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ENHANCING SUSTAINABILITY OF POLYMERIC FILMS

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ABSTRACT

Certainly, the modification of biopolymers, such as Chitosan and K-Carrageenan through chemical and physical methods can enhance their properties and capabilities. They both are used in food packaging industries and pharmaceuticals. Composed of Chitosan and K-carrageenan polymeric film, and their characterization was conducted including elemental analysis such as FTIR, TGA, SEM, XRD. These analytical techniques provides that composition, structure, thermal properties, understanding of their properties and potential applications. The other side natural drug Indian bael loaded film were prepared for examine Chitosan and K-carrageenan antibacterial properties opposed to *E.coil* bacteria. After that use of UV Spectroscopy for determine the concentration of molecule that present in Indian bael drug extraction. The both polymer have Good antibacterial properties and a their properties biodegradable that used for food and pharmaceutical industries.

Keywords: Chitosan, k-carrageenan, UV-spectroscopy, FTIR, XRD, TGA, SEM, Antibacterial, PF study, Gelatin Expansion

1. INTRODUCTION:

In recent research on therapeutic delivery, polymers have garnered significant attention worldwide. Throughout the 20th century, there were remarkable advancements in polymer synthesis and the development of biodegradable polymeric molecules. These biodegradable polymeric biomaterials have played a crucial role in enhancing drug

delivery methods and have found further applications in the pharmaceutical and biomedical fields. In essence, polymers have revolutionized therapeutic delivery and continue to drive progress in these important areas of healthcare **[1]**. Growing awareness of the need to reduce plastic packaging waste has prompted both academic and industrial sectors to investigate natural resource based biodegradable and compostable polymer through research efforts **[2]**. Carrageenans, which are extracted from marine algae, are indeed gaining attention as a renewable biomaterial with the potential to replace conventional synthetic plastics. Carrageenans do have limitations in the context of flexible films due to their natural hydrophilic properties. Researchers are exploring ways to address these challenges to fully harness their potential as a sustainable alternative to plastics **[3]**. To alter the physical and chemical characteristics of carrageenan , various changes are needed. While carrageenan serve multiple biological function because of its high viscosity but limits in their use in non food applications **[4]**. Chitosan a derivative of Chitin, found in a various living organisms, has notable antibacterial properties that make it a preferred polymer for creating active packaging to enhance food safety by inhibiting the growth of microorganism. Additionally, in the visible range, pure Chitosan films are optically transparent with high transmittance values, which is advantageous for creating clear films **[5]**. In similar terms, Chitosan a natural polymer, was initially tested for its ability to kill or inhibit the growth of bacteria. Then, researchers checked if Chitosan effectively prevent the growth of microorganisms on real food, specifically Emmental cheese. This was done to see how the cheese itself might affect to effectiveness of Chitosan coating in preventing bacterial growth **[6]**. For the centuries human have relied on plant as a valuable source of medicinal compounds to treat various physical and mental illness. Plants have provided remedies and support for a wide range of health issues throughout history. Plants are a valuable source for producing combination that have the potential to treat various aliments and act as disinfectants, making them valuable for healing and recovery the effectiveness of plant extracts in combating microbes has been recognized worldwide. For instance, Indian Bael (*Aegle marmelos*) is one of India's most significant medicinal plants with a history dating back Charak in 1500 B.C **[7]**.

2. METHODS AND MATERIAL:

Materials:

K-Carrageenan was purchased by Yashvi Fine Chem, Ankleshwar (Gujarat). Chitosan was bought via….

Method:

Formation of Chitosan:

The Chitosan film was made by mixture of 0.50g of Chitosan powder mix with solution of (49ml distilled water + 1ml Glacial acetic acid), heating on Magnetic stirrer for 1 or 1.5 hours at 70 to 80^{o} c. the solution kept at room temperature.

Formation of K- Carrageenan:

The K-Carrageenan film was made by mixture of 1g of k-Carrageenan power mix with 50ml of distilled water, heating on Magnetic stirrer for 10 to 15 minutes at 35 to 40^{o}c. the solution would kept at room temperature.

Extraction of Natural Drug (Indian Bael):

Firstly take Indian Bael leaves. Dry bael leaves in an oven at 60 to 70^{o} c. Grind the dried leaves into a powder with the help of grinder. Prepare a hydroalcoholic solution of 55ml Distilled water + 45ml Methanol. Take 3g of bael powder and mix with hydroalcoholic solution. Let the mixture rest for at least 48 to 72 hours. After that separate the mixture using filter paper to remove solid particles and collect the liquid filtrate **[7]**.

Preparation of Drug loaded film:

Take a mixture of K-Carrageenan and Chitosan in a different beaker. Add 3-4 ml of natural drug extraction in to this different beaker. Take one beaker and put it of magnetic stirrer for some to get mix all those things. Repeat the process for another beaker. Take both mixture in to two different petri dish and put it on room temperature for the set.

3.Chemical Analysis:

PF Study Test:

A solution of pf made by mixture of 8.307 g of Nacl and 0.367 g of $Cacl_2$ dissolve in one liters of distilled water for swelling test of two different polymeric film. Now cut two different polymeric film small pieces and weighted it separately. Put two different polymeric film in pf solution around 30 minutes and after 30 minutes take it on filter paper and dried it and the last take weight of that dry polymeric films. Repeat this process for 6-7 times.

The equation of pf(swelling test) is:-

$$SR=(Mt-Mo)/Mo\ g/g$$

Where Mo is initial mass and Mt is mass at different time intervals.

Gelatin Expansion:

This Chemical test use for check film expansion. A solution of Gelatin Expansion made by 10 g Gelatin powder and 100 ml of Distilled water of this test. Take k-carrageenan and Chitosan cut it into round shape. Take two different petri dish and pour 20 ml Gelatin solution each petri dish. Put

both round cut piece in middle of petri dish filled with gelatin solution. Take reading after 20 minutes. Repeat this process and take 4 – 5 readings.

ER = Diameter at time (D_t) / Initial diameter (D_0)

4. Characterization:

Antibacterial Study:

Start with prepare a solution for Antibacterial test 2.9 g of nutritional agar powder in conical flask and add 100 ml of water. Before this process should check that petri dish and flask are fully cleaned. Let the media cool at room temperature, after that spread the E. coil organism on agar in two different petri dish, put small piece of drug loaded Chitosan and k- carrageenan film on different petri dish. Placed it on controlled environment at 36o for at least 24 hours for growing of bacterial.

Ultraviolet-Visible Spectroscopy:

Uv-vis spectroscopy relies on the Beer-Lambert law to quantitatively analyze the concentration of absorbing in a sample by measuring the amount of incident light absorbed in the UV light range 200 to 780 nm. This method correlates the absorbed light with the concentration of the compound, the samples path length, properties of absorbing molecule and interaction of chemicals with light **[8]**.

Fourier Transform Infrared Spectroscopy:

FTIR is a multifaceted analytical technique widely employed to assess numerous materials by analyzing their chemical compositions. It uses for identify certain chemical groups of sample. FTIR finds successful applications is polymerization process and polymer structure characterization **[9]**.

X-Ray Diffraction:

X- ray diffraction techniques employ the pattern or intensities of diffracted X- ray to investigate how atoms are arranged within each unit cell, the precise positions of these atoms, and the angles between atomic spacings. X- ray diffraction is a non-destructive method widely used for analyzing various materials like minerals, metals, polymers, ceramics, plastics, semiconductors, and solar cells. Surprisingly, there have been limited technical reviews of discussions on the theories and applications of X- ray diffraction and its role in understanding crystal structures **[10]**.

Thermogravimetric Analysis:

Thermal analysis is a crucial testing method used to assess how material respond to changes in temperature, which can reveal valuable information about their chemical, physical, and structural properties. In essence, temperature is a fundamental factor influencing a wide range of processes, from

chemical reactions to material transformations. The concept of thermal analysis encompasses any scientific or technological characterization of a material where temperature serves as an experimental variable. Historically, it was often associated with specific techniques involving thermogravimetry and calorimetry, but it's now widely acknowledged that the core principle involves measuring the temperature difference between a sample and a reference material **[11]**.

Scanning Electron Microscopy:

Scanning Electron Microscopy (SEM) is a crucial technique for studying nanoscale material. Unlike tradition light microscopy that uses photons, SEM employs subnanometer spatial resolution, revealing topological and compositional features. This is essential in fields like nanofabrication, and forensics. However, SEM can be destructive to soft and dielectrical materials, causing issues like electron charge build up and deformation due to heating. As a result, it's challenging characterize to reliably characterize certain samples, biological specimens, polymers and hydrogel, structures, using SEM **[12]**.

5. Result of Chemical Analysis:

Pf study test Result:

Pf swelling study provides that increasing weight of polymeric film. The difference between k-carrageenan and Chitosan film had that k-carrageenan film weight are increase as compare to Chitosan. Take readings after 30 minutes. After seven readings at 30 minutes than take reading at after 24 hours. That difference between K-Carrageenan and Chitosan polymeric film that weight of K-Carrageenan were increases as compare to Chitosan.

The Pf study have one equation:

SR=(Mt-Mo)/Mo g/g

No	Time (Min)	K-Carrageenan	Chitosan
1	0	0.078	0.079
2	30	0.492	0.121
3	60	0.672	0.124
4	90	0.704	0.174
5	120	0.911	0.232
6	150	0.995	0.275
7	180	1.235	0.312
8	24hours	3.266	2.356

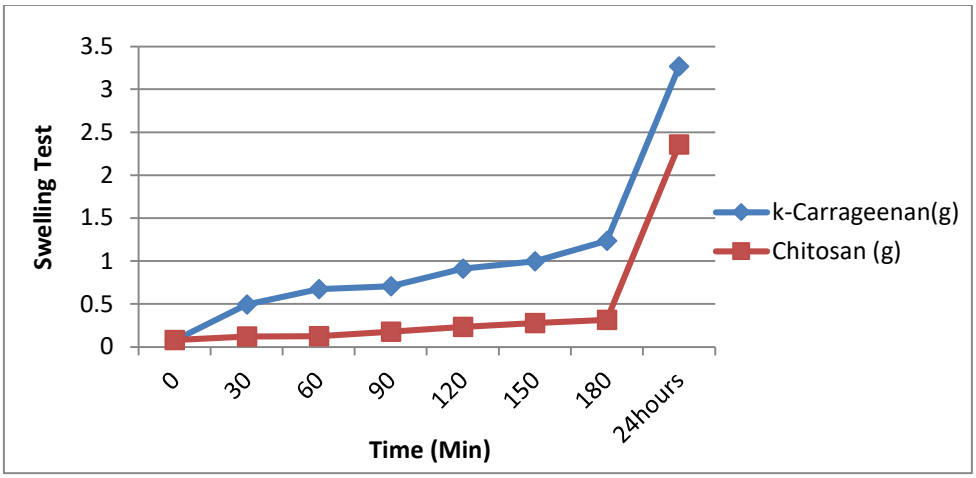


Figure 1: Graph of Pf swelling test ratio vs time

Gelatin Expansion Result:

Gelatin Expansion proves that polymeric film can extant their diameter. Take Gelatin solution in two different petri dish than put round shape k-carrageenan an Chitosan pieces into that petri dish. And take reading after 20 minutes. Repeat that process and take 4-5 readings. The difference between K-Carrageenan and Chitosan that diameter or size of Chitosan piece were increases as compare to K-Carrageenan piece. Size or diameter of K-Carrageenan was constant at particular range and the other side size or diameter of Chitosan was increases.

No	Time	Size of K-carrageenan	Size of Chitosan
1	0	0.9	1.0
2	20	1.5	1.8
3	40	1	1.9
4	60	1	2
5	80	1	2.1

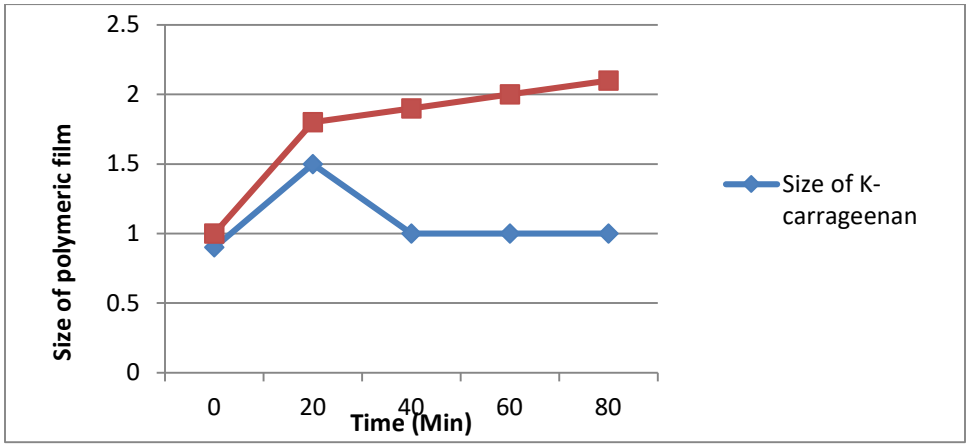


Figure 2: Graph of Size of polymeric film vs Time

6. Result of CHARACTERIZATION:

Result of Ultra violet spectroscopy:

These improvements aim to enhance sensitivity, precision, and accuracy while reducing analysis cost and time, UV-Vis spectroscopy has found applications in various fields, including environmental analysis. pharmaceutical research and the identification of specific analytes such as organic compounds and individual elements. Range of Indian bael leaves extraction is 100 to 800 nm **[13]**.

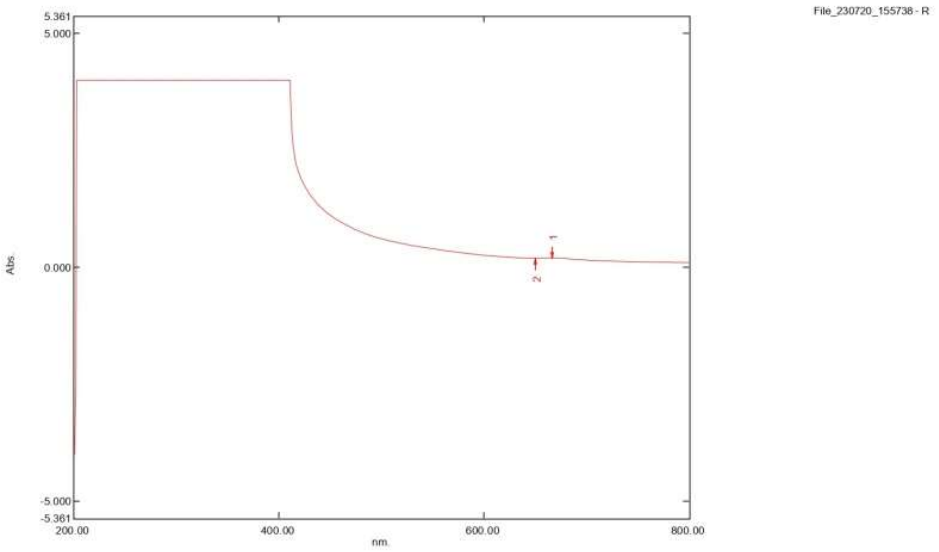


Figure 3: UV of Natural Drug Extraction (Indian Bael)

Result of Thermogravimetric analysis:

Thermogravimetric Analysis and it's derivatives curve which shows the rate of mass loss with respect to temperature. These techniques are often used to analyzed the thermal properties of material. TGA analyzed for two separate different polymeric film, one is a Chitosan and second is a K-Carrageenan. Temperature of TGA is 400^{o}c. The graph of polymeric film is shown in the below **Figure 04(a)** and **Figure 04(b) [14]**.

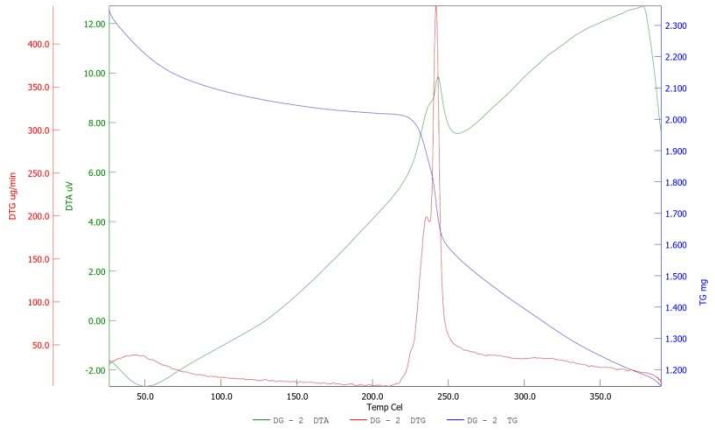


Figure 4(a): Thermogravimetric Analysis of Chitosan polymeric film

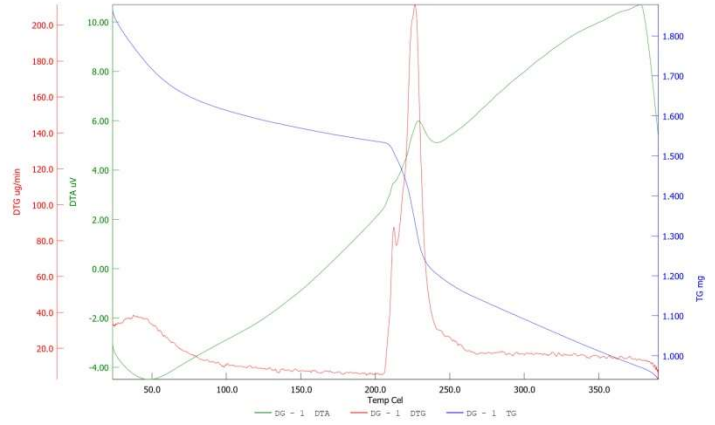


Figure 4(b): Thermogravimetric Analysis of K-carrageenan polymeric film

Result of Scanning Electron Microscopy:

The Scanning Electrode Microscopy techniques is primarily used to evaluate surface morphology, including roughness and the homogeneity of nanomaterials dispersion in a polymer matrix. It provides detailed images of surface at high magnification, making it suitable for such application. SEM analyzed a two different individual polymeric film like K-Carrageenan and Chitosan different images of these different polymeric film shown in below in **Figure 5**.

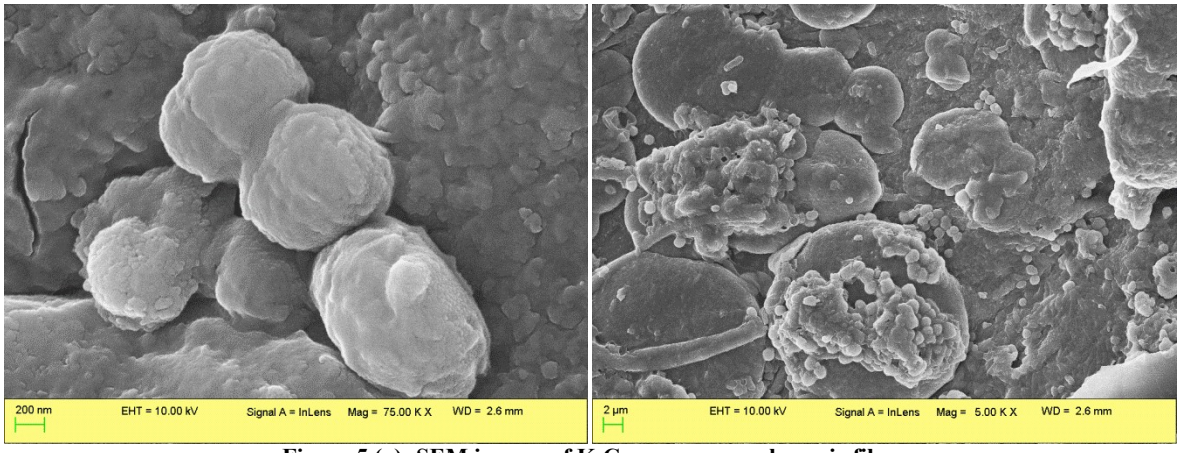


Figure 5 (a): SEM images of K-Carrageenan polymeric film

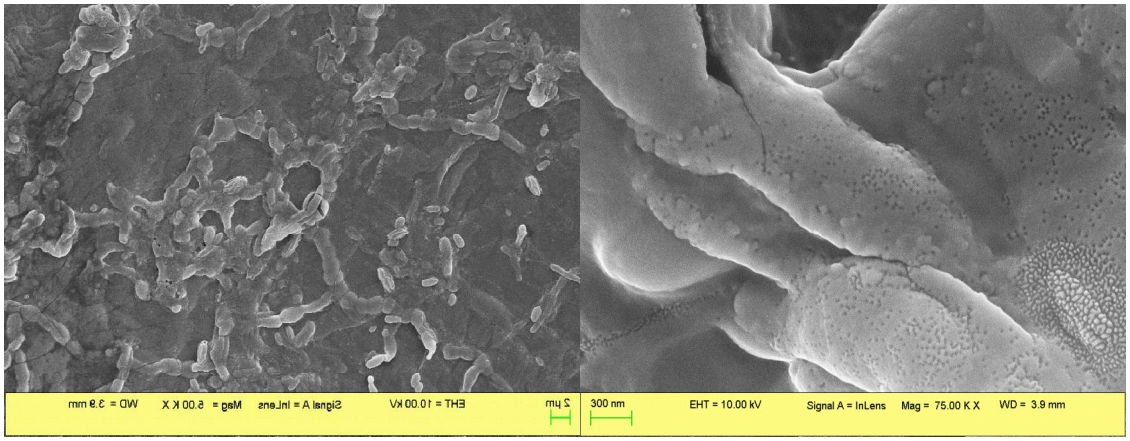


Figure 5(b): SEM images of Chitosan polymeric film

Result of Antibacterial Study:-

Weight of 2.9 g of nutritional agar powder add in to 100 ml filled distilled water conical flask. Allow the agar solution to cool at room temperature. In a petri dish, spread a culture of *E.coli* bacteria evenly on the agar surface. Take one piece of different polymer in different petri dish, on one petri dish take K-Carrageenan piece and other petri dish take Chitosan piece. Seal the petri dish to prevent contamination and place them in a controlled environment. Allow the bacteria to grow for at least 24 hours. After 24 hours bacteria's are growing in both petri dish. But as compare that in k-carrageenan petric bacteria were more growing as compare to Chitosan petri dish.

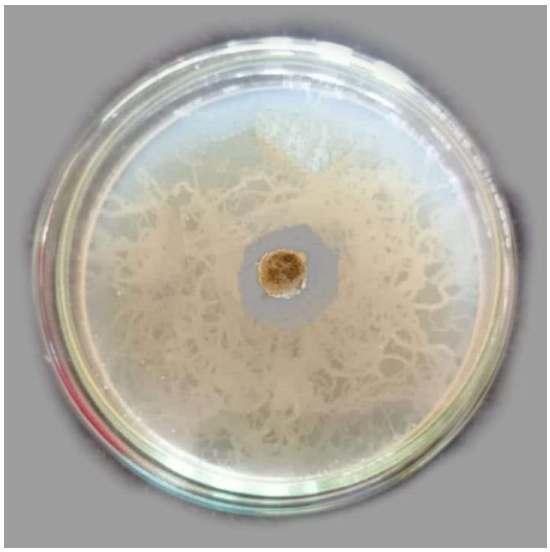
(a)   (b)

Figure 6(a): Antibacterial Study of K-Carrageenan and fig.06(b) Antibacterial Study of Chitosan

Result of X-Ray Diffraction:-

Absolutely, X- ray diffraction (XRD) is a powerful non-destructive testing technique that utilizes the interaction of X-rays with materials to reveal information about their atomic structures. This method is particularly valuable for analyzing crystalline materials because X-rays have wavelengths. A XRD graph of different polymeric film shown in this **Figure 08(a) and 08(b)[15]**.

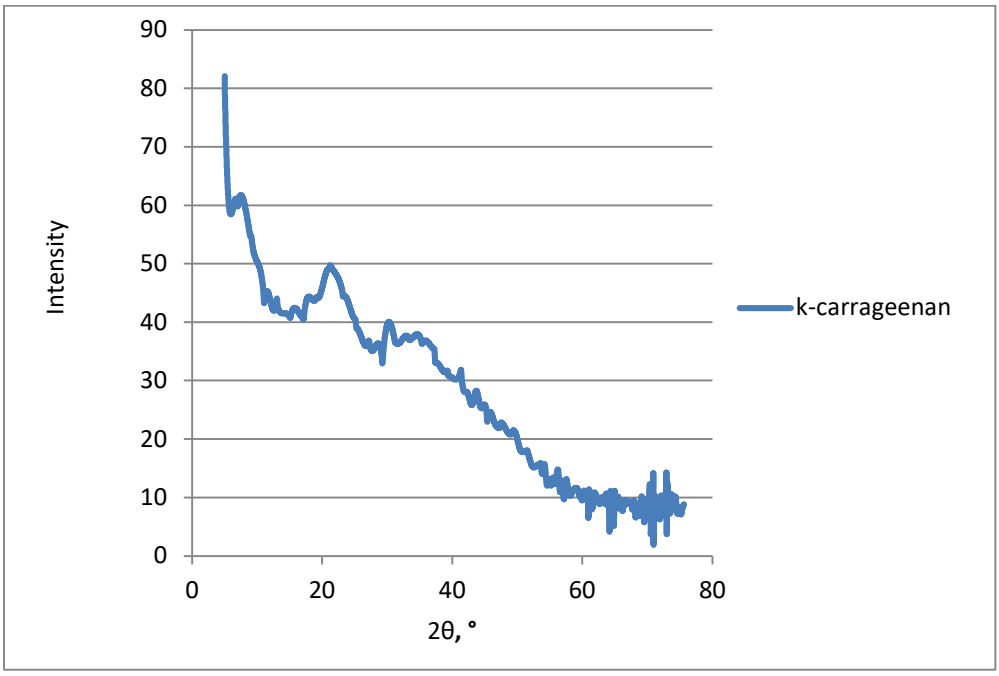


Figure 8(a): Graph of K-carrageenan in X-Ray Diffraction

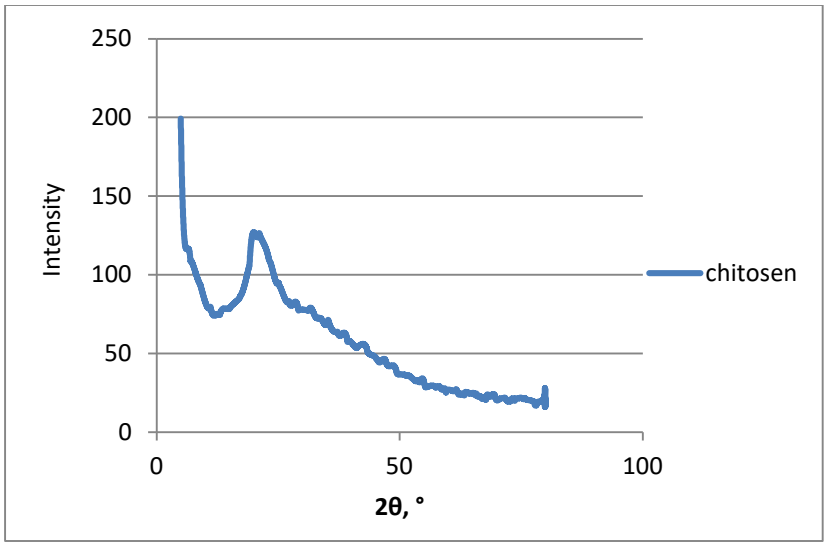


Figure 8(b): Graph of Chitosan in X-Ray Diffraction

Result of Fourier Transform Infrared Spectroscopy:

FTIR is a commonly used technique in polymer science and engineering to analyze the chemical structure and function groups of polymers. This information is crucial for understanding the properties and behavior of polymers. FTIR technique use for indentification of two independent polymeric film. Firstly identify the functional group and chemical structure of K-Carrageenan film and then Chitosan film. K-Carrageenan have carbohydrate with sulphonated compound. Chitosan have polysaccharide molecules with amino group.

K-Carrageenan polymeric Film:

First IR peak at 3351.60 cm^{-1} it range between 3200-3600 cm^{-1} this peak indicates O-H bond stretching vibration. C=O stretching peak at 1634.22 it suggesting the present of carbonyl group with ketone functional group. At 1426.22 cm^{-1} C-H bending methyl group, it range between 1440-1480. C-H bending in methyl (CH_2) groups at 1377.48 cm^{-1}. C-O-C (ether)stretching vibrations. At 733.77 cm^{-1} C-H bending vibrations. C-S stretching vibrations are any sulfated groups present at 699.17 cm^{-1}.

Chitosan polymeric Film:

First peak at 3776.37 cm^{-1} at associated with O-H stretch of a hydroxyl group and other O-H vibrations at 3352.10 cm^{-1} it range between 3200-3600 cm^{-1}. At 2925.67 cm^{-1} C-H stretching vibrations in alkyl groups, range between 2850-3000. Nitrile group associated at 2363.70 cm^{-1}. Carbonyl group(C=O) associated at 2015.83 cm^{-1} it range between approx 2150 cm^{-1}. At 1590.03 cm^{-1} amide group or another functional group. C-N stretching vibrations at 1123.31 cm^{-1}.

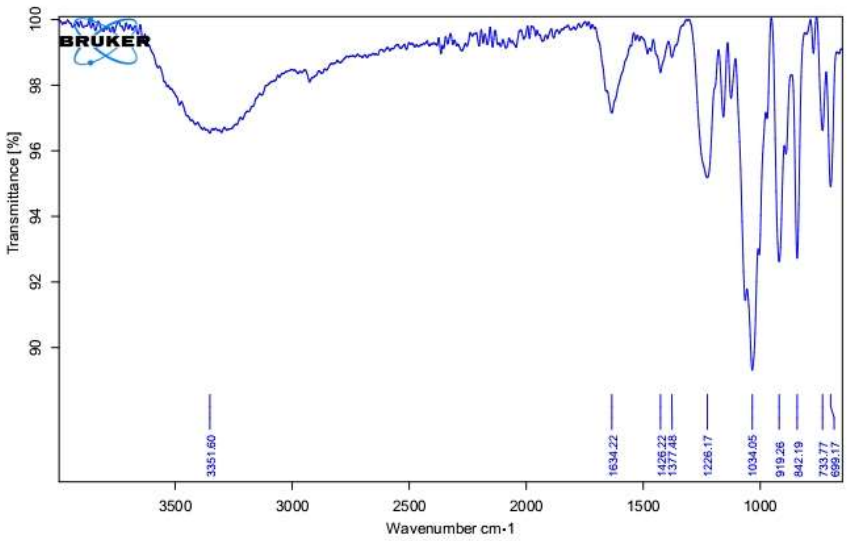


Figure 9(a): FTIR graph of K-Carrageenan

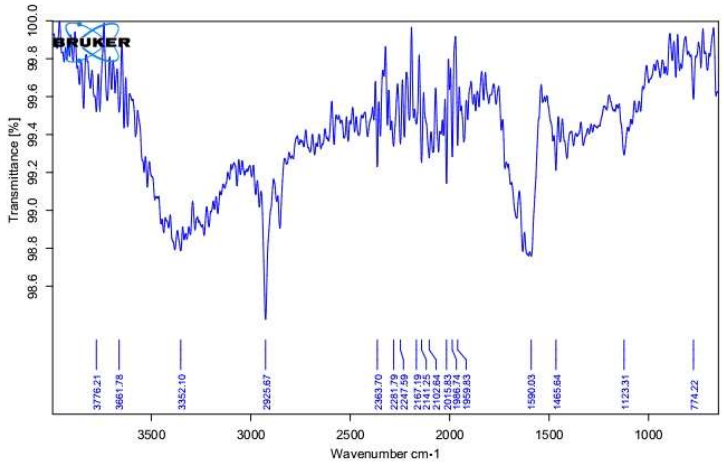


Figure 9(b): FTIR graph of Chitosan

7. CONCLUSION:

Natural polymers are useful in various types industries like pharmaceutical, polymer industries, produced biodegradable polymer etc. K-Carrageenan and Chitosan both are natural polymers that can be used in food packaging and many pharmaceutical industries. Then use of Natural drug extraction Indian Bael for medicinal purpose and prevent the wound dressing from the harmful bacteria, for that use of natural drug extraction with two different polymer like K-carrageenan and Chitosan drug loaded polymeric film. Antibacterial properties of K-Carrageenan and Chitosan are great the prevent bacterial properties, but K-carrageenan antibacterial

properties are more powerful than Chitosan. Chitosan has good food packaging properties. Both the polymers are biodegradable and good at antibacterial properties.

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