development are sourced from plastic garbage [[6]]

1.3 CLASSIFICATIONS OF BIO DEGRADABLE POLYMER:

The Bio degradable polymer are classified into three parts, they are polysaccharides, polynucleotides and polypeptides.

1.3.1 Polysaccharides:

The most common type of carbs in diet are polysaccharides, also known as polycarbohydrates. These are polymer carbohydrate of longer chains made up of monosaccharide linked by glycosidic bonds. Using amylase enzymes as a catalyst, these carbohydrates can react with H_2O (hydrolysis), releasing carbohydrates (monosaccharide, or oligosaccharides).

They come in a various shape, from straight to heavy branching. Examples are structural polysaccharides like cellulose, chitin, starch, glycogen, and galactogen.

Often quite diverse, recurring unit variations can be seen in polysaccharides. These macromolecules' characteristics can differ from those of their monosaccharide building units depending on the structure. They might even be water insoluble or amorphous.

Homopolysaccharides, also known as homoglycans, are polysaccharides that contain only one kind of monosaccharide; meanwhile, heteropolysaccharides, also known as heteroglycans, are polysaccharides that contain many types of monosaccharides.

Natural saccharides consist of monosaccharides and are simple carbohydrates with the formula $(CH_2O)_n$, where n is two or higher. Monosaccharides include sugars including glucose, fructose, and glyceraldehyde. The standard formulae for polysaccharides are $C_x (H_2O)_y$, where x is often a big value from 200 and 2500. The generic formula becomes $(C_6H_{10}O_5)_n$ when the two subunits in the polymeric matrix are six-carbon monosaccharides, which is frequently the case. Typically, n 3000.

The physiological and physicochemical properties of alginates are governed by the ⁴⁵ M/G ratio, the arrangement and distribution of the acid blocks in the polymers backbone, and other factors. According to the species, the type of cells, age, or

harvesting season, these variables change. This is because rigid and brittle the alginate gels have been shown to have minimal M/G ratios while elastic and flexible works are known to possess elevated M/G ratios. They are particularly well-liked food additives because of their stabilising, thickening, and gelling properties..[7]

1.3.2 Polynucleotides:

The ester bonds between the phosphoryl and the hydroxyl of the carbohydrate of the following nucleotide provide the basis of a biopolymer that is made up of a continuous, linear chain of nucleotides.

A polynucleotide is a mixture of several nucleotide (as opposed to oligosaccharides comprised of only a few, i.e., about three to twenty). Each isomeric component is made up of a phosphate group, a 5-phosphate moiety, and a nucleobase. The monomers are joined to form a chain by ester bonds, which are created by the group of phosphates of a single nucleotide and a hydroxyl group of the glucose in the nucleotide after it. Polynucleotides are one of the primary bio polymers, along with polymers and polypeptides.

A pentose, a nitrogen base, and a phosphate molecule are the three components that make up each monomer. A phosphodiester connection connects the phosphate groups and pentose sugar. Adenine, Cytosine, Guanine, and Thymine or Uridine are the four nitrogenous bases.

1.3.3 Polypeptides:

A longer, unbranched, continuous peptide chain is referred to as a polypeptide. Polypeptides are with a molecular mass of one million Da or more are considered proteins. Chains with fewer than 20 amino acids are referred to as oligopeptides and include dipeptides, tripeptides, and tetrapeptides. Peptides, along with nucleic, disaccharides, polysaccharides belonging to the vast chemical like biological polymers with oligomers.

Enzymes are biocatalysts that take part in reactions, act on certain substrates, and hasten the transformation of those substrates into useful products. The potential for

microorganisms to break down the plastic that pollutes our environment has raised interest in the fundamental process by which microbes can break down this extremely durable polymer [8]

1.4 PHYCO-COLLOID

The phyco-colloids that are extracted from diverse red and brown seaweeds include agar, alginate, and carrageenan. They are an extremely large-molecular, non-crystalline material that dissolve in water to produce a viscous solution. These are water-soluble carbohydrates that are used to stabilize some goods, such as ice cream, thicken aqueous solutions, make gels (jellies) of varied degrees of stiffness, and form water-soluble films. These phycocolloids are used in a variety of industries.

1.4.1 Agar

Agar makes up the majority of the cell wall of red seaweed from the families Gracilariaceae, Gelidiellaceae, and Gelidiaceae. *Gelidium* sp, *Gelidiellaacerosa*, *Pterocladia* sp, and *Ahenfeltia* sp. are all used to make agar. A chain of 9-B galactopyranose units connected by 1, 4 bonds to a sulphated L-galactose makes up agar.

Agar's propensity to gel and the special qualities of these gels make them frequently used in a variety of applications. A little portion of the agar produced is used in bacteriology and other biotechnological applications, while the majority of it is used for food applications. Agar has been designated as Safe by the USFDA. Agar is utilized in the baking industry as a stabilizer and thickener in pie fills, icings, and meringues since it can resist higher temperatures. Pies, buns, and are frequently pre-packaged in a variety of contemporary wrapping materials and frequently adhere to them, particularly when it is hot, but by lowering the amount of water and adding some agar, this issue can be solved.

Agar for bioplastic has primarily been produced via the extrusion method and is still in the early stages of development. The melting point, thermal decomposition, and chemical qualities must be understood for the optimal extrusion. Water addition during the extrusion process for producing agar-based bioplastic was noted [9]

It won't melt while being sterilized and canned. Because of its stronger gel and

greater melting temperature than gelatin, agar is also utilized in the production of gelled meat and fish items.

Agar has been utilized to stabilize ices when combined with other gums. Agar is not easy to digest, therefore it adds less calorific value to meals, improving the quality of dairy like cream, cheese, and yoghurt. It serves as a meat alternative in vegetarian cuisine. Agar is used in canned fish and meat products as a protective covering against the impact of metal cans and also against shaking while these products are being transported. Wines, beers, and liquors can all benefit from the clarifying properties of agar. It serves as a laxative for those with chronic constipation, a medication delivery system in the pharmaceutical sector, and an ion exchanger in the production of ion exchange resins.

Agar is used as a cleaning and sizing agent in the paper companies as well as a component of skin lotions and ointments in the cosmetic sector. As a growth medium, nutrient-supplemented agar gels can be used to produce clones or duplicates of specific plants. Meristems, or the portion of the plants with continuously dividing cells, are often the stem tips that are cultivated in gel until they are large enough to be transplanted and have developed enough roots. This technique has the benefit of allowing for sterile cultivation of the plants. In order to test for microorganisms, we utilize purified bacteriological agar.

1.4.2 Alginate

Alginate has been extensively employed in a variety of biomedical applications, including drug administration, regenerative medicine, and wound dressing.

The phyco-colloids that are extracted from diverse red and brown seaweeds include agar, alginate, and carrageenan. They are an extremely large-molecular, non-crystalline material that dissolve in water to produce a viscous solution. These are water-soluble carbohydrates that are used to stabilize some goods, such as ice cream, thicken aqueous solutions, make gels (jellies) of varied degrees of stiffness, and form water-soluble films. These phycocolloids are used in a variety of industries

Alternative methods were employed to create covalent cross-linked alginate hydrogels in order to increase the stable and ion cross-linked alginate hydrogels, which can dissolve under physiological conditions via the interchange of divalent with monovalent cations. Therefore, the study explains to valorize the waste production following a standard alginate extraction from brown seaweed species in order to extract less pure cellulose-based fractions using more straight forward extraction procedures. Additionally, the effectiveness of these fractions in producing bio-polymeric films for use in edibles packaging is assessed, looking over the impact of the various fractions' compositions on the functioning of the films.

Alginate was modified a decade ago to allow for hydrolysis in physiological settings, permitting the utilization of alginate-based hydrogels for purposes where hydrogel breakdown was necessary. Alginate's backbone can be functionalized with hydroxyls to produce oxidized alginate (OA), also known as alginate di-aldehyde. However, the application of bioplastics made from alginates is restricted due to their high stiffness, high brittleness, low deformability, and moisture sensitivity when compared to synthetic polymers used in everyday life. However, these issues can be solved by using composite technology in combination with additional natural polymers, plasticizers, and reinforcement elements [10]

Algin is used as a filler in the production of tablets, pills, and as the base of any topical application. It is also employed as an emulsifier in watery emulsification with fats, oils, and waxes. A blood-stopping plaster is made of alginate gauze. Alginate is regarded as a slimming agent since it transforms into a gel in the abdomen and causes a sated feeling. Laminar flow hoods employ ammonium alginate wool as a microorganism filter.

Due to their capacity to form films, alginates are used in the cosmetic, detergent, and soap-making industries as thicken and dispersion agents in the manufacture of ointments, cream, liquid emulsions, lotions, and toothbrush as well as an addition in hair dye and shampoos. Shaving creams' consistency is improved by alginates. Alginates are used to create fixatives for denture moldings.

Alginates are a component of baking emulsions and enhance the baking qualities in the food sector. They are utilized to create fruit imitations and sugar glazes. Products created from jelly are made from insoluble alginates and water (calcium alginates).

Alginates are frequently recommended as a gelation ingredient in jams and marmalades in many different nations. Alginates are frequently found in dairy goods including soft cheese, custard, custard powder, milkshake combined with chocolate, and cheese. Alginates provide milk mixtures a uniform viscosity and high whipping ability when employed as stabilizers. Alginates are used in beverages as foam stabilizers in beer, a clarifying agent for wines, and a raw spirit of sugar and molasses.

Products containing meat and sausage are given a longer shelf life using alginate film. Especially for vegetarians, artificial casing with an alginate basis have been created for tiny sausages. For the deep cooling of fish, meat, and poultry products, alginate gel is used. Because they are biodegradable and biocompatible, alginate chitosan polyelectrolyte complexes are extensively researched [[11]. Chitosan alginate polyelectrolyte complexes outperform polymers alone when employed as coated membranes or controlled release delivery systems because they are more resilient to pH changes and more effective at safeguarding enclosed components.[12]

1.4.3 Carrageenan:

Carrageenan actually is a sulphated galactan polymer which is derived from a variety of red seaweeds that belong to the groups Gigartinaceae, Solieriaceae, and Hypneaceae. Its larger sulphated fraction and higher ash content are its key differences from agar. The 1, 3, and 1, 4 connected D-galactopyranose units that make up the carrageenan polymer's backbone differ in their level and location of sulphated esterification. There are two fractions of carrageenan that may be distinguished: kappa carrageenan, which has a branched polymer chain, and iota carrageenan, which has a linear polymer chain. Carrageenan typically has a high molecular weight, ranging from 100 to 1000 kDa on average. Other polysaccharide residues and substituents such as glucose, xylose, uronic acids, methyl ethers, and

pyruvate groups are also present⁶ in addition to the ester sulphate and galactose groups as the major backbone in its structure.[13]

Dairy products are the principal application for carrageenan. Whey separation is avoided by adding 0.01–0.04% of Kappa carrageenan to cream cheese and ice cream. Comparable numbers of kappa can be added to keep the cocoa in hot chocolate suspended; this creates a weak highly viscous liquidated gel that's firm when vigorously shaken. By avoiding the separation of fat, lambda or a combination can also enhance liquid coffee whiteners. Kappa may have been added to the tiny bottles of ultra-high temperature sterilized milk seen in the fridge of some hotels to stop the separation of the fat and protein.

Carrageenan is used in the culinary industry to clarify beer, fruit juices, and other beverages, as well as to prepare condiment goods, syrups, whipped creams, ice desserts, and cheese. Making spaghetti and parottas with wheat flour now has better quality. The majority of their customers' needs can be met by carrageenan producers by combining different carrageenan with locust bean gum, konjac flour, and starch to produce an array of warming and non-melting gels and gel textures.

To successfully commercialise carrageenan films in a manner similar to PLA, bio-PBS, and other a commercial bio-based polymers, significant creative breakthroughs are required all through every step of the manufacturing process, from growing seaweed and harvesting, transportation, the carrageenan extraction, and finally the production and distribution of products. When compared to some other materials,⁶ carrageenan-based plastics can offer consumers significant overall environmental benefits, which makes them an additional important factor that helps offset the higher production costs. Such viewpoints have historically been connected to increasing market demands.[14]

Due to its low oil content, typically comes out thin, resembling hand lotion. For thickening and stabilize the oil-water emulsion, ingredients like carrageenan and xanthan work well. Brine solution is used in the preparation of gammon by being pumped into it and then being mixed with carrageenan. Is well known for raising the quality of the final product because carrageenan retains soluble protein by interacting with protein and binding free water.

The demand from consumers for pre-cooked poultry items like chicken and turkey parts is rising. The loss of freshwater during cooking as well as the resulting decrease in texture and feeding quality worried poultry processors. The meat's texture and softness were increased by infusing a brine containing salt into the muscle. Carrageenan absorbs water in the muscle and enhances texture.

Meat and poultry may lose their tenderness, juiciness, and flavor when fat or salt is lowered. Carrageenan and phosphate-based low-fat products can aid in regaining the softness and juiciness of meat. Half of the typical fat can be replaced by kappa carrageenan. Fresh ground beef can be combined with iota carrageenan, which when cooked gives the product qualities similar to those of fat and moisture retention. The optimal method for producing it has been found to be precipitation in alcohol solution since ⁶the gelling strength of -carrageenan is not as great as that of -carrageenan, making ⁶the filtrate of -carrageenan unsuitable for dehydration using the gel-pressing process. After heat extraction, the liquor extract is passed through a fine filter, allowed to evaporate, and then isopropanol is added to precipitate the liquid to produce a fibrous carrageenan coagulum.[15]

1.5 APPLICATIONS OF BIO POLYMER:

- ¹¹ To improve the intended features and usefulness of these biopolymers, they are mixed with other materials to strengthen their inherent qualities.
- ¹¹ They also possess barrier qualities that are not found in other polymers, such as water resistance.
- The automotive industry uses biopolymers to create interior and exterior components, electrical parts, engine, exhaust, steering wheels, etc.
- Used to produce nanomaterial. Biopolymers are advantageous in particular scientific fields, such as green chemistry, due to their distinctive features.

CHAPTER 2 - LITERATURE SURVEY

M. Martínez-Sanz al. (2021) published an article under the title “**Valorization of alginate-extracted seaweed biomass for the development of cellulose- films**”. 0.25 g of the extracted fractions (dry weight) were dispersed in 50 mL of distilled water to create cellulosic films. It took about a minute of ultraturrax churning to homogenize the mixture. After that, water was removed from the dispersions using vacuum filtration with PTFE filters having 0.2 m pore sizes. The remaining solid material in the filter was then dried at room temperature over the following day. Peeling the produced films off the filters allowed them to be kept in a desiccator at 0% RH. Using a Palmer electronic digital micrometer, the film's thickness was determined to be between 25 and 60 m.[16]

Guodong Feng al. (2019) wrote a journal named “**Synthesis of Bio-base Plasticizer Using Waste Cooking Oil and Its Performance Testing in Soft Poly (vinyl chloride) Films**”. Following the addition of 50 mL of THF, the PVC resin powder (3 g) was combined with 1.2 g of various plasticizers (40 phr, a, b, c, and DOP). At 40°C, the mixes were vigorously stirred to create a transparent, uniform solution. The solutions were then poured into various glass petri dishes with a diameter of 22 cm, dried for 7 days at room temperature, followed by 7 days of vacuum drying at 50°C to remove any remaining THF and produce various plasticized PVC films (a/PVC, b/PVC, c/PVC, and DOP/PVC). Arifa Shafqat al. (2020) published a scientific journal called “**A review on environmental significance carbon foot prints of starch-based bio - plastic: A substitute of conventional plastics**”. Starch-based bioplastics are the most promising alternative because of the abundance of starch in nature. Bioplastics can be made from natural organic components such as polysaccharides, proteins, and lipids. A variety of starch-based biodegradable bioplastics made from banana peels, rice starch, corn starch, cassava starch, tapioca starch, sago starch, and potato starch, and other sources, have been successfully fully created by many researchers. However, the development of bioplastics is not enough due to the high cost of manufacture, which has some limits. To effectively green-synthesis bioplastics, new studies on producing biodegradable bioplastics as effective, affordable, and environmentally friendly as feasible are required.[17]

R. Scalenghe (2018) wrote a paper on the topic of “**Resource or waste? A perspective of plastics degradation in soil with a focus on end-of-life options**”.

Renewable resources are used to make bio-based polymers. Polylactic acid (PLA) is a bio-based polymer made from lactic acid monomers obtained from biomass. At 25 C for 4, 12, 20, or 24 months (about 2 years), PLA buried in (unknown) soils exhibits no weight change and no discernible physical changes. The test results are highly ambiguous; in fact, after 4 months, an open burial trial conducted at 20 C in (mystery) soil exhibited evidence of disintegration. However, it takes high temperatures (>50 C) for PLA to decompose in the soil environment, which takes a few months. After 20 months (about 1 and a half years) of soil burial, there may be a degradation of 20% to 75%. Understanding which soils speed up or slow down the phenomenon of degradation is not possible based on the current body of information. Instead, it seems like the characteristics of soil matter; for instance, adding PLA to soil drastically reduces pH.[18]

Abdul Rehman et al. (2021) published a paper under the title “**Plastics degradation by microbes: A sustainable approach**”. The biodegradability of polymeric materials can currently be measured using a wide range of techniques. International Standard Organization (ISO) and American Society for Testing and Materials (ASTM) have created several test procedures to evaluate the potential biodegradability of plastics, including gas chromatography, stereomicroscopy, micro- Fourier transform infrared spectroscopy, and mass spectrometry (GC-MS) (m-FTIR). Loss is a sign of decay in biological material due to changes in molecular weight distribution, weight, tensile strength, dimensions, chemical and physical qualities, carbon dioxide production, soil bacterial activity, and weight.

Natalie Stephanie Sawada Nunes al. (2022) wrote a journal with the topic “Optimal conditions for alkaline treatment of alginate extraction from the brown seaweed *Sargassum cymosum* C. Agardh by response surface methodology”. Alginate extraction required ethanol pretreatment of the seaweed to remove phenolic compounds, an acid treatment followed by an alkaline treatment, which was assessed using BBD with various temperature, duration, and pH values. The dried algae (6 g) were subjected to two treatments with ethanol (200 mL) while being stirred for three hours in an orbital shaker (Model TE141, Tecnal, Piracicaba SP, Brazil), and they were then allowed to dry for an entire night at 40 °C in a convection oven (Model 420-1D, EthikTechnology). In an orbital shaking incubator (Model Q816M22, Quimis, Diadema, SP, Brazil), the resulting residue was dispersed in 0.1 M HCl (Impex, Diadema, SP, Brazil), the pH was adjusted to 2.0, and stirring (250 rpm) at 45 °C for 110 min was maintained. The acquired residual biomass was cleaned with distilled water, then subjected to an alkaline treatment using 2 percent (w/v) Na₂CO₃ (Synth, Diadema, SP, Brazil) to modify the pH (8, 9, and 10), while altering the temperature (50, 65, and 80 °C) and duration of the process (90, 195, and 300 mins). Alginate was subsequently removed from the liquid phase using a 1:2 ethanol solution, and it was dried for 15 hours at 45 °C in a convection oven. Equation used to compute the SA yield (%) is: $\text{Yield \%} = (\text{Dry weight of alginate} / \text{Dry weight of seaweed}) \times 100$ [19]

L. Pérez-Alvarez al. (2022) wrote a paper titled “Electro and magnetoactive printed bi-functional actuators based on alginate hybrid hydrogels”. In 20 mL of deionized water, various concentrations of iron zerovalent NPs (1, 2, 3, 5, 10 percent w/w) were mechanically distributed. After that, sodium alginate was added to create a 10 percent weight-to-weight solution while keeping a moderate stir and avoiding magnetization for 24 hours. The prepared solutions were then put into the printer cartridges and various shapes were printed onto a petri dish that had previously been treated with a 1 M calcium chloride solution using an extrusion 3D printer (Cellink+, InkRedible+). The hybrid hydrogel strands were printed in three dimensions using an extrusion 3D printer (Cellink+, InkRedible+). To carry out the optimization of the printing settings, strands of a 10 percent w/w alginate solution with a viscosity of 7048 cP were printed at different speeds (300, 600, and 800 mm/min), with variable injection pressures (25, 30, 35, and 40 kPa). Adhesive

Dispensing Ltd. Employed two distinct imprint tips with internal diameters of 0.41 and 0.254 mm (about 0.01 in). Finally, using Fiji software, the diameters of the impressions were determined from a total of three strands for each condition. The hybrid hydrogels deflect in the direction of the magnetic field when they are near a magnet or towards the cathode when subjected to an electric field (15 V). It has been demonstrated that the material's electromechanical and magnetic response is favorably influenced by an increase in nanoparticle content (from 0% to 10%). These alginate hybrids, in contrast to previous comparable systems, have high mechanical stability and can be printed as three-dimensional actuators that can be controlled remotely.[21]

M.A.I. Schutyser al. (2022) wrote a paper titled “**Shear-induced structuring of phase-separated sodium caseinate - sodium alginate blends using extrusion-based 3D printing**” Creation of anisotropic aligned micron-size fibrous structures and macroscale filament bundles”. For 30 minutes, a 1 weight percent agar solution (aq) was heated at 90 °C to promote disintegration. The heated agar solution was run through a lab-scale colloid mill (IKA magic LAB®, IKA Staufen, Germany) with circulating cooling water at 5 C to produce agar fluid gels. With a rotational speed of 20,000 rpm, the gap width was fixed to 0.159 mm. The agar fluid gel was repeatedly sheared and cooled until it reached a temperature of 15 C. Agar fluid gel was given CaCl₂ to crosslink printed SC/SA blend. CaCl₂ was either combined directly into the created agar fluid gel or added to a heated agar solution prior to the shear-cooling process to evaluate the effect of CaCl₂ on the rheological properties of the agar fluid gel. Agar fluid gel or heated agar solution was treated with CaCl₂ at varying concentrations (0.12, 0.25, 0.33, 0.55, and 1.1 wt.%) [22]

Alessandro F. Martins al. (2020) wrote a journal on “**Biodegradable films based on commercial κ-carrageenan and cassava starch to achieve low production costs**”. The casting procedure, as previously described elsewhere with changes, was used to generate films based on κ-carrageenan, cassava starch, PVA, and glycerol [24]. Under magnetic stirring, distilled water was used to dissolve glycerol and PVA. The aqueous glycerol and PVA solution were then gradually supplemented with the desired amounts of κ-carrageenan and cassava starch while magnetically stirred for 20 minutes. For creating polymer blends and promoting

starch gelatinization, the mixture was heated to 90 °C for 30 min while being magnetically stirred. To eliminate air bubbles, the mixtures were introduced to an ultrasonic bath at 25 °C for 10 min. The mixtures were then transferred to Petri dishes, which are 150 mm diameter polystyrene plates. The solvent evaporated at 40 °C for 16 hours. The casting method is effective for creating films with various carrageenan: starch concentrations of cassava starch, PVA, glycerol, and carrageenan. The mechanical, physical, and chemical characteristics of the films were significantly influenced by the weight ratio of -carrageenan to starch. When the weight ratio of carrageenan to starch was equal to 1, the WVP was lowest. A film can be chosen for the desired application based on its features. [23]

Ramon Moreira al. (2022) wrote an article named “Effect of the addition of different sodium alginates on viscoelastic, structural features and hydrolysis kinetics of corn starch gels”. Alginates were hydrated overnight after being dissolved in distilled water. The alginate solutions were then given a weighted addition of corn starch. To aid in the homogenization of these mixes, they were physically shaken for 60 s. Following that, mixtures were heated at 100 °C for 20 min while being gently stirred by hand every 5 min for the final 10 s before gel formation. For a subsequent study, the starch gels were cooled (for 20 min) to 37 °C. The gels were made using a fixed ratio of maize starch to water (1:4) and three different amounts of alginate (w/w, starch base, 0, 1, and 2%). The appearance of elongated and uneven voids and the creation of linear partition walls that structured a spatial anisotropic network were significant effects of the addition of sodium alginates to the viscoelastic properties and structural features of the corn starch gels. Regardless of the tested alginate content, these structures remained intact. The rheological properties were dramatically altered by the addition of alginates with various origins and production processes. With the addition of alginates, weaker gels (with lower elastic modulus) were produced and viscosity rose. When the hydrophilic character of the alginates was high, stronger gels were produced by increasing the alginate content.[24]

Jong-Whan Rhim al. (2019) wrote an article titled “**Preparation of carrageenan-based functional nanocomposite films incorporated with melanin nanoparticles**”. Using a solution casting technique, MNP (0, 0.25, 0.5, 1 and 2 wt. percent based on carrageenan) were created. For the creation of the film solution, a predetermined quantity of MNP was dissolved in 200 mL of 0.1 M KOH while being stirred vigorously with a magnetic stirrer (Model VCX 750, Sonics & Materials Inc., Newtown, CT, USA) [19]. Next, 4 g of carrageenan was dissolved into the MNP solution while being stirred vigorously with a magnetic stirrer at 90 °C for 30 min. The film solutions were applied to a glass plate with a coated Cole-Parmer Instrument Teflon film that was levelled and allowed to dry at room temperature. Films were removed from the glass plate after drying and conditioning for 48 hours at 25 °C and 50% RH. Melanin nanoparticles (MNP) with a zeta potential of - 30.83 0.61 mV and a polydispersity index of 0.196 0.01 were monodisperse spheres with an average diameter of 98 22 nm. [26]

CHAPTER 3 - AIM AND SCOPE

The primary goal of this work is to obtain a biopolymer film with sodium alginate as the source material. Glycerol is used as a plasticizer despite other options due to its better compatibility with sodium alginate. These biopolymer films are created with one main goal in mind which is to overthrow the usage of non-bio degradable plastics which has been continuously affecting the ecosystem in worst way possible.

This is the starting step towards a huge revolution and the focus is set on perfecting the film properties to compete with commercial polymer films used to make bags.

The scope of this project describes about the degradable films which has several positive outcomes. The price of the film matters just next to the way of investing on it. A large-scale production of these bags makes disposing easier, making huge savings for money spent on disposal of commercial and industrial wastes every year. Easier processing and creation of film further makes it an efficient alternative to polymer bags that consumes more space and investments for production.

Choosing phycocolloids, specifically alginate derived from brown algae is chosen due to its specific binding and film forming properties which is discussed at further part of the paper. This paper is a complete analysis of what phycocolloids are, their classifications and the experimentation process to obtain desired film along with its characterization tests.

CHAPTER 4 - MATERIALS AND METHODOLOGY

4.1 MATERIALS REQUIRED:

The materials required for the synthesis of an alginate-based film are as follows:

- Sodium Alginate (powdered)
- Polyethylene glycol
- Glycerol
- Carboxy-methyl cellulose
- Starch
- Polyvinyl alcohol
- Distilled water

4.1.1 Apparatus Required:

- Beaker (200-400 ml capacity)
- Spatula
- Measuring tube
- Petri Plate

4.1.2 Equipment Required:

- Magnetic stirrer heater
- Weighing machine
- Vacuum oven

4.1.3 Process Image Description:

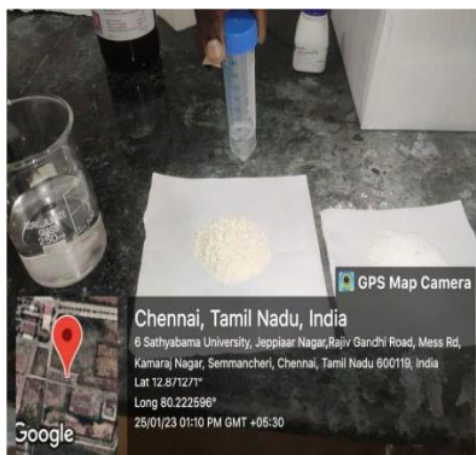
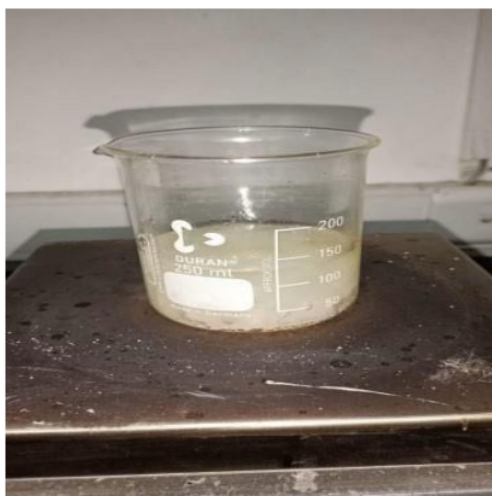


Fig 4.1 The samples of the chemicals to be added: Polyethylene glycol, glycerol, carboxy methyl cellulose, sodium alginate and beaker of water.



Fig 4.2 weight of sodium alginate



51
Fig 4.3 mixture of components



Fig 4.4 mixture being placed in a magnetic stirrer heater and processed.



Fig 4.5 The sample obtained as a result

4.1.4 Experimental Procedure:

- ❖ Sodium alginate is an extract from brown seaweed (sargassum) and is collected in fine powdered form.
- ❖ Polyethylene glycol (PEG), glycerol, carboxymethyl cellulose (CMC) and starch are purchased from Sisco Research Laboratories Pvt Ltd. Polyvinyl alcohol is purchased from Sigma Aldrich Co.
- ❖ The obtained chemicals are weighed in desired quantities and kept ready for mixing.
- ❖ A beaker containing 100 milliliters of distilled water is taken. The beaker is kept in a magnetic and stirring heater.
- ❖ The chemicals are added one after one when the stirrer activates. The sample is prepared at 80°C for 2 hours at continuous stirring.
- ❖ The sample turns to gel consistency after the timeline. The processed sample is then transferred to a petri plate.
- ❖ The petri plate is kept at room temperature for 12 hours to allow sample to cool

and settle.

- ❖ Then the plate is further placed ²⁹ in a vacuum pressure oven under 60°C for 24 hours.
- ❖ Finally, the film is formed on the surface of the plate which is removed carefully.
- ❖ The obtained sample shows properties like that of a polymer film.
- ❖ The obtained sample undergoes characterization tests

4.2 METHODOLOGY:

4.2.1 Weighing Of Chemicals:

Each chemical is weighed respectively at same ratio per sample. A total of twelve samples are prepared out of which one sample is chosen to undergo further tests.

The more the sample shows the properties of the film, the more likely it is chosen as the expected product result. The list of samples prepared are shown in the table as follows:

SAMPLE	PEG	ALGINATE	GLYCEROL	CMC	STARCH	PVA
A	5	5	5	5	x	x
B	1	1	1	1	x	1
C	2	2	2	2	x	2
D	2.5	2.5	2.5	2.5	x	2.5
E	4	4	4	4	x	4
F	3	3	3	3	x	3
G	1	1	1	x	1	x
H	2	2	2	x	2	x
I	2.5	2.5	2.5	x	2.5	x
J	3	3	3	x	3	x
K	2.5	2.5	2.5	x	2.5	2.5
L	1	1	1	x	1	1

Table 4.1 Sample and chemical composition

4.2.2 Mixing And Heating:

100 ml is the standard amount of water for every sample that is prepared. The film-forming solution was prepared by a casting process.[27]

A 200ml/400ml beaker is taken and filled with 100 ml of distilled water. A magnetic pellet is dropped inside it and placed in a magnetic stirrer heater. The stirrer is set at 500 rpm (rotations per minute). As the water begins to stir, the chemicals are added one by one, alginate being the last. The chemicals should be added very slowly to ensure that they mix well and do not form clumps. Formation of clumps makes dissolving of alginate difficult and disturbs even distribution while obtaining film. Then 80°C is set and stirrer is left undisturbed for 2 hours.

4.3 DESCRIPTION OF CHEMICAL COMPONENTS:

4.3.1 Sodium alginate

Alginic acid along with gum are primarily taken from the cell wall of brown algae to create sodium alginate, which has chelating action. Sodium alginate binds to and prevents the intestinal absorption of several radioactive isotopes. Its molecular formula is $(C_6H_7NaO_6)_n$. It is available in the form of dry powder. The color of this substance is described as 'cream-colored' or 'yellowish brown'. Sodium alginate is almost odorless and tasteless. It is insoluble in alcohol, chloroform, ether, aqueous acid solution below pH 3, and in hydro-alcoholic solution greater than 30% wt/wt but soluble in water forming viscous, colloidal solution. A polyuronide with 1,4 linked d-mannuronic acid and l-guluronic acid units and

Possible additional linkage. It does not swell in a medium that is acidic. The viscosity of the solution is based on the temperature, concentration, mole weight, and the presence of polyvalent metal cations; commercial molecular weights range between 32,000 and 200,000, with a "degree of polymerization" ranging from 180 to 930.

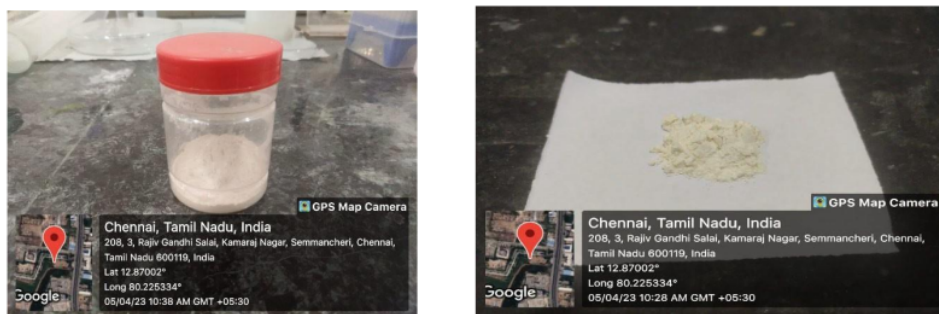


Fig 4.6 sodium alginate powder

4.3.2 Polyethylene Glycol:

Being a polyether chemical produced from petroleum, polyethylene glycol has numerous uses in both industrial and medicinal processes. Based upon its molecular weight, PEG is also known as polyethylene oxide (PEO) or polyoxymethylene (POE). The structure of PEG is commonly expressed as $\text{H}-(\text{O}-\text{CH}_2-\text{CH}_2)_n-\text{OH}$. PEG is insoluble in diethyl ether and hexane but soluble in water, methanol, ethanol, acetonitrile, benzene, and dichloromethane. To create non-ionic surfactants, it is linked with hydrophobic compounds. PEG, a hydrophilic polymer, has been used to passivate microscope glass slides to prevent proteins from clinging to the slides in a non-specific manner when performing single-molecule fluorescence experiments. Low toxicity polyethylene glycol is utilized in several goods.

The polymer is used to cover various surfaces with a lubricant in both aqueous and non-aqueous settings. PEG is a water-soluble, flexible polymer that can be used to produce extremely high osmotic pressures. Additionally, it is unlikely to interact specifically with molecules found in living things. PEG, when using the osmotic stress technique, is one of the most helpful compounds for providing osmotic pressure in biochemistry and bio membranes investigations.

PEG is considered biologically inert and safe by the FDA

Appearance (Color)	White
Appearance (Form)	Fakes/powder
Solubility (Turbidity) 50% aq. solution	Clear
Solubility (Color) 50% aq. solution	colorless
¹⁶ Molecular Weight	~8000
pH (5% aq. solution)	5.5 - 7.0
Chloride (Cl)	max. 0.001%
Sulphate (SO ₄)	max. 0.002%
Iron (Fe)	max. 0.0002%
Heavy Metals (Pb)	max. 0.0005%
Sodium (Na)	max. 0.02%
Potassium (K)	max. 0.02%
Water (KF)	max. 1.0 %

Table 4.2 Properties of Polyethylene Glycol

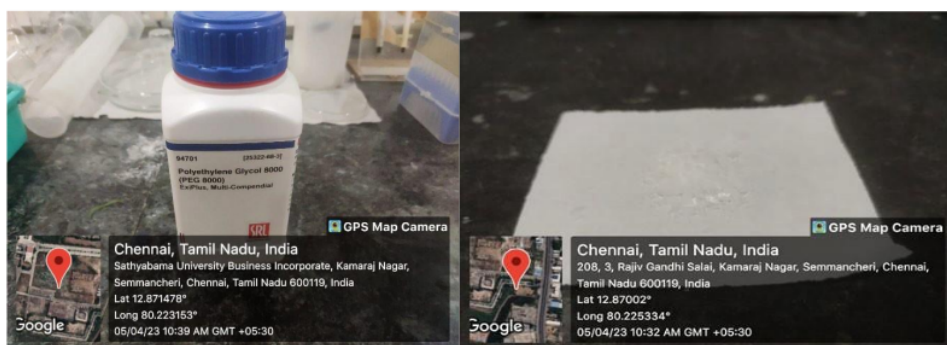


Fig 4.7 polyethylene glycol

4.3.3 ¹⁰Carboxy Methyl Cellulose:

Carboxymethyl cellulose (CMC), often known as cellulose gum, is a cellulose derivative in which part of the hydroxyl groups of the glucopyranose monomers that make up the cellulose backbone are linked to carboxymethyl groups (-CH₂-COOH). It is frequently used as sodium carboxymethyl cellulose, which is its sodium salt.

Available in White solid or Powdered form and is hygroscopic. It is nearly odorless. CMC is utilized in a variety of goods, both food- and non-food-related, to stabilize emulsions and modify viscosity. Since the primary source fiber is either softwood pulp or cotton linter, it is utilized largely because it has a high viscosity, is Nontoxic, and is generally thought to be hypoallergenic. Sodium CMC has the chemical formula

of $C_8H_{15}NaO_8$ and its molecular weight is 262.19.

Appearance (Color)	White to off - white
Appearance (Form)	powder
pH (1% aq. suspension)	6.5 - 8.0
Loss on drying	max.10%
Viscosity (2% aq. suspension, at 25°C)	1100 - 1900 CPS

Table 4.3 Properties of Carboxy Methyl Cellulose

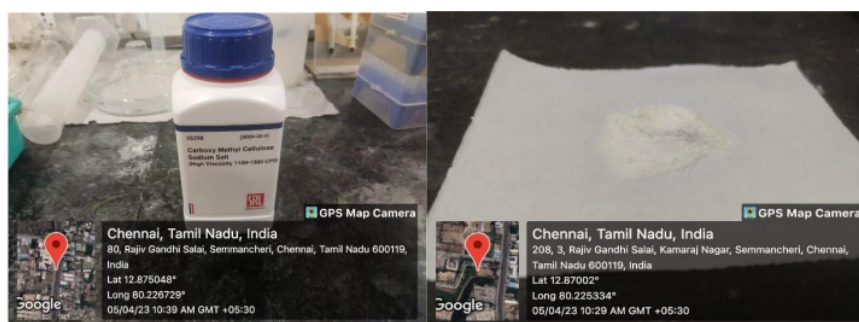


Fig 4.8 Carboxy methyl cellulose

4.3.4 Starch

A polymeric carbohydrate known as starch ¹² is made up of many glucose units connected by α -(1 $\rightarrow$ 4)- glycosidic linkages. Most green plants synthesize this polysaccharide as a means of storing energy. It is the most prevalent carbohydrate in human diets worldwide and is present in significant levels in common foods like wheat, potatoes, maize (corn), rice, and cassava (manioc).

A white, flavorless, and odorless powder known as pure starch ²² is insoluble in both cold water and alcohol. It is made up of two different kinds of molecules: branched amylopectin and linear and helical amylose. ⁵⁰ Glycogen is a more intricately branched form of amylopectin, which serves as an animal's energy reserve.

The experimental gelatinization of the starch may partially account for the observed differences, but one cannot completely rule out the influence of SA properties.

A complicated molecule (such as starch) must be broken down into its most basic form throughout the digestive process (i.e., glucose). In vitro techniques are frequently used to examine how food behaves in the gut while replicating digestion processes.[28]

Appearance (Color)	White
Appearance (Form)	Fine powder
Solubility (Turbidity) 2% aq. hot solution	Slight opalescent
Solubility (Color) 2% aq. hot solution	Colourless
Loss on drying	max. 15%
Sulphated Ash	max. 1%
Reducing sugars (maltose)	max. 0.5%
Chloride (Cl)	max. 0.04%
Heavy Metals (Pb)	max. 0.001%
Acidity	max. 4ml N%

Table 4.4 Properties of Starch

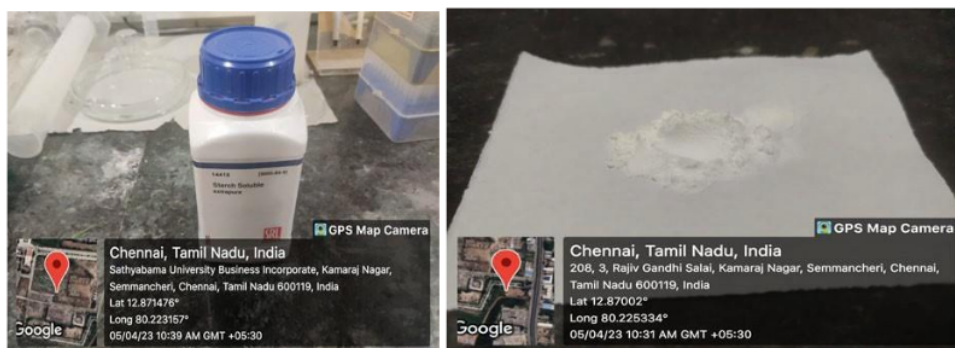


Fig 4.9 starch

4.3.5 Glycerol

²⁷ Glycerol is a triol with hydroxy groups substituting at positions 1, 2, and 3 in the propane molecule's structure. It functions as a human metabolite, an algal metabolite, a solvent, a detergent, a Gero protector, and other things. It's a triol and an alditol. Triglycerides (also known as fats and oils) and phospholipids both include a significant amount of glycerol.

⁴⁷ Molecular Formula $C_3H_8O_3$ or $CH_2OH-CHOH-CH_2OH$ Its molecular weight is 92.09. It is a clear, colorless, odorless, syrupy liquid or solid (below 64 °F). [Note: ²⁰ The solid form melts above 64 °F but the liquid form freezes at a much lower temperature. ³¹ It has mild to no odor and a sweet, warm taste. The boiling point is around 290°C and the melting point is 18°C. ⁴¹ Insoluble in petroleum ether, benzene, carbon tetrachloride, chloroform, carbon disulfide, and mildly soluble in ethyl ether.

Appearance (Clarity)	Clear
Appearance (Color)	Colorless
Appearance (Form)	Liquid
Colour (APHA)	max. 10
Assay (NaOH titration)	min. 99.5%
Refractive Index (20°C)	1.474 - 1.475
Density (g/ml) @ 20°C	1.257 - 1.260 g/ml
pH (10% aq. solution)	6.0 - 7.0
Residue after ignition	max. 0.01%
Chloride (Cl)	max. 0.0001%
Sulphate (SO ₄)	max. 0.001%
Iron (Fe)	max. 0.0001%
Heavy Metals (Pb)	max. 0.0001%
Fatty Acid Esters	max. 0.08%
Sugars (Glucose)	max. 0.004%
Reducing Substances	Passes

Table 4.4 Properties of glycerol

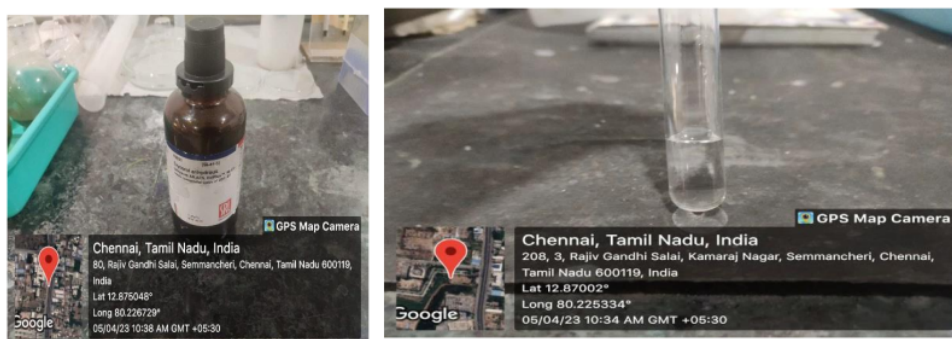


Fig 4.10 Glycerol

4.3.6 Polyvinyl Alcohol:

Vinyl alcohol and vinyl acetate can be copolymerized to create polyvinyl alcohol (PVOH), a hydrophilic linear polymer. As a result, the degree of polymerization and hydrolysis determines the structural characteristics of polymers made of polyvinyl alcohol. These modifications include esterification, etherification, crystallization, and ion-polymer complexation in the polymer, among other chemical and physical processes. PVOH structures that have been modified can be used in biomedical applications. To create a mixed-matrix membrane, NaA zeolite particles were combined with a poly (vinyl alcohol) matrix. This membrane will be used to research the pervaporate separation of water-butanol mixtures. Biocompatible polymeric scaffolds made of gelatin and poly (vinyl alcohol) have been utilized to build 3D cancer models.

Linear Formula: $[-CH_2CHOH-]_n$

For usage in food, polyvinyl alcohol comes in the form of a translucent, tasteless, and white or cream-colored granular powder. While it is insoluble in other organic solvents, it is soluble in water and just marginally soluble in ethanol. A typical pH range for a 5 percent solution of polyvinyl alcohol is 5.0 to 6.5. The melting point of polyvinyl alcohol is between 180 and 190°C.

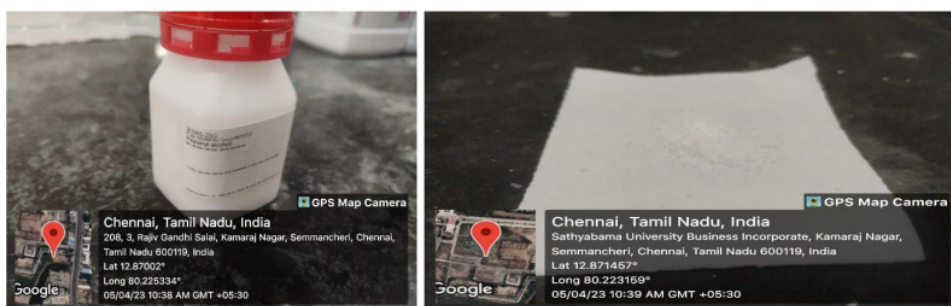


Fig 4.11 polyvinyl Alcohol

4.4 COOLING AND DRYING:

The obtained sample from the stirrer is transferred from the beaker to a petri plate. It is left unclosed for a few minutes. The petri plate is then closed and left undisturbed overnight. Then the sample is placed ²⁹ in a vacuum oven under 60°C for 24 hours. The residual moisture content from the sample is removed by the oven and the plate is then taken out.



Fig 4.12 Dried Sample

4.5 EXTRACTION OF PREPARED FILM:

The film formed on the surface of the Petri plate is carefully removed using forceps. An aluminum foil can also be used as a base to obtain the fragile sample without tear. The extracted film is transferred to an airtight cover.



Fig 4.13 Obtained Film

4.6 SAMPLE OVERVIEW:



Fig 4.14 Sample A

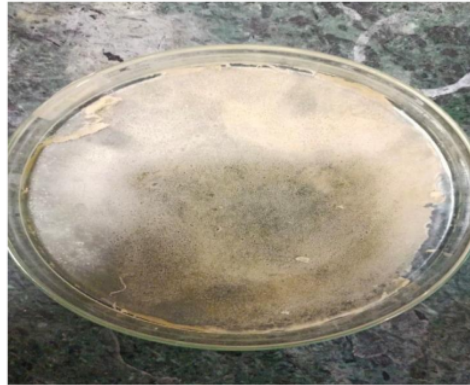


Fig 4.15 Sample B



Fig 4.16 Sample C



¹⁹
Fig 4.17 Sample D



Fig 4.18 Sample E



Fig 4.19 Sample F



Fig 4.20 Sample G



Fig 4.21 Sample H



Fig 4.22 Sample I



19
Fig 4.24 Sample J



Fig 4.25 Sample K



Fig 4.26 Sample L

CHAPTER 5 - RESULTS AND DISCUSSION

5.1 CHARACTERISATION RESULTS:

5.11 FTIR Analysis:

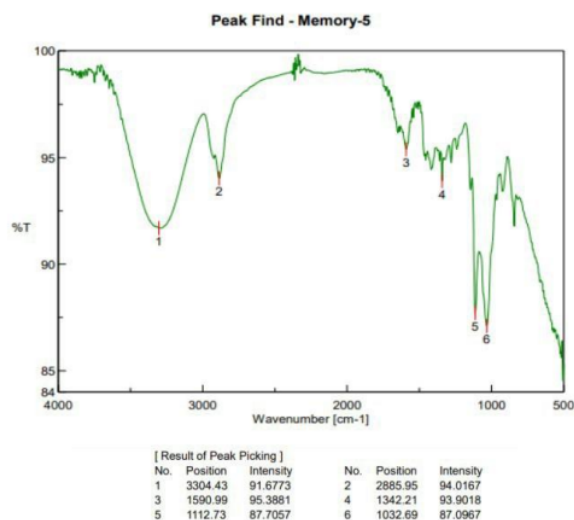


Fig 5.1 FTIR analysis

Because of the O-H group's stretching frequency, the alginate film's absorption band at 3304.43 cm⁻¹ is clearly visible. Upon combining all of the ingredients with the alginate film, the O-H band in the alginate powder was moved. Alginate's absorption in the COO⁻ band was boosted when carboxylate-containing groups in CMC at (1590 cm⁻¹) were combined with it. According to this, the polymer matrix's intermolecular hydrogen bonds were broken, which caused vibrations of the C-O and C = O to be amplified. Shifts at 1342 cm⁻¹ observed in the alginate film were attributed to the C-O stretch in the ester bonds formed between the hydroxyl groups in glycerol and PEG and the carboxylic acids found in CMC and alginate. This established a stable structure and demonstrated compatibility.

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5.1.2 Energy Dispersive X-Ray (EDX Analysis):

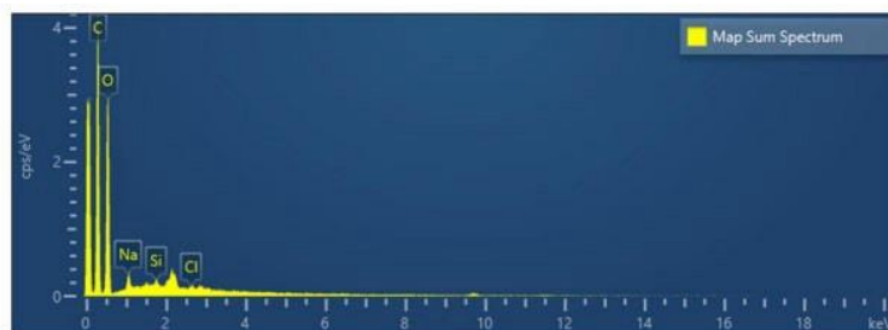


Fig 5.2 EDX analysis

Map Sum Spectrum				
Element	Line Type	Weight %	Weight % Sigma	Atomic %
C	K series	55.74	0.53	62.91
O	K series	42.87	0.52	36.33
Na	K series	1.00	0.09	0.59
Si	K series	0.22	0.04	0.10
Cl	K series	0.18	0.04	0.07
Total		100.00		100.00

Table 5.1 Map sum spectrum

The EDX pattern with weight percentage of alginate film. The elemental composition of the film sample was studied using EDX analysis pattern confirms that the prepared alginate sample primarily contains carbon (55.74%), oxygen (42.87%) and sodium (1%).

5.1.3 FESEM Analysis:

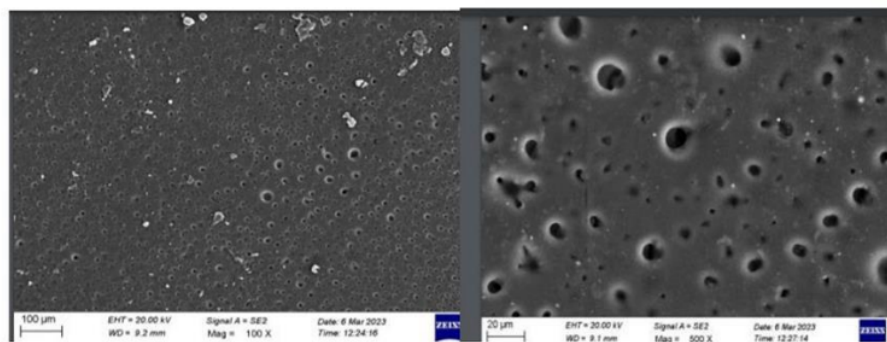


Fig 5.3 FESEM Analysis

The morphology of the prepared Alginate sample was analyzed using SEM studies. SEM images of the sample show a rough and porous surface without certain geometry.

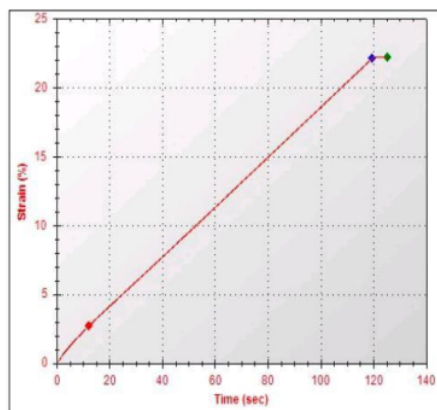
5.1.4 Tensile Strength Test

The prepared biopolymer film undergoes tensile strength test. The test is done by machine model M-50. The specimen is given as 6 samples with the dimensions of (15mm x 2mm). the specimen thickness is specified as 2 mm.

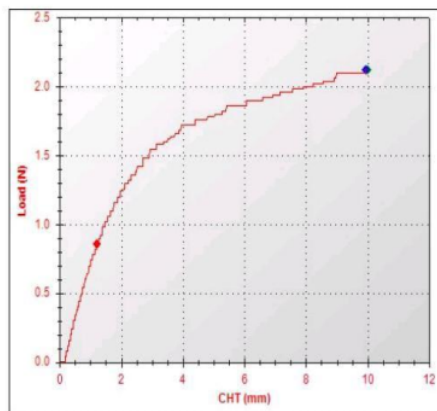
The initial G.L for percentage of elongation is 45mm. the output data shows load at yield to be 0.86N. Elongation at yield is 1.210 mm and elongation at peak is 10.006 mm. Elongation at 10.006 mm. The load at peak and break are both 2.120 N. Yield stress is 0.029 N/mm^2 . The tensile strength of the film is shown as 0.071 N/mm^2 .

Three graphs depicting the tensile properties of the polymer film are as follows:

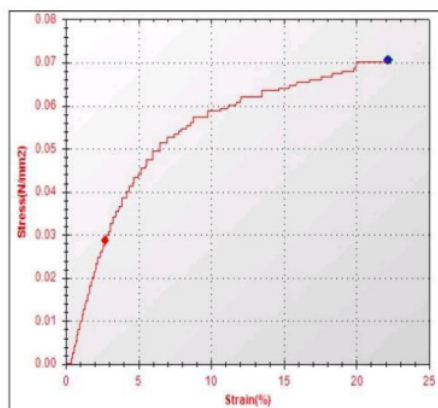
Strain Vs Time



Load Vs. Cross Head Travel



Stress Vs. Strain



5.2 CONVERSION TO BIOPOLYMER BAGS:

The obtained film is made into a long rectangular film. This film is then heat pressed on parallel sides to be converted into usable bags.



Fig 5.4 biopolymer bag

CHAPTER 6

SUMMARY AND CONCLUSION

Polysaccharides from seaweed proves to be one of the best alternative sources for production of bio based plastic films. Alginate is made strong and flexible by the copolymers. Alginate is a crucial industrial polysaccharide due to qualities including high viscosity, gelling abilities, and high stability. Polymer films obtained from polysaccharides have shown the best results in previous studies. Alginate has shown exceptional compatibility with the chosen materials for reinforcement and plasticizers. Binding affinity of glycerol has made it an obvious choice as a plasticizer. Additionally, carboxy methyl cellulose and polyvinyl alcohol slightly enhances the mechanical properties of the obtained alginate films. This paper follows the process of thermal mixing and casting to obtain the alginate films. Mixing alginate along with plasticizer and reinforcement materials under a controlled process environment with stable temperature and fixed time. The heated sample is then allowed to cool for extracting films easily. Vacuum oven is used to dry the sample under stable conditioning. Under previous studies this process has proved to be effective and shows promising results. Moreover, the requirement of low amount of equipment and low energy consumption compared to other techniques for extraction makes this process a more optimal choice and solution.

Several combinations of samples were prepared and the combination showing a more positive and expected result is chosen. Collection of experimental data from every sample proved to be effective to obtain a result easily. Based on physical appearance and resemblance to an actual polymer film, the sample is chosen for further analysis. Therefore, choosing the right models and creating an effective experiment are essential for getting accurate results. Overall, the application of alginate as a source of this alternative film production and using thermal mixing and cooling presents a viable strategy for process improvement, cost reduction, and the creation of a productive and scalable process.

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