PAPER • OPEN ACCESS

Evaluation of mechanical and antimicrobial properties for indigenously developed Biofilm for food packaging industries

To cite this article: Balakrishnaraja Rengaraju *et al* 2021 *IOP Conf. Ser.: Mater. Sci. Eng.* **1059** 012001

Evaluation of mechanical and antimicrobial properties for indigenously developed Biofilm for food packaging industries

Balakrishnaraja Rengaraju[1], M Jeevanantham[2], S Shanmugaraja[2], A Selvakumar[3], and S Tamilselvi[2]

[1] Department of Food Technology, Bannari Amman Institute of Technology, Sathyamangalam, India
[2] Department of Biotechnology, Bannari Amman Institute of Technology, Sathyamangalam, India
[2] VIT Fashion Institute of Technology, Vellore Institute of Technology, Chennai, India

balakrishnaraja@gmail.com

Abstract. The preparation of the film based on aloe vera gel and polyvinyl alcohol (PVA) were carried out in this work. The film has high adhesion due to the presence of polyvinyl alcohol. The mechanical properties like tensile strength and the transparency of the film were tested. The temperature withstanding ability of the film is tested with Thermo gravimetric analysis. The functional groups of the film were identified. The films prepared were evaluated by incorporation of an antifungal and an antibacterial agent which shows marked inhibition on growth of mold, yeast and bacteria. The Shelf life of the vegetables was tested using the film.
Keywords: organic biofilm, antimicrobial film, Aloe vera

1 Introduction

Polymer and plastics produced using petrochemical inferred polymers, for example, poly (ethylene teraphthalate), poly (vinyl chloride), poly (ethylene), poly (propylene), poly (styrene), poly (amide), ABS copolymer and so on by proper embellishment strategy are assuming essential jobs in all the human exercises, for example, nourishment bundling, farming mulching, convey sacks, medical clinic bed covers, removal cups, plate, as scratch verification meagre film coatings and so forth. Polymers are generally utilized for these applications on account of their accessibility, minimal effort, great mechanical properties (tractable and tear quality) destructive opposition [1].A few biopolymers have been utilized to create eco-accommodating nourishment bundling materials. Usually, films dependent on biopolymers are profoundly touchy to natural conditions and for the most part present low mechanical opposition.

1.1 Properties of polymeric Biofilm

Therefore, a few examinations have been completed to create films dependent on blends of biopolymers and manufactured polymers. Naturally degradable plastics have pulled in developing consideration on account of their latent capacity use in the substitution of conventional non degradable plastic things getting from petroleum derivative feed stocks. Poly vinyl Alcohol (PVA) has been broadly used for the planning of mixes and composites with a few characteristic, inexhaustible polymers [2]. PVA is a material with mechanical potential which has a wide scope of utilizations because of its special physical and synthetic properties. It is a nontoxic, exceptionally crystalline issue and has great film forming and high hydrophilic properties. PVA, cellulose and Chitosan are polar polymers; in this manner a nanocomposite of PVA, Chytosin and nano crystalline cellulose (NCC) is probably going to create a material including phenomenal mechanical properties. Installing NCC into PVA framework changes the physicochemical properties of PVA and improves polymer structure in both sub-atomic and morphological levels [3]. During the time spent biodegradation the right off the bat the long polymer atoms are diminished to shorter and shorter lengths and experience oxidation (oxygen bunches append themselves to the polymer particles). This procedure is activated by heat (raised temperatures found in landfills), UV light (a part of daylight) and mechanical pressure (for example wind or compaction in a landfill). [3, 2]

1.1.2 Microbial Biofilm Degradation

Oxidation makes the particles become hydrophilic (water pulling in) and sufficiently little to be ingestible by microorganisms, making way for biodegradation to start. Biodegradation happens within the sight of dampness and microorganisms regularly found in the earth. The plastic material is totally separated into the remaining results of the biodegradation procedure. As microorganisms expend the corrupted plastic, carbon dioxide, water, and biomass are created and come back to nature by method for the bio cycle [4]. One of the primary research regions in nourishment bundling has concentrated on growing new bundling systems fit for improving nourishment conservation properties dependent on their connection with bundling. Such procedures are known as "dynamic bundling frameworks". A dynamic bundling can be characterized as a kind of material that changes its bundling conditions to broaden timeframe of realistic usability, cooperating straightforwardly with the nourishment, upgrading security and looking after quality. Specifically, the antimicrobial bundling is one of the most imaginative and promising dynamic bundling types created over the most recent decade, which incorporates frameworks fit for hindering microorganism activity and staying away from loss of nourishment quality [5]. Nonetheless, because of the couple of reports that have been made on films with high mechanical and warm properties, the planning of PVA/starch based biodegradable antibacterial films show extraordinary importance in the field of nourishment bundling. Along these lines, the reason for the current examination is to utilize starch and polyvinyl alcohol [6].

PVA material is universally applied due to its high efficiency and usability involving the alteration of physical/ chemical properties [7] Polymers are generally utilized for these applications on account of their accessibility, minimal effort, great mechanical properties (tractable and tear quality) destructive opposition [8].

2 Materials and Methods

2.1.Synthesis of Biofilm.

The films were prepared using proportions of polyvinyl alcohol i.e., 1.5%, 2.5%, and 3.5% in which *Aloe vera* is added with respect to the proportion of PVA. The film was produced using casting method. The PVA powder of about 1.5g is added in 100 ml of deionised water and kept under constant mixing in the sonicator. *Aloe vera* is added in the PVA aqueous solution 50% by mass with respect to the mass of PVA powder. It is kept under constant stirring for about 3h at 90^0C. Then the solution were poured into a dye and dried for 24h at room temperature (the same procedure is followed for preparation of 2.5% and 3.5% film).[9, 10]

2.2.Mechanical Analysis.

In this analysis, tensile strength (TS) was determined according to the standard method, works on the constant rate of transverse principle (universal testing machine is used to test the tensile strength of the films).

2.2.1 Film thickness: The thickness of the film was determined by using the Vernier calliper and measured as the average of 3 mm for each sample.

2.2.2 Opacity: The opacity of the film is determined by cut the sample into rectangular shape and the transmittance curve of various spectrums (300nm -600nm).

2.2.3 Thermal properties: The film sample were dried and cut into pieces after that Thermo gravimetric analysis (TGA), Differential scanning calorimeter (DSC), Derivative thermal analysis (DTA) analyses were performed on a NETZSCH STA 2500 and heated from 0 to 500^0C.

2.2.4 FTIR analysis: It is used to confirm the chemical nature of the film components.1.5%, 2.5%, 3.5% film were analysed by Fourier transform infrared spectroscopy at the resolution in a 4000 to 400 per cm range, using air as background.

2.3 Biocompatibility Analysis.

The biodegradation test was done by burying the film in the soil in the closed environment. Before that the mass of the film were measured and kept for five days. The weight losses of the film were then measured. For this test, tomato is taken and cut into pieces and packed with the biofilm produced and observed. The food is kept in the room temperature and photographed at different times.

3 Results and Discussion

The different concentrations of the films were produced by using the casting method that is 1.5%, 2.5%, 3.5 %. Each film shows that it can withstand high temperature and can hold more weight. It is used as to increase shelf life and to carry substance.

Film thickness: The thickness of the 1.5%, 2.5%, and 3.5% films were 0.02mm, 0.029mm, and 0.033mm respectively. It is measured by using the verniarcaliper.

Opacity: The transparency of each film is measured using UV visible spectrometer to find the opacity of the film by using transmittance curve. It shows that transparency of the film is mostly similar to each other and the PVA film is known for transparency. The transmittance curve is shown in graph 1, 2 and 3.

FTIR Analysis: It is used for the chemical characterization of the produced biofilm by FTIR Analysis. It is used to obtain spectra of the each film. The adsorption is done in the resolution of 4000-400 per cm range. The obtained results were shown in the graph 4, 5 and 6.

Mechanical properties: The tensile strength of each film was tested using the universal testing machine which shows that it has the ability to carry around one kilo gram. The results are shown in the Table 1.

Thermal properties: In the thermal decomposition test, the temperature used is ranged from 0 to 500 degree Celsius. In this analysis it is revealed that the major mass loss at 260^{0}C. These thermal analysis are shown in the graph 7, 8 and 9 respectively.

Biodegradable test: Bio degradable of the prepared film is identified by the wet soil, and each concentration of the films are weight loses every day.

Behaviour on foods: The 2.5% PVA film has increase the shelf life of the tomato by covering the pieces in the film biolayer.

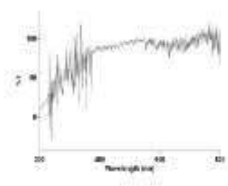


Figure 1.

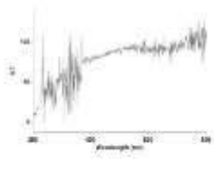


Figure 2.

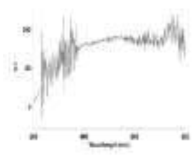


Figure 3.

Transmittance curves Figure. (1), (2) & (3)are for 1.5%, 2.5% and 3.5% respectively

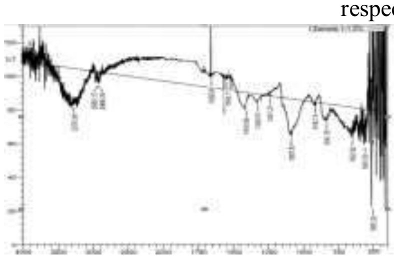


Figure 4.

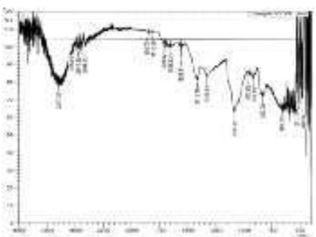


Figure 5.

FTIR Analysis Figure. (4) and (5) are for 1.5% and 2.5% respectively

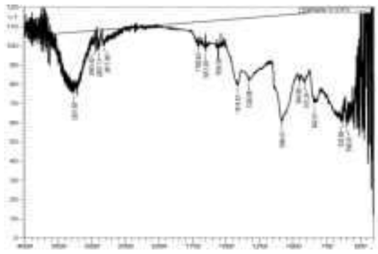


Figure6.

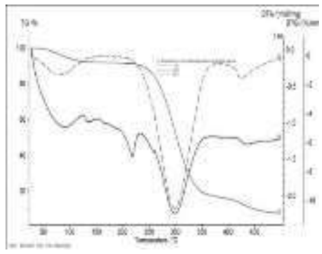


Figure7.

FTIR Analysis Fig. (6) of 3.5% and Thermal analysis (7) of 1.5% film respectively

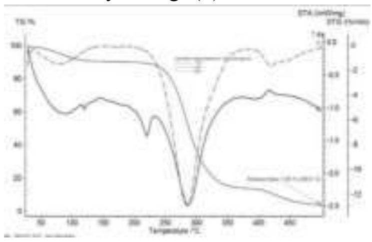


Figure8.

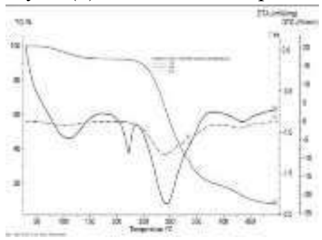
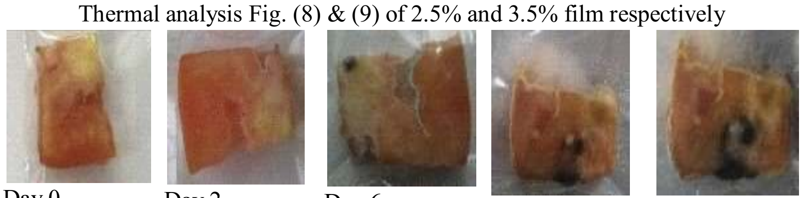


Figure9.

Thermal analysis Fig. (8) & (9) of 2.5% and 3.5% film respectively



Day 0 Day 2 Day 6 Day 10 Day 15

Figure10. Shelf life test on tomato with 2.5% PVA film

Table 1. Tensile strength of each films

Film Conc. (%)	Load (KN)	Displacement (mm)
1.5%	0.0025	57.15
2.5%	0.0125	147.56
3.5%	0.0150	196.250

Table2. Biodegradation Assay of the film with different concentration

Days	**Film Concentration**		
	1.5%	**2.5%**	**3.5%**
1	0.0014	0.0020	0.0032
2	0.0010	0.0014	0.0027
3	0.0005	0.0009	0.0021
4	0.0002	0.0005	0.0017

IOP Conf. Series: Materials Science and Engineering 1059 (2021) 012001 doi:10.1088/1757-899X/1059/1/012001

4 Summary and Conclusions

Thus the produced biofilm can able to withstand high temperature and has antimicrobial activity and can hold more weight which is used for packaging and increase shelf life of vegetables. The different concentration of film shows the transparency to the light which is used for light required ailments.

Acknowledgments

The authors are thankful for the support rendered by the Principal and Management of Bannari Amman Institute of technology towards project support

References

[1] Eliassaf J 1972 Detection of small quantity of Poly (vinyl alcohol) in Poly (vinyl chloride) resins *Polymer Letters* **16** 225-235

[2] Cha D S Cookseyb K Chinnana M S and Park H J 2003 Antimicrobial films based on Na-alginate and kappa-carrageenan *Food Science and Technology Lebensmittel-Wissenschaft und-Technologies* **35**(8) 715-719

[3] Arvanitoyannis I Kolokuris I Nakayama A Yamamoto N and Aiba S 1997 Physico-chemical studies of chitosan-poly (vinyl alcohol) blends plasticized with sorbitol and sucrose *Carbohydrate Polymers* **34**(1-2) 9-19.

[4] Abugoch L E, Tapia C, Villamán M C, Yazdani-Pedram M and Díaz-Dosque M 2011 Characterization of quinoa protein-chitosan blend edible films *Food Hydrocolloids* **25**(5) 879-886

[4] Agustín González, Cecilia I and AlvarezIgarzabal 2013 Soy protein – Poly (lactic acid) bilayer films as biodegradable material for active food packaging* *Food Hydrocolloids* **33**(2) 289-296

[5] Kester J J and Fennema O R 1986 Edible Films and Coatings A Review *Food Technology* **40** 47-59.

[6] Masuhiro T, Giuliano F and John S C1994 Structure and Compatibility of Poly(vinyl alcohol)-Silk Fibroin (PVA/SA) Blend Films *Journal of Polymer Science* B: Polymer Physics **32** 243-248

[7] Sudesh K and Iwata T 2008 Sustainability of Biobased and Biodegradable Plastics *Clean Soil Air Water* **36** 433-442

[8] Yufei Han Kuang Li ID, Hui Chen and Jianzhang Li 2017 Properties of Soy Protein Isolate Biopolymer Film Modified by Graphene *Polymers* **9** 312

[9] Follain N, Joly C, Dole P and Bliard C 2005 Properties of starch based blends. Part 2. Influence of poly vinyl alcohol addition and photocrosslinking on starch based materials mechanical properties, *Carbohydrate Polymers* **60**(2) 185-192