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Preparation & Characterization of Bio-Basedpva/Gelatinfilm Extracted from Hilsa Ilisha Fish

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Abstract

Fish consumption has steadily increased during the last few decades, accompanied by an increase in aquaculture production at the expense of wild capture. In line with this trend, the preferences of an increasingly wealthier and urbanised population are turning towards convenience foods, driving the fish industry to transition away from marketing whole fish and towards filleted products. Gelatin is created by partially denaturing collagen, the primary structural protein in connective tissue, resulting in a more soluble material with a larger range of applications. Gelatin properties vary based on animal species, age, source tissue, and extraction circumstances. In fish, the skin yields more and higher-quality gelatin than the bone.

Fish skin waste can be widely used for biopolymer extraction.Gelatin extraction using saline and alkaline solutions. FTIR was also used to examine the chemical structure and thermal degradation. The current study focuses on the extraction and characterisation of gelatin from fish skin, as well as the preparation of a gelatin/PVA/ZnO based biodegradable blend film prepared solvent casting method. The effect of several parameters, such as mechanical, thermal, optical, and morphological qualities, on different blend film compositions was investigated. Differential scanning calorimetric and scanning electron microscope examinations of gelatin/PVA/ZnO blend films revealed miscibility, interaction, and micro phase separation of chitosan, PVA, and ZnO molecules. The created mix film can be used for biodegradable packaging.

Keywords: Fish Skin, Gelatine, PVA, ZnO, Biodegradable and Blend

Introduction

Due to their biological applications and potential as catalysts in organic reactions, transition metal oxide nanoparticles have received a lot of attention in the field of materials chemistry. By adjusting the reaction conditions and the material used for synthesis, transition metal oxide nanoparticles of various types and sizes can be produced. Semiconductor particles are a very essential material for usage in industries because of their flexibility in band gap tailoring, which enables alterations in their optical properties [1,2].

With a wurtzite structure, zinc oxide is an n-type semiconductor material with a straight broad band gap of 3.37 eV and a high excitation binding energy (60 meV) [3,4]. Electro-optic devices, piezoelectric devices, photonic devices, photo luminescent devices, ultraviolet absorbers, light emitting diodes, spintronic devices, dye-sensitized solar cells, gas sensors, cosmetics, and photo catalyst are a few potentials uses of ZnO nanoparticle-containing materials [5,6].

Solgel, combustion, precipitation, hydrothermal, solvothermal, chemical vapor deposition (CVD), microemulsion precipitation, and microwave assisted thermal oxidation have been the most common methods used to create ZnO nanoparticles [7-12]. Different morphologies of ZnO nanoparticles have been created, including nanoflower, nanobelt, corallike, tube-like, nanonail, ellipsoidal, nanocolloids, and nanopowders[13,14]. The majority of these synthetic processes need expensive precursors, risky inorganic acids, high reaction temperatures, and lengthy reaction times, which restrict their industrially significant large-scale production.

In the recent years, numerous physical, chemical, and biological methods for producing ZnO nanoparticles have been established. Using capping agents including trioctylphosphine oxide (TOPO), 1-octadecanol, diethylanolamine (DEA), oleic acid, and methyl methacrylate (MMA),ZnO nanoparticles are produced have seen widespread usage [15-17].

Due to their versatility of preparations in various morphologies with a wide variety of characteristics and size, these capping approaches expand existing applications. Its exceptional biocompatibility and biodegradability make gum tragacanth unique. This quality makes it a crucial substance for uses in the disinfection, cosmetics, and health industries. A novel method for creating ZnO nanoparticles is to use materials with a botanical origin. Hazardous solvents and toxic chemical environments might cause unintended chemical reactions and by-products when ZnO nanoparticles are produced there.

This team has chosen to use biodegradable capping agents of plant origin to help overcome this challenge and maintain a pristine environment for synthesis. A method was devised to create ZnO nanoparticles utilizing a natural binder derived from plants, in an aqueous media, at ambient temperature. Due to the gum tragacanth's high water solubility, it was chosen. It is a revolutionary method to make ZnO nanoparticles utilizing polysaccharides, which are low-cost, natural binders. D-galactameric acid, D-xylose, L-fucose, and D-galactose are all components of this polysaccharide chain.

This method, which relies on a Polyol hydrolysis, uses just two reactantszinc acetate and ammonium carbonateand minimizes the addition of any surfactant [18-23]. The creation of new synthesis techniques that reduce environmental pollution has drawn a lot of interest in recent years. With this objective in mind, heterogeneous catalysts are a great tool to prevent harmful substances like organic solvents.

Materials

Fish skin present on the body of fish is hard and thin plate like structures and provide protection to scale of fish. These skins have large number of organic contents like collagen, fats, and vitamins about 40-55%. The raw fish skin used in the present work was collected from fish market of Lucknow, Uttar Pradesh. It is a refined form of water obtained by simple distillation process, in which is free from electrolytes, minerals, & bacteria from water. Its pH value between (5.4-5.7) Sodium chloride is an inorganic compound which is known as salt with chemical formula - NaCl, molar mass – 58.44g/mol, boiling point – 1,4650C, and density2.16g/cm3.Glycerol is an organic compound also known as glycerin having chemical formula C3H8O3 it acts as a plasticizer that are used to improve the flexibility of film.

It is taken in the current work was purchased from LOBA ChemiePvt. Ltd. Mumbai. It is colorless, odorless, viscous liquid having molecular weight. 92.09, density 1.25g/cm3, melting point, 20°C, boiling point. 182°CSodium hydroxide with the chemical formula NaOH is a strong base that dissociates in water to produce Na+ and OH _ ions. Sodium hydroxide is utilized in the present work was purchased from LOBA Chemie Pvt. Ltd. Mumbai. It was 97% extra pure, white flakes, odorless and had molecular weight. 40.00g/mol, density 2.13g/cm3, boiling point 1390°C, melting point 318°C.

Polyvinyl alcohol is one of the thermoplastic biopolymer which is made from the hydrolysis of vinyl acetate. It has the chemical formula (CH2CH)n due to its excellent mechanical, barrier, film forming properties. It is widely utilized. PVA taken in the current work was pruchased from LOBA Chemie Pvt. Ltd. Mumbai. It was colorless having molecular weight. 1,15000, density@ 1.269g/cm3, melting point. 200°C.Zinc oxide nanoparticle is the most important compound which show great antimicrobial property with the polymer matrix and shows good antibacterial properties for both gram (+) and gram (-) bacteria it is also used a as additive for UV blocking. Zn-ONP also increase the mechanical property of the final product which make by the combination of Zn-ONP and the polymer matrix

Experimental Methodology

Extraction of Gelatin from Waste Fish Skin

The extraction process of gelatin from waste fish skin is illustrated in Figure.1.1. The extraction process includes Pretreatment and alkaline method [24-43]. The waste fish skin was collected from the fish shop of Sitapur, Uttar Pradesh. In this step firstly, fish skin pretreated with NaCl for ½ hrs the washed with distilled water. There were soaked in 0.1M NaOH for 24 hours than clean with distilled water for removing its impurities, after that the extraction carried out with distilled water at 70°C for 2 hours. Further the solution was then centrifuged for 10 minutes at 10,000 rpm. The precipitated liquid was carefully collected and then filtered the remaining particles using filter paper. Then the remaining particles were undergoing for drying it in petri-dish at temperature of 50°C for 2-3 hours to get the sample.



Figure 1.1: Flow Diagram of Extraction Method of Fish Skin Gelatin

Preparation of Gelatin/PVA/ZnO Blend Film

The extracted gelatin was dissolved in 100ml of distilled water & the solution was homogenised using mechanical stirrer for 45 minutes. At the same time, Polyvinyl alcohol was dissolved in 100 ml heating (750C) was provided using heating mantle. Zinc oxide nanoparticle (dissolved in 50ml distilled water) was added to gelatin/PVA solution and stirred for 10 minutes. Later on, 40% wt. of glycerol was added to solution. The viscous solution was poured into petridish and dried in hot air oven for 24hrs at 500 [44]. The prepared film is shown in Figure 1.2.

| Sample code | Gelatin (weight %) | PVA (weight %) | ZnO (weight%) | Glycerol (weight %) |
|-------------|-----------------------|-------------------|------------------|------------------------|
| GPZ-0 | 0 | 100 | 0.5 | 30 |
| GPZ-1 | 1 | 99 | 0.5 | 30 |
| GPZ-2 | 2 | 98 | 0.5 | 30 |
| GPZ-3 | 4 | 96 | 0.5 | 30 |

| Table 1.1: Preparedthe Differe | ent Compositions of | f Gelatin/PVA/ZnO Film |
|--------------------------------|---------------------|------------------------|
|--------------------------------|---------------------|------------------------|



Figure1.2: Preparation of Gelatin/PVA/ZnOBlend Film Testing & Haracterization

Fourier Transform Infrared Spectroscopy

FTIR spectra of raw EFB and nanocellulose fibers were obtained by using Spectrum One-Perkin Elmer with software spectrum v5.02. The fibers were crushed into small particles and then blended with potassium bromide (KBr) followed by pressing the mixture into ultrathin pellets. In this analysis, ratio of fiber to KBr was approximately 1: 99. A total of 100 scans were recorded in the range 370–4000 cm⁻¹ with a resolution of 2 cm⁻¹ for each sample

Scanning Electron Microscopy

The surface morphology of the film samples was investigated by using a JEOL JSM6390LV scanning electron microscope, with the accelerating voltage of 50 kV. All specimens were coated with gold and then observed.

Mechanical Properties

The tensile strength and elongation at break of the composite films were measured on the 2.5 kN Lloyd tensile tester according to the ASTM D882. Samples with rectangular shape were cut into 60 mm × 13 mm strips from the films. The cut films were conditioned at the temperature and relative humidity of $23 \pm 2^{\circ}$ C and $50 \pm 10\%$, respectively, for more than 40 hours prior to measurement of mechanical properties. Tensile testing was conducted at a cross-head speed of 10 mm/minute and a gauge length of 40 mm. six samples were tested for each set and averaged.

Water Absorption Properties

The water absorption capacity of the composite films was measured by drying the film in a vacuum oven at 50° C for 24 hours. Then, the film was cooled in desiccator and immediately weighted. The conditioned film was fully immersed in distilled water for 5 minutes. Subsequently, the remaining water on the surface of film was removed by using filter paper and immediately weighted. All measurements were performed for four specimens and averaged.

Soil Burial Degradation Properties

The films were cut into 50 mm \times 50 mm strips and then were weighted. The degradation test was carried out by burying the films in the soil placed in a flower pot at the depth of 5 cm. The humidity, temperature, and moisture values were negligible and do not require any adjustment in order to provide a realistic environment, where soil humidity, temperature, and type and amount of microorganisms are in less control and change with weather. At a 15-day interval, the films were taken out carefully from the soil. The remaining soil on the surface of the film was removed and then weighted

Results and Discussion

Results of GelatinYield

The yield percentage of the extracted fish skin gelatin was calculated as per the equation 5.1.1(a) given below

Yield (%) =
$$\frac{\text{Total weight of extracted gelatin}}{\text{Total weight of fish skin}} \times 100$$
 5.1.1(a)

As per the above equation, the yield percentage was found to be 25.93% [18].

FTIR Analysis of Gelatin

The extracted gelatin from green fish skin was characterised by using FTIR, as shown in figure 2.1the analysis of functional groups & fingerprint region was done in the range of 4000cm⁻¹ to 450cm⁻¹. A sharp and strong absorption band at 3734.09cm⁻¹ represents the existence of OH stretching, Transmittance at 3667.2cm⁻¹ corresponds to Amide-A & at 2953.02cm⁻¹ peak shows the region of Amide-B. There is a band of stretching (OH) at 1718.7cm⁻¹, which indicates the Amide-I. Band at 1511.5cm⁻¹ & 1295.3cm⁻¹ indicates Amide-II, Amide-III and the band between 1087.1cm⁻¹ and 480.4cm⁻¹ shows C-O stretching and C-O band. The characterization of the extracted gelatin from fish skin by FTIR analysis gave relevant peaks, confirming the quality of gelatin with minimal impurities [21]. Shown in table 2.0.

| Peaks (cm ⁻¹) | Functional group |
|---------------------------|------------------|
| 3734.09 | OH- stretching |
| 3667.2 | Amide-A |
| 2953.02 | Amide-B |
| 1718.7 | Amide-I |
| 1511.5 -1295.3 | Amide-II |
| 1087.1 | Amide-III |
| 480.4 | C-O stretching |

Table 2.0: FTIR Analysis of Gelatin



Figure 2.1: FTIR Spectra of Gelatin

Thermo Gravimetric Analysis of Gelatin

The Thermo gravimetric analysis was done under nitrogen atmosphere at temperature up to 600°C, the heating rate of 10°C/minute. The thermal degradation of extracted gelatin is shown in figure 2.2. It was found that the thermal degradation of extracted gelatin occurred in three phases. The first weight loss of extracted gelatin which occurred at temperature range of 50°C-150°C and mass loss at about 20% due to weight evaporation of volatile substances, primarily water. The second loss between 220°C-550°C with its onset degradation temperature at 240°C & mass loss about 75% primarily caused by the decomposition of organic matters like gelatin primarily caused by the carbonization of organic matter and non-volatile substances.



Figure 2.2: TGA Graph of Gelatin

Result of Gelatin/PVA/ZnO Blend Film Mechanical Properties

The preparedGelatin/PVA/ZnO blend film was tested for mechanical properties by using universal testing machine as shown in figure 2.3 Figure shows the TS. Mechanical properties of blend films It is clearly observed from figure film showed increase in tensile strength, & tensile modulus (14.31MPa & 9.39 MPa) whereas decrease in elongation @ break % (531.7) [28]. The mechanical properties also positively affected incorporation of gelatin. It is due to the presence of strong hydrogen bonding interaction between the amino group of the gelatin& hydroxyl group of the PVA. The crystalline order of the PVA molecules was distributed during process, detonated the hydroxyl groups to hydrogen bonds with amino group of gelatins. The amino groups from gelatin were protonated to solution. As a result, chemical bonds of blend film were stronger &more difficult to break. At the same time, when PVA concentration gradually increased, the tensile strength their hydrogen bonds were weaker. And also at the same time, when the glycerol and ZnO was loaded

with constant weight % ratio (40%), then tensile strength & tensile modulus decreased, but elongation @ break % increased, with increase in concentration of gelatin. This may be due to greater free-moment space provided by glycerol loading, allowing the glycerol molecules to slide between the amino chains. This reduces the polymer's ability to interact with itself to avoid the formation of stiff structures simultaneously, softening the polymer & increases the elasticity of blend film. Shown in table 2.1 [42].





| Samples | Tensile strength (MPa) | Tensile modulus (MPa) | Elongation @ break% |
|---------|---------------------------|-----------------------|---------------------|
| GPZ-0 | 12.27 | 7.18 | 430.9 |
| GPZ-1 | 14.31 | 9.39 | 531.7 |
| GPZ-2 | 9.86 | 6.09 | 492.8 |
| GPZ-3 | 8.92 | 4.37 | 253.9 |

Table 2.1: Data of Tensile Strength, Tensile Modulus, & Elongation @ Break of Prepared Blend Film

Optical Properties

The prepared Gelatin/PVA/ZnO blend film was tested for optical properties by using haze meter, as shown in figure 2.4 shows the luminous (%) transmittance & haze of different sample with different weight% of Gelatin/PVA/ZnO with constant weight% ratio of glycerol. (GPZ-0) film has showed 89.7% transmittance & haze of 41.9% due to the amorphous nature of gelatin. And in case of (GPZ-1, GPZ-2, GPZ-3) blend film, it is clearly observed from figure. that the % transmittance was found lesser than the (GPZ-0) film, with the increase in concentration of starch [45-50]. The luminous% transmittance & haze of blend films are shown in table 2.2.



Figure 2.4: Luminous % Transmittance & Haze of Prepared Blend Film

| Samples | Luminous % transmittance | Haze % |
|---------|--------------------------|--------|
| GPZ-0 | 89.71 | 41.09 |
| GPZ-1 | 86.90 | 43.08 |
| GPZ-2 | 85.12 | 52.09 |
| GPZ-3 | 81.40 | 52.28 |

 Table 2.2: Data of Luminous %Transmittance & Haze of Prepared Blend Film

Water Absorption Test

The prepared Gelatin/PVA/ZnO blend filmwas analysed through water absorption test. It is clearly observed that (GPZ-0) film showed higher water absorption%, but decreased gently with gradual increase in the gelatin concentration. The gelatin is hydrophobic in nature that restricts to absorb water, due to the presence of amino groups [49]. Due to incorporation of gelatin, in PVA/ZnO the hydroxyl group of PVA and ZnO formed intermolecular hydrogen bond with amino group of gelatins that restrict the absorption they may enhancement of hydrophobicity of blend film as observed in figure 2.5. The water absorption% of blend film is shown in table 2.3.



Figure 2.5: Water Absorption% of Prepared Blend Film

| Samples | Water absorption% |
|---------|-------------------|
| GPZ-0 | 35.15 |
| GPZ-1 | 32.10 |
| GPZ-2 | 28.22 |
| GPZ-3 | 25.12 |

Table 2.3: Data of Water Absorption% of Prepared Blend Film



Figure 2.6: Water Absorption Test

Soil Burial Test

The prepared Gelatin/PVA/ZnO blend film was subjected to broad's analysis in a soil burial test for 14days. And the result obtained that the film (GPZ-0) has showed lower degradation rate than the blend films (GPZ-1, GPZ-2, GPZ-3) due to the antimicrobial properties of gelatin. When gelatin concentration was gradually increased in PVA, the degradation rate was slightly increased, due to the hydrophobic nature of gelatin [50]. Also decreased, due to the strong hydrogen bonding interaction between Gelatin, PVA &ZnO as observed in figure 2.7 the weight% loss blend film shown in table 2.4.



Figure 2.7: Weight % Loss after Soil Burial Test for 14 Days of Prepared Blend Film

| Samples | Weight loss (%) |
|---------|-----------------|
| GPZ-0 | 25.15 |
| GPZ-1 | 28.10 |
| GPZ-2 | 32.19 |
| GPZ-3 | 41.55 |

Table 2.4: Data of Weight % Loss of Prepared Blend Film after 14days Soil Burial Test



Figure 2.8: Soil Burial Test

FTIR Analysis of (GPZ) Blend Film

The gelatin/PVA/ZnO blend film was characterized by using FTIR, as shown in figure 2.9. The analysis of functional groups & fingerprint region was done in the range of 4000cm⁻¹ to 450cm⁻¹. The IR spectra of blend film showed peaks at 1035.5cm⁻¹ which are characteristics of a ZnO (due to C-O stretching,). The N-H bending (amide II) band was found at 1529.5cm⁻¹, due to the interaction between amino group of gelatin& hydroxyl group of PVA. The bands near 1736.6cm⁻¹ were characterized as corresponding to the Amide-I group. The peak at 2946.2.cm⁻¹ is attributed to the C-H stretching. The O-H stretching, which overlaps the N-H stretching, due to the inter & intra-molecular hydrogen bond was shifted at 3758.3cm⁻¹. And the bands from 859.9cm⁻¹ to 915.8cm⁻¹ corresponds to C=C bending & C-H bend. Changes in typical spectrum peaks represent chemical interactions. These results showed good compatibility & interaction between the (GPZ) blend films [31].



Figure 2.9: FTIR Analysis of (GPZ) Blend Film

SEM Analysis of Blend Film

The scanning electron microscope of pure chitosan film& (CS) blend film are shown in figure 2.10 at magnification of 500x. And result obtained that the SEM image of virgin film (GPZ-0) have a coarse surface that increases the heterogeneity of PVA/gelatin film., And in film (GPZ-1) also, due to the addition of ZnO in PVA/gelatin globular particles found. BecauseZnO is hydrophobic in nature in drying process ZnO crystals found. This may responsible for modification of polymer chain structure [32].



Figure 2.10: SEM images of Prepared (GPZ-0) & (GPZ-1) blend film

Differential Scanning Calorimeter Analysis of (GPZ-0) & (GPZ-1) Blend Film

The differential scanning calorimetric was performed at a heating rate of 100C/minute for all the samples (GPZ-0 & GPZ-1) as shown in figure 2.11. During this analysis, derivatives are also produced mainly for the identification of endothermic phase change. We can observe the endothermic peak of the sample. It may be assigned to be absorbed liquid material because of hygroscopic nature of PVA material from the graph in figure 2.12 it is clearly observed that the blended film had only one Tm peak indicating that the blend film was single phase. Gelatin is a type of protein that has Eighteen type of different amino acids that can be made hydrogen bond with hydroxyl group of PVA that increases the melting energy which will improve the Tm of blend film. As compared to GPZ-0 film showed Tm at 179.23°C and GPZ-1 at 184.65°C. it indicates the increase in crystallinity. The addition of gelatin there is increment the Δ H values this indicates that blended film is less hydrophilic therefore it is concluded that prepared film is compatible and shows more crystalline nature as compared to virgin PVA/ZnO film [10]. The endothermic peaks of gelatin/PVA/ZnO film of samples are shown in table 2.5

| Samples | Exothermic peaks (0C) | Enthalpy (J/g) |
|---------|-----------------------|----------------|
| GPZ-0 | 179.230C | 2.9915 |
| GPZ-1 | 184.650C | 17.896 |

| Table 2.5: Data of | (GPZ-0) & | (GPZ-1 |) Blend Film |
|--------------------|-----------|--------|--------------|
|--------------------|-----------|--------|--------------|



Figure 2.11: DSC Analysis of Prepared (GPZ-0) Blend Film



Figure 2.12: DSC Analysis of Prepared (GPZ-1) Blend Film

Thermo Gravimetric Analysis of (GPZ-0) & (GPZ-1) Blend Film

The Thermo gravimetric analysis was done under the nitrogen atmosphere at temperature up to 600°C, & the test was performed at heating rate of 10°C/minute. The thermal degradation of (GPZ-0) & (GPZ-1) are shown in figure 2.13. It was found the thermal degradation of film occurs in three phases. The first weight loss of (GPZ-0) & (GPZ-1) blend film was found at temperature range between 85.23°C, &105.21°C This mass loss was due to the evaporation of water. While the second weight loss of the temperature range between 140.55°C and170.22°C respectively. This is due to the complex process including the depolymerisation& break down of hydroxyl chain unit. In comparison to PVA, the thermal decomposition temperature of blend films changed to slightly higher temperature with increase in gelatin concentration [25]. And the third weight loss of blend film the temperature range between 260.22°C, & 280.91°C, these higher weight losses started above 270°C, due to gelatin char formation, & the remaining residue was inorganic as a result of the pyrolysis of carbonated chemicals [35].

| Samples | 5% weight loss (°C) | 10% weight loss (°C) | 50% weight loss (°C) |
|---------|---------------------|----------------------|----------------------|
| GPZ-0 | 85.230C | 140.55 | 260.22 |
| GPZ-1 | 105.210C | 170.22 | 280.91 |

Table 2.6: Data of (GPZ-0) & (GPZ-1) Blend Film



Figure 2.13: TGA Analysis of Prepared GPZ-0 & GPZ-1 Blend Film

Conclusion

Gelatin from fish skin was successfully extracted by using alkaline hydrolysis method. The extracted gelatin showed 25.93% yield, the extracted gelatin was characterized using FTIR & TGA. The strong absorption band of hydroxyl group (OH) at 3734.09cm⁻¹, peak at 1718.7cm⁻¹ showed Amide-I, & band between 1087.1cm⁻¹ to 480.4cm⁻¹ showed features of C-O stretching and C-O band. Thermo gravimetric analysis showed onset degradation temperature at 240°C. The extracted gelatin from fish skin was blended with PVA/ZnO& analysed the effect of extracted gelatin on the particular blend film. The gelatin was added different weight% ratio of 0%, 1%, 2%, 4% respectively with constant weight% ratio 40% of glycerol. The mechanical properties were analysed by UTM machine like tensile strength, tensile modulus of the blend film increased whereas %elongation @ break decreased as compared to virgin film. The luminous% transmittance of blend film decreased with increase in haze as compared to virgin film.

The blend film showed hydrophobic nature & also virgin film showed higher hydrophilic nature, the biodegradability test analysed by soil burial method & it was found that weight% loss was higher. The functional groups & fingerprint region was analysed by using FTIR. The O-H stretching overlapped the N-H stretching & peak was shifted to 3758.3 cm⁻¹. The N-H bending (amide II) band found at 1529.5cm⁻¹ due to the interaction between amino groups of gelatin& hydroxyl group of PVA, & peaks at 1035.5cm⁻¹ showed characteristics of ZnO. The morphology of blend film analysed by using SEM, which confirmed the surface was coarse, & no any phase separation in both case blend film increasing in heterogeneity of film due to addition of ZnO. Thermal analysis by using DSC. And the thermal stability of (GPZ-1) blend film highest exothermic peak found at 184.65°C.TGA showed the sample (GPZ-1) had best result with highest thermal stability. According to the above best result of mechanical properties, optical properties, water absorption, & biodegradability test, & surface morphology between gelatin/PVA &ZnO. The results obtained from this study shows that the prepared blend film can be used for packaging application, which is fully biodegradable in nature.

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