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**INNOVATIVE BIODEGRADABLE FILMS: ENHANCING SKINCARE  
WITH GELATIN INCORPORATING ALOE VERA AND HIBISCUS, AND  
BOOSTING FOOD PACKAGING WITH SILVER NANOPARTICLES  
INFUSED PLA FILMS**

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**ABSTRACT**

In the pursuit of sustainable and efficacious skincare solutions, this research explores the development and characterization of two innovative materials for face sheet masks and food packaging. The initial substance is a film made of gelatin polymer that includes Aloe vera gel and Hibiscus extract. It is created to provide soothing and moisturizing advantages for skincare. The second substance consists of a film made of PLA (Poly lactic Acid) polymer that contains silver nanoparticles. Its purpose is to offer antimicrobial properties for food packaging. The gelatin film, which contained Aloe vera gel and Hibiscus extract, was examined using FTIR, SEM, and TGA. FTIR analysis confirmed that the important functional groups were present, indicating successful incorporation. SEM imaging showed the surface structure of the film, while TGA provided information about its thermal properties. Furthermore, antibacterial tests were conducted on E. coli bacteria to evaluate the film's ability to inhibit microbial growth. The results indicate that the gelatin-based face sheet mask material has potential for use in skincare applications. The PLA polymeric film containing silver nanoparticles was analyzed using FTIR, SEM, TGA, and UV-Vis

techniques. FTIR spectroscopy confirmed the presence of functional groups, while SEM provided information about the film's surface. TGA analysis was conducted to assess its thermal stability. The purpose of incorporating silver nanoparticles was to give the film antimicrobial properties, specifically for use in food packaging. UV-Vis analysis was also performed to highlight the distinct absorbance spectrum of the silver nanoparticles. Our aim is to develop and characterization of materials for food packaging and skincare, with an emphasis on their attributes, uses, and possible applications, are the main goals of this research.

**Keywords:** Skincare solutions, gelatin polymer, aloe vera gel, PLA polymer, silver nanoparticles, antimicrobial properties, food packaging

## 1. INTRODUCTION

In and around the end of 2019 an unknown sickness affecting the upper respiratory tract that has swiftly spread around the world was first reported in Wuhan, Hubei Province, China. The scientific community swiftly discovered that this highly contagious disease was caused by a novel coronavirus, SARS-CoV-2, and the sickness was dubbed COVID-19 (Coronavirus Disease-2019) [1]. The World Health Organization (WHO) labeled the epidemic a global pandemic in March 2020 [2]. In that diseases Patients need a high viral dose of SARS-CoV-2 to develop symptoms, for that most are asymptomatic, making it incredibly difficult to control the transmission of the disease [3]. As a consequence, COVID19 is much more infectious in terms of human-to-human transmission, which is evident by the high number of reported cases and deaths during this pandemic (WHO, 2021). However to

counter the spreading of that diseases measures applying the spray of disinfectant and alcohol on the surfaces along with that using PERSONAL PROTECTIVE EQUIPMENT (PPE) this all leading to the abrasions on the skin. Using PPE on an hourly basis leaves tension, itching, increase the humidity and temperature and this all helps in to develop abrasions on skin [4]. To prevent this and also for the betterment of the skin as skincare especially on a face, Gelatin polymer based polymeric film come into the actions as Gelatin polymeric films can work effectively as face sheet masks by leveraging their unique properties to provide several skincare benefits. As Gelatin is a biopolymer with exceptional film-forming characteristics that is derived from the controlled hydrolysis of collagen widely used in pharma industries [5], the most abundant protein in our skin, and it shares many of the same structural properties.

This natural connection makes it highly compatible with the skin, reducing the risk of irritation or adverse reactions. Gelatin's unique characteristics make it an ideal choice for crafting transformative face sheet masks as its hydrophilic nature allows it to absorb and retain water, providing a moisture-rich environment that instantly rejuvenates and hydrates skin. This deep hydration helps combat dryness, leaving skin feeling supple and refreshed [6]. Today's growing understanding of sustainability has shifted the emphasis from standard plastic materials to more ecologically friendly alternatives in a variety of domains of use such as alternative to traditional petroleum-based plastics including food packaging. In response to consumer demand and market trends, poly (lactic acid) (PLA) can provide a sustainable option for food packaging across a wide range of commodities applications [7]. Polylactic Acid (PLA). PLA is a biodegradable and compostable polymer derived from renewable resources. The biodegradability of PLA presents a notable benefit for food packaging. When properly disposed of in industrial composting facilities, PLA packaging can undergo decomposition within a relatively short period of time, effectively diverting organic waste away from landfills and mitigating the release of greenhouse gases that

are typically associated with the degradation of conventional plastics. Poly (lactic acid) (PLA) exhibits exceptional optical characteristics, leading to a transparent or translucent aesthetic. This attribute holds significant value in the context of food packaging as it enables consumers to visually perceive the contents, thereby augmenting its visual allure.

## 2 MATERIALS AND METHODS

### 2.1. Materials

Poly (lactic acid) (PLA: 92% L-lactic and 8% meso -lactic) was provided in pellet from the Banka Bio Limited (IND). Gelatin was provided by SIMSON PHARMA LIMITED. Fresh neem leaves collected from the university campus. Hibiscus flower and aloe vera were also collected from the university campus. Silver nitrate ( $\text{AgNO}_3$ ) (ANALYTICAL REAGENT) was provided by the Enzyme Bioscience (P) Ltd.

### 2.2. Methods

#### 2.3 Preparation of gelatin polymeric film

Gelatin films were prepared by solution casting method as reported in [8]. Gelatin solution was provided by dissolving 5 g gelatin in 30 ml distilled water for 30 min and then heated at 45 °C for 30 min while continuously stirring, in the end, a specific quantity of a solution that forms a film was added to petri dishes made of polystyrene and

left to dry at room temperature for a period of 3 days.

## **2.4 Preparation of hydrogel sheet mask based on gelatin**

### **2.4.1 Extraction of hibiscus flower**

Hibiscus oil is used in a variety of skincare and haircare products. To make this oil, we gathered fresh hibiscus flowers from the university campus and allowed them to dry for several days. Once dried, we powdered the flowers and added them to a beaker with water. We then boiled the mixture for 5 to 10 minutes and filtered it to collect the extracted oil for future use.

## **2.5 Synthesis for silver nano particles**

### **2.5.1 Preparation of leaf extracts from Azadirachta indica (Neem) leaves**

Fresh neem leaves were obtained from the University Campus. The leaves were carefully cleansed using running water to eliminate any dirt or dust present on their surfaces. Then leaves were dried on room temperature. 10 gm of finely incised parts of leaves were then collected and added to 50 ml distilled water and boiled for 15 min and then cooled and filtered extract was stored for future use. This solution was utilized to perform a green synthesis of silver nanoparticles (AgNP) by reducing the silver ions [9].

### **2.5.2 Synthesis of silver nano particles**

Silver nitrate (AR) was used to prepare 100 ml of 1 mM solution of silver nitrate. Then 8 ml of this solution were added to 1,2,3,4,5 ml of neem extraction solution [9]. And this solution was kept in incubator for 24 hours to counter the photo activation of silver nitrate at room temperature.

### **2.6 Preparation of drug loaded gelatin film**

First of all, take 50 ml of hibiscus extract add 10 ml of aloe vera gel to it and then add 5 gm gelatin to it. Gently heat the mixture while stirring constantly until it becomes a uniform solution. Pour the gelatin mixture into a film casting mold. Allow the gelatin film to cool down at room temperature for 3 days.

### **2.7 Preparation of PLA polymeric film**

A mixture of PLA was made by dissolving 1.5gm pla pellets in 50 ml chloroform while being stirred with a magnet at a speed of 400 rpm at room temperature (approximately 25 degrees Celsius). The resulting solution was then poured onto a glass plate and left to dry in a dark area in a hood for 3 days at room temperature, allowing the solvent to evaporate [8].

### **2.8 PLA film incorporated with silver NPs**

A mixture of PLA was made by dissolving 1.5gm PLA pellets in 50 ml chloroform while being stirred with a magnet at a speed of 400

rpm at room temperature (approximately 25 degrees Celsius). Now add 5 ml of extracted aqueous solution of silver NPs to it and then, the resulting solution was then poured onto a glass plate and left to dry in a dark area in a hood for 3 days at room temperature, allowing the solvent to evaporate.

### 3. Characterization

#### 3.1 UV- VIS SPECTROSCOPY

The broth made from neem leaves contains different phytochemicals like polyphenols, flavonoids, and alkaloids. These compounds have unique absorption spectra in the UV and visible regions. By using UV-Vis spectroscopy, it is possible to detect the presence of these compounds by analyzing their absorption patterns at specific wavelengths. UV-Vis spectroscopy is employed to identify the surface plasmon resonance (SPR) phenomenon in AgNPs. The UV-Vis spectrum displays a distinct SPR peak for silver nanoparticles, which is caused by the synchronized movement of unbound electrons on the nanoparticle surface when exposed to light [9]. All this characterization of uv vis spectroscopy for the neem broth and silver nano particles were carried out on the Shimadzu UV-1280 UV-VIS Spectrophotometer and the range were set to 200 to 800 nm, and carried out with all the safety measurements.

#### 3.2 FTIR (Fourier Transform Infrared Spectroscopy)

3.2.1 FTIR (Fourier Transform Infrared Spectroscopy) was employed to determine the chemical makeup of gelatin films. It offers insights into the various functional groups found in the polymer, including amide bonds, hydroxyl groups, and other chemical components. This aids in verifying the presence of gelatin in the film.

3.2.2 FTIR spectroscopy was used to determine the chemical makeup of PLA films. It can identify specific functional groups in PLA, such as ester groups (-COO-), carbonyl groups (C=O), and methyl groups (-CH<sub>3</sub>). This data confirms that PLA is present in the film. The spectra were collected within the wavelength range of 4000 to 400 cm<sup>-1</sup>. FTIR analysis was provided by the DEPT. OF PARUL INSTITUTE OF PHARMACY AND RESEARCH. All this sample analysis was carried out with all the safety measurements [10].

#### 3.3 SEM (SCANNING ELECTRON MICROSCOPE)

3.3.1 The surface morphology of gelatin film was analyzed using SEM. SEM offers detailed images of the surface morphology of gelatin films, enabling the observation of surface characteristics like pores, roughness, cracks, and patterns. This information is crucial for

comprehending the film's visual and textural properties [11]. The use of SEM allows for detailed imaging of the surface structure of PLA films. It enables us to observe and analyze surface characteristics such as roughness, topography, and the presence of any flaws or abnormalities. This data is crucial in comprehending the texture and visual appearance of the film [12]. SEM analysis was provided by the PNP Analytical solutions laboratory in Vadodara, Gujarat, India. All the safety measurements were taken care off during analysis.

### 3.4 TGA (Thermogravimetric Analysis)

**3.4.1** The thermal stability of gelatin films was evaluated using TGA. TGA helps determine the temperature range at which the film breaks down, loses weight, or degrades due to heat. This information is important for understanding how the film will behave during processing and storage [11]. The thermal stability of PLA films was evaluated using TGA. TGA helps determine the temperature range at which the film breaks down, loses weight, or undergoes thermal degradation. This information is important for understanding the behavior of PLA films during processing, storage, and potential uses

[12]. this analysis was provided by the DEPT. OF CHEMISTRY SARDAR PATEL UNIVERSITY, ANAND, GUJARAT. All the safety measurements were taken care off during the testing.

### 3.5 DLS (Dynamic Light Scattering)

DLS is a technique used to determine the size of nanoparticles in a liquid solution. It considers both the core size of the nanoparticle and any surrounding solvation layer or ligands to provide an accurate measurement of the effective size. This method also gives insights into the distribution of nanoparticle sizes in the liquid medium [13]. DLS test analysis was provided by the DEPT. OF PARUL INSTITUTE OF PHARMACY AND RESEARCH

## 4. RESULTS AND DISCUSSION

### 4.1 UV VIS SPECTROSCOPY

#### 4.1.1 Spectra of neem broth

**Figure 1** illustrates the absorption of the neem broth at various wavelengths. As we can see that peak (2) has the absorption of 2.782 at the wavelength of 386 nm. Peak (3) has the optical density of 2.557 at the wavelength of 326. So this peak confirms the presence of neem within the broth.

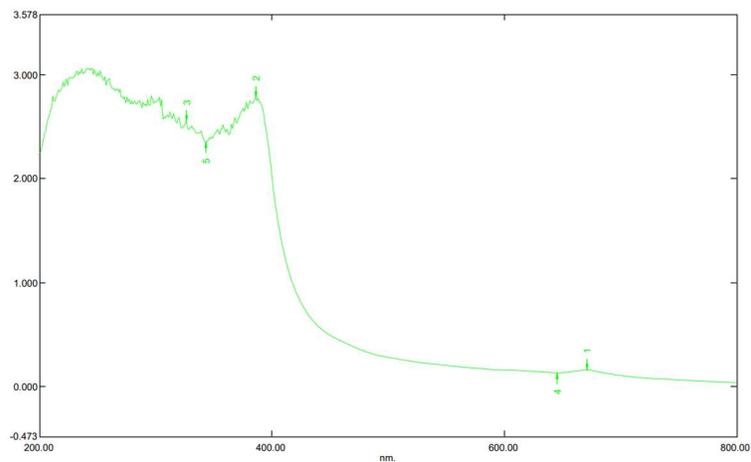


Figure 1: UV VIS Spectra of Neem Broth

#### 4.1.2 Spectra of silver nano particles

Here In Figures (2) and (3), it is evident that the color changed from a light yellow shade in Figure (2) to a brownish hue in Figure (3). Ensuring the extraction of silver nanoparticles in a solution containing 1mM AgNO<sub>3</sub> and neem broth. Five samples were taken and the concentration of neem broth added to the

1mM AgNO<sub>3</sub> solution are as follows; S1 (1ml neem extract + 8 ml AgNO<sub>3</sub> solution), S2 (2ml neem extract + 8 ml AgNO<sub>3</sub> solution), S3 (3ml neem extract + 8 ml AgNO<sub>3</sub> solution), S4 (4ml neem extract + 8 ml AgNO<sub>3</sub> solution), S5 (5ml neem extract + 8 ml AgNO<sub>3</sub> solution), starting from the left side in the figure.

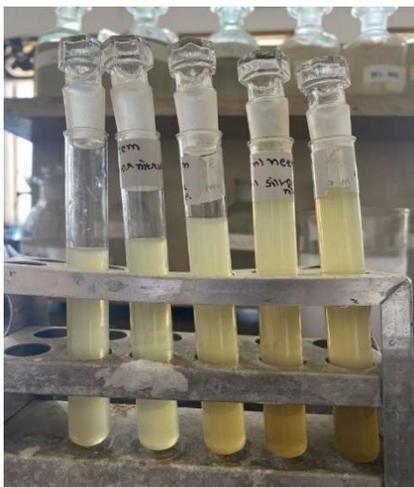


Figure 2: mixture of AgNO<sub>3</sub> and neem broth before



Figure 3: mixture of AgNO<sub>3</sub> and neem broth after

## UV VIS SPECTRA OF SILVER NANO

Here in the UV vis spectra of silver NPs we can see that in **Figure (4)** there is overlay graph spectrum of 5 samples that were prepared. S1 at wavelength of 360 nm

absorbance recorded was 1.6, at 420 nm it was 2.1. For S2 at 360 nm it was 1.8, at 420 nm it was 2.4. For S3 at 360 nm it was 1.9, at 420 nm it was 2.6. For S5 at 360 nm it was 2, at 440 nm it was 3.

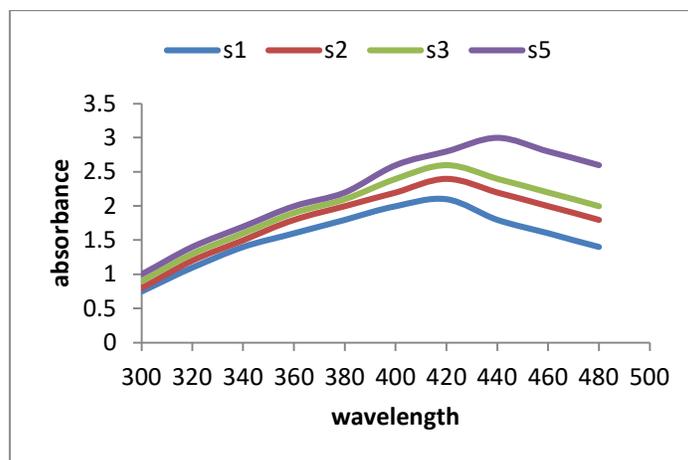


Figure 4: overlay graph of absorbance of Ag NPs

## 4.2 FTIR

### 4.2.1 FTIR SPECTRA OF GELATIN FILM

Here in the **Figure 5**. The FTIR spectra of gelatin polymeric film is given that shows the absorption bands of the gelatin have specific characteristics that reveal details about its functional groups and chemical composition.  $3288.08 \text{ cm}^{-1}$ , this peak represents a wide absorption band around  $3288 \text{ cm}^{-1}$ . In FTIR spectra, broad bands usually indicate the existence of O-H (hydroxyl) stretching vibrations. Therefore, this band confirms the presence of hydroxyl groups within the gelatin molecule, which are integral to the protein's

structure. The presence of aliphatic hydrocarbons in the gelatin polymeric film is indicated by the peak observed at  $2930.58 \text{ cm}^{-1}$ . In gelatin, these aliphatic hydrocarbons are commonly found in the CH<sub>2</sub> groups. Gelatin, a protein obtained from collagen, which is a primary structural protein in connective tissues, can be identified by the presence of C-H stretching bands. These bands indicate the protein's structure and the existence of CH<sub>2</sub> groups within the protein molecule. The stretching band at  $1630.08 \text{ cm}^{-1}$  in the FTIR spectrum of a gelatin polymeric film confirms the existence of the Amide I band, which is a distinctive feature in gelatin's FTIR spectra.

This band indicates the stretching vibrations of the C=O (carbonyl) bonds within the peptide bonds of the protein. The stretching band at  $1539.06\text{ cm}^{-1}$  in the FTIR spectrum of a gelatin film corresponds to the Amide II band. The Amide II band corresponds to the bending of N-H bonds and the stretching of C-N bonds in the peptide bonds of the protein. It confirms the presence of protein structure

within the film. The stretching band at  $1451.58\text{ cm}^{-1}$  and  $1236.10\text{ cm}^{-1}$  confirms the amide III band which also represents the protein structure within the film. The stretching band at  $1080.69\text{ cm}^{-1}$  is associated with C-O (carbon-oxygen) stretching vibrations. Which confirms the presence of C-O bonds within the film [14].

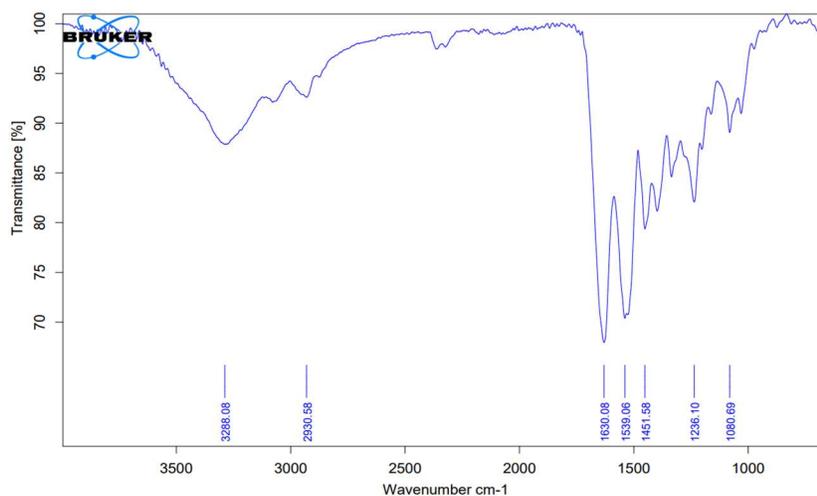


Figure 5: FTIR spectra of gelatin film

#### 4.2.2 FTIR SPECTRA OF PLA FILM

Here in the (Figure 6) the stretching band observed at  $3000.47\text{ cm}^{-1}$  represents the stretching vibrations of C-H bonds in the methyl (CH<sub>3</sub>) groups. It is commonly known as the symmetric stretching band of CH<sub>3</sub>. The stretching band observed at  $1749.85\text{ cm}^{-1}$  is indicative of the stretching vibration of the C=O (carbonyl) bond. This band is generated

by the stretching movements of the carbonyl (C=O) groups in the ester connections of the PLA polymer chains. So this band is critical in FTIR spectra of PLA film as it confirms the presence of PLA within its film. a stretching band at  $1453.91\text{ cm}^{-1}$  is indicating the C-H bending vibrations. The stretching band observed at  $1081.37\text{ cm}^{-1}$  is linked to the stretching vibration of the C-O-C (carbon-

oxygen-carbon) bonds. This band represents the stretching vibrations of the C-O-C

connections in the PLA molecule, which are distinctive features of ester groups [15].

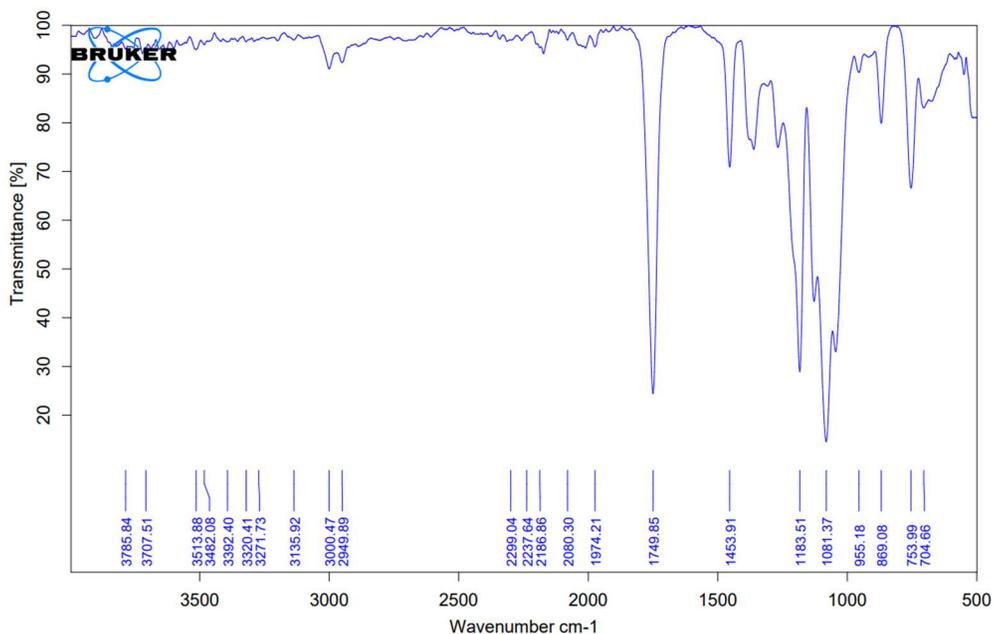


Figure 6: FTIR spectra of PLA film

#### 4.3.1 PLA GRAPGH

Here in the (Figure 7). The thermal decomposition behavior of a polymer film made of Poly(lactic acid) (PLA) was studied using Thermogravimetric analysis (TGA). The weight loss is given in the percentage form. As shown in the (Figure 7). At the outset of the analysis, a slight decrease in weight was noticed around 100.0°C, representing 2.400% of the total weight of the sample. This initial weight loss is showing the elimination of moisture or volatile substances that are adsorbed in the PLA film. The notable

decrease in weight was observed between temperatures of 100.0°C and 150.0°C. The weight loss decreased from 2.000% to 1.600%. This phase corresponds to the initial breakdown of the PLA polymer, which involves the decomposition of ester linkages within the PLA structure. Between the temperatures of 275.0°C and 350.0°C, there was a consistent decrease in weight, going from 1.600% to 1.000%. This temperature range indicates the continuous breakdown of PLA. After this breakdown process slows down until it reaches its end.

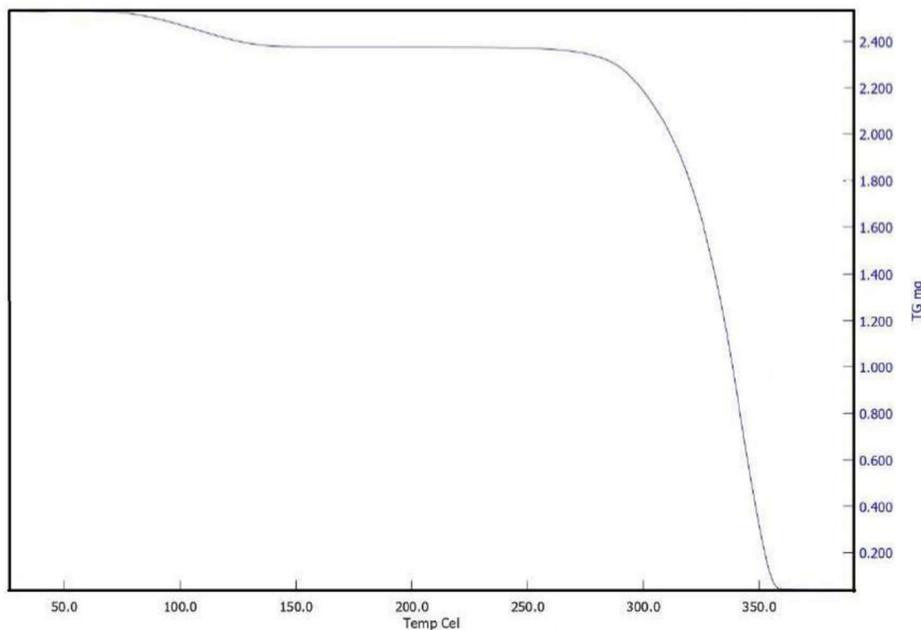


Figure 7: TGA graph of PLA film

#### 4.3.2 GELATIN TGA

The thermal decomposition behavior of a polymer film made of Gelatin was studied using Thermogravimetric analysis (TGA). Here in the (Figure 8). Temperature range was set to 30°C to 400°C, heating rate of 10°C/min, sample mass of 6.0 mg, and nitrogen flow rate of 0.2 mL/min. The analysis was conducted with an empty pan and a nitrogen atmosphere. The nitrogen flow rate during the analysis was 150 mL/min. As shown in (Figure 4). The gelatin film remains relatively unchanged in weight at 50.0°C, suggesting that there is minimal to no weight

reduction at this temperature. However, at 100.0°C, the film starts to lose weight, and this weight loss progressively intensifies with higher temperatures. The initial decrease in weight attributed to the elimination of moisture or volatile elements from the gelatin film. At 250.0°C, the weight loss continues to rise, shows that the gelatin polymeric film is breaking down or deteriorating when subjected to higher temperatures. At 350.0°C, the weight loss remains fairly consistent, showing that the main decomposition processes have probably already taken place, and there is minimal additional weight loss.

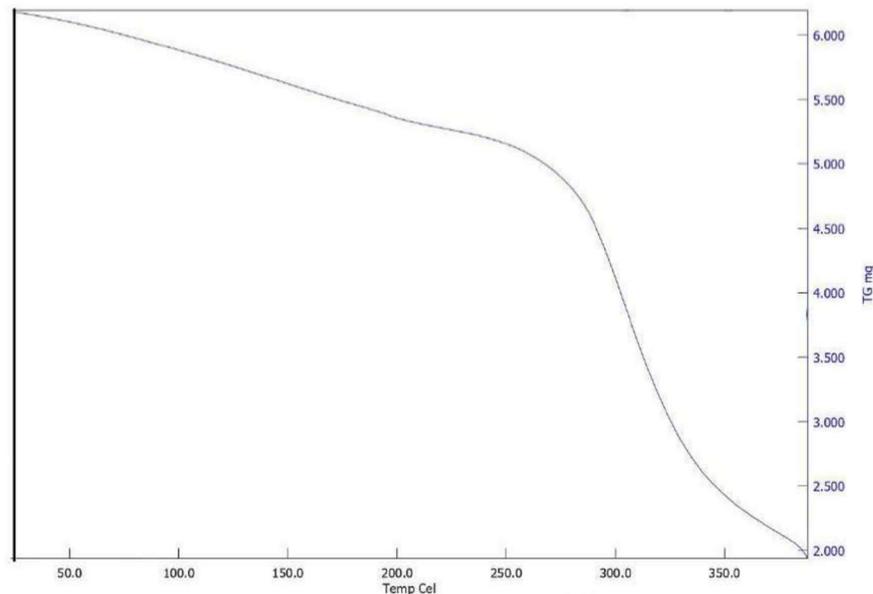


Figure 8: TGA graph of gelatin film

#### 4.4 SEM (SCANNING ELECTRON MICROSCOPE)

##### 4.4.1 GELATIN

The microstructure and surface morphology of gelatin films were analyzed using SEM, which allowed for the visualization of their characteristics and provided information about the quality and properties of the film's surface. The SEM is focused in close

proximity to the sample at a working distance of 200 nanometers. The SEM uses a voltage of 10.00 kilovolts (kV) to speed up electrons. The objective lens is situated 3.8 mm from the gelatin polymeric film. We can see that there are small voids in the **Figure (9) and (10)**, this presence of voids shows that the surface of this film is porous.

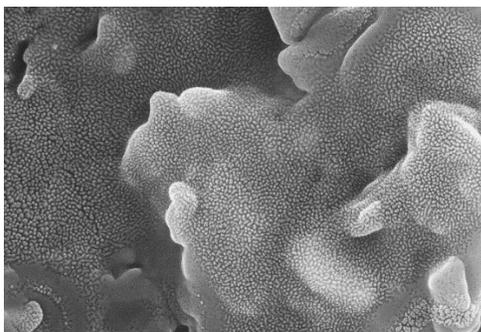


Figure 9: SEM image of gelatin film

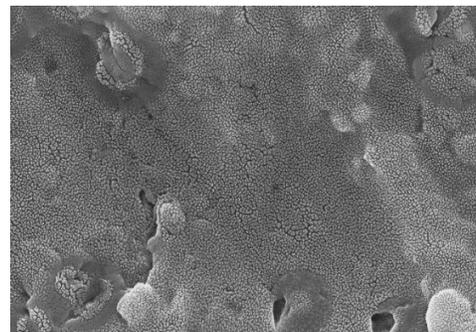


Figure 10: SEM image of gelatin film

#### 4.4.2 PLA

The microstructure and surface morphology of PLA films were analyzed using SEM, which allowed for the visualization of their characteristics and provided information about the quality and properties of the film's surface. A voltage of 10.00 kilovolts (kV) is

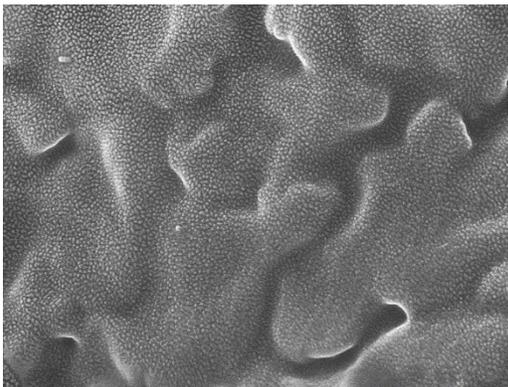


Figure 11: SEM image of PLA film

applied to accelerate electrons in the SEM. A working distance of 1.7 millimeters (mm) was set. Here in **Figure (11) and (12)** we can observe that the surface is porous type by the presence of small voids also it is appearing to be the smooth surface because it has the less bumps and hills in the figures.

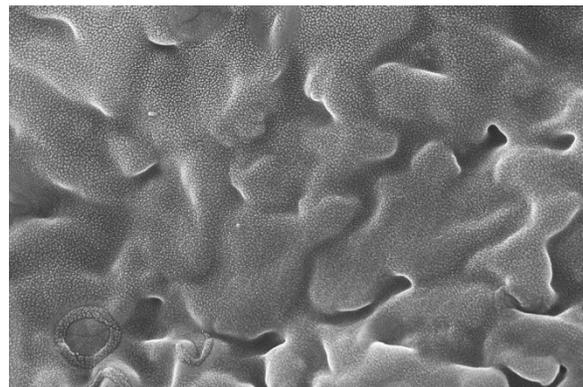


Figure 12: SEM image of PLA film

#### 4.5 Antibacterial study

As shown in **Figure 13** that a study was conducted to test the antibacterial properties of a drug-loaded gelatin film. The target bacteria for the study were *E. coli*. By using

*Escherichia coli* as test organism antibacterial activity of drug carried. Drug loaded with gelatin showed antimicrobial activity on log culture of bacteria after 24 hrs. of incubation measuring around 1.2 cm **Figure (13)**.

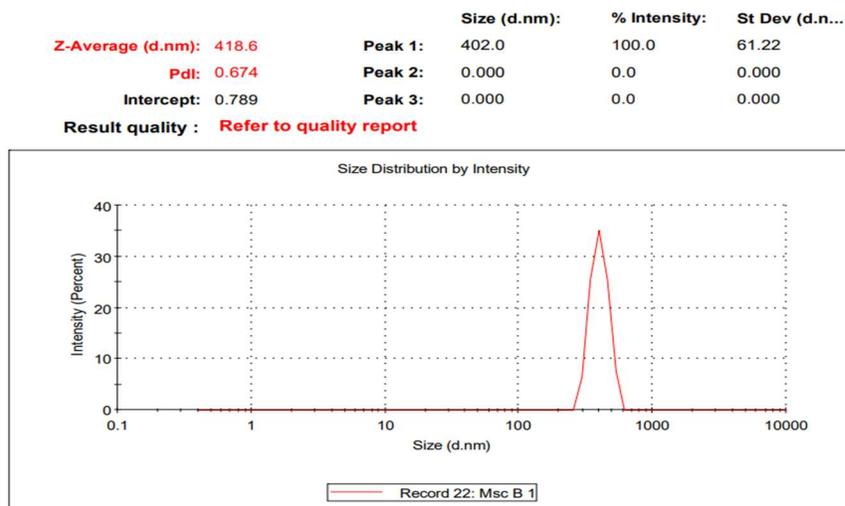


Figure 13: Antibacterial test

#### 4.6. DLS

DLS was performed to determine the size of silver NPs. Here in **Figure (14)** we can see

that the Z –Average (d.nm) was 418.6 for the S1 sample, poly dispersity index was 0.674.



**Figure 14: DLS graph of Ag NPs**

#### 5. CONCLUSION

Disposable face sheet masks and food packaging are frequently used once and then thrown away, which adds to the accumulation of waste in landfills. Using biodegradable options can assist in decreasing the quantity of waste that does not naturally break down. Here in this Paper we have used gelatin for the making of face sheet mask as Gelatin, which is made from collagen, is a protein-based substance. It is generally considered safe and well-tolerated for the skin, making it a suitable ingredient for facial masks. FTIR, SEM, TGA were used to determine the functional group, structure and shape of film, and thermal stability respectively. Here we have added natural extract of aloe vera gel and hibiscus

extract to gelatin film as, Aloe vera is renowned for its ability to soothe and heal. Hibiscus, on the other hand, is packed with antioxidants that promote overall skin health. When combined, these two ingredients work together to alleviate sensitivity and inflammation in the skin. We conducted antibacterial test to see its property against bacteria. Next, we have used PLA as best biodegradable polymer that can be used for food packaging as, the utilization of PLA assists in addressing the issue of plastic pollution. Conventional plastics can take an extensive amount of time to break down, whereas PLA degrades at a faster rate, here we added silver NPs to this PLA film as the antimicrobial properties of silver

nanoparticles are potent, as they can hinder the growth of bacteria, fungi, and other microorganisms. This makes them highly effective in preventing food spoilage and prolonging the shelf life of food products. Here we did FTIR, SEM, TGA to determine the functional group, structure and shape of film, and thermal stability of it. We did DLS to see the size of silver NPs. UV vis spectroscopy to confirm the extraction of silver NPs from the neem broth.

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