International Journal of Scientific Research in Science, Engineering and Technology

Print ISSN - 2395-1990
Online ISSN : 2394-4099

OPEN ACCESS

Available Online at : www.ijsrset.com
doi : https://doi.org/10.32628/IJSRSET2310664

Chitosan/PVA Nanocomposite Films with Improved Structural, Vibrational and Optical Properties

G. Jeya Jothi, P. Kanchana, R. Vinotha

Department of Physics, Sakthi College of Arts and Science for Women, oddanchatram Dindigul, Tamil Nadu, India

ARTICLEINFO

Article History :

Accepted: 15 Dec 2023
Published: 06 Jan 2024

Publication Issue :

Volume 11, Issue 1
January-February-2024

Page Number :

18-22

ABSTRACT

Herein, the solvent costing method was used to prepare the chitosan/poly vinyl alcohol (CS/PVA) nanocomposite films and the properties of structural, vibrational, optical, thermal and electrochemical of these films have been reported. XRD and SEM were confirmed the presence of CS in PVA matrix. The vibrational properties and functional group assignment were studied. The thermal stability and electrochemical properties of chitosan/poly vinyl alcohol nanocomposite films were reported.

Keywords : CS/PVA, XRD, SEM, Properties of Structural, Vibrational, Optical, Thermal and Electrochemical

I. INTRODUCTION

Fuel cells have been recognized as a prime candidate for new energy resources and have extensively studied as an alternative to limited fossil fuels that are generally characterized by electrolyte material. Among electrolyte material, solid polymer-based electrolyte membranes offer advantages such as high efficiency and high energy density. Fuel cells have attracted attention due to their potential as a promising alternative to traditional power source. Recently, the efficient and environmentally being biopolymer “chitosan” have been extensively used as a novel material for its application in fuel cell. Polyvinyl alcohol (PVA) is a biodegradable synthetic polymer that presented high ionic conductivities. The positive charge arising due to high protonated amino functionalities enables chitosan to polyelectrolyte complex. The objective of this review is to investigate the current status of fuel cells and advances in utilization of chitosan biopolymer for polymer electrolyte membrane technologies.

II. EXPERIMENTAL METHODS

Preparation of basic solution of chitosan:

1g of chitosan istaken with 60ml of deionized in a beaker and it set in a stirrer. Then 1g of chitosan is added to the deionized water. The stirrer is set at the speed at 700- 900 rpm. The acetic acid of 5 drops is added and stirred for more than 5 hours to make it in solution form.

Preparation of basic solution of PVA:

1g of Polyvinyl alcohol (PVA) is takenwith 10 ml of deionized in a beaker and set in a stirrer. The stirrer is again set at the speed of 90-120rpm speed. The solution

is stirred for more than 4 hours to make it in solvent form.

Ratio : The basic solution of chitosan 9ml is taken along with the basic solution of PVA 1ml. The solution is taken in a beaker and is set in the stirrer. Then the stirrer is again set at the speed of 100rpm speed. The solution is stirred for about 20 minutes. Now the both basic solutions are completely mixed well. Then the form a solution. The solution of the mixture is now poured in a Petri dish for the evaporation under vacuum. With the mixture of the precursors, a membrane was formed with the solvent evaporation technique (casting).

III. RESULTS AND DISCUSSION

3.1 Characterizations of nanocomposite films

3.1.1 FTIR Analysis

The FTIR spectra of different concentration of CS/PVA nanocomposites were recorded and the observed peak shown in Fig.2. From table 1, the presence of certain functional group in the molecule was confirmed by using FTIR spectra. The O-H and N-H stretching were assigned in the wavenumber range from 3363 to 3564 cm-1. The wavenumber 2924 to 2955 cm-1 were observed at O-H stretching vibration. The N-H bending vibration was observed in the range of 1463 to 1643 cm-1. The wavenumber 1327 to 1382 cm-1 were observed at O-H and C-H bending. The C-N and C-O stretching were assigned in the wavenumber range from 899 to 1153 cm-1. The wavenumber 850 to 855 cm-1 and 609 655 cm-1 were observed at N-H and C-H rocking and OH and C-H bending respectively.

Table. 1 Vibrational assignment for FTIR bands

Wavenumber in cm-1						Vibrational assignment
Pure CS	CS/PVA 1 wt%	CS/PVA 2 wt%	CS/PVA 3 wt%	CS/PVA 4 wt%	CS/PVA 5 wt%	
3363.1	3459.1	3434.1	3399.9	3427.3	3563.9	O-H and N-H Stretching
		3295	3305.8	3296.7		
2924.8	2939.8	2939.8	2939.8	2939.2	2954.6	O-H Stretching
2881.5						C-H Stretching
					2173.9	
	1732	1731.8	1733.8	1727.2	1731.2	
1643.1	1649.9	1649	1653.3	1651.9	1654.1	N-H bending
1563.2	1564.1	1562.9	1564.9	1564.7	1569.1	N-H bending
1409.7	1415.7	1417.5	1423	1424.2	1462.9	N-H bending
1382.3	1377.7	1377.2	1376.1	1376.2		O-H and C-H bending
		1326.5	1325.9	1327.1		O-H and C-H bending
1322.5	1258.8	1257.9	1255.4	1258.9		O-H bending and C-N and C-O stretching
1153.4	1103.2	1084	1091.3	1078.1	1147.9	C-N and C-O stretching
1079.2	947.4	947.4	946.9	946.9	948	C-N and C-O stretching
899						C-N and C-O stretching
	849.9	848.2	850.4	849.3	855.3	N-H and C-H rocking
654.6	654.8	654.3				OH and C-H bending
619.28	611.5	611	608.9	609		OH and C-H bending

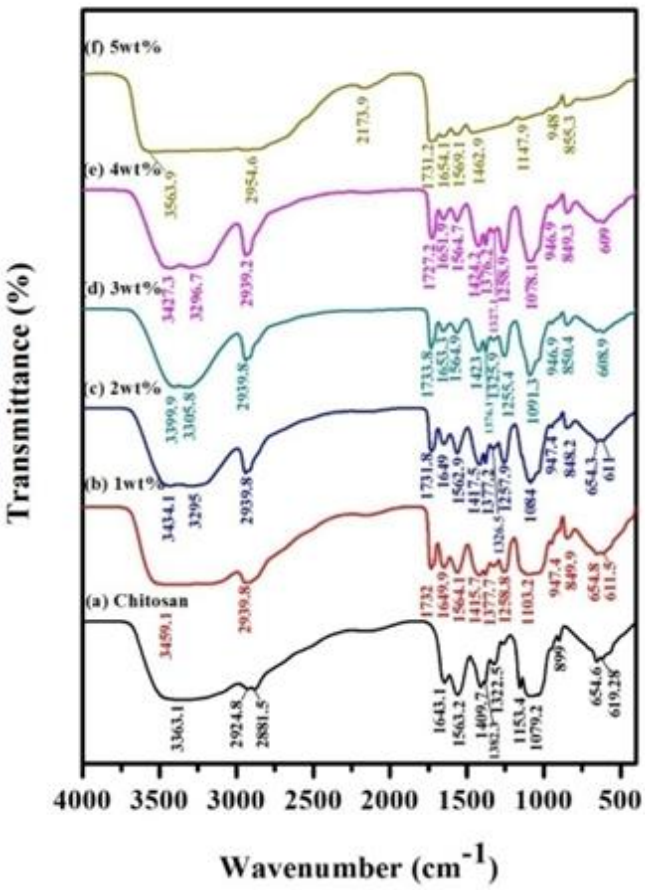

Fig. 2 FTIR spectra of CS/PVA nanocomposite films with different concentration

3.1.2 Morphological Analysis

The morphological structure of prepared pure CS and CS/PVA with different concentration of the samples were observed by using high resolution SEM images as shown in Fig. 2 depicts the pure CS and the observed range of particle size from 137 to 191 nm. In fig. 2 b-f shows that the SEM images of CS/PVA films with different concentration. The particle size were obtained in the range from 39 to 134 nm for 1 wt%, 106 to 142 nm for 2 wt%, 60 to 250 nm for 3 wt%, 58 to 176 nm for 4 wt% and 77 to 188 nm for 5 wt%. The dispersion of as-prepared CS/PVA has been evaluated via increasing its density by increasing the CS loading through PVA. The CS content increasing with increase the size of nanoparticle up to 3 wt% of CS in PVA matrix. The smoothed surface area was diminished by raising the concentration of CS.

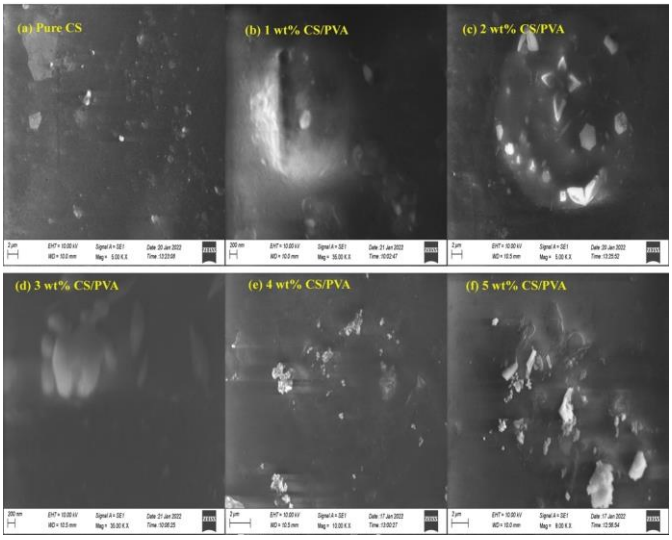

Fig. 3 SEM images of CS/PVA nanocomposite films with different concentration

3.1.3 Thermogravimetric Analysis (TGA)

The decomposition of CS/PVA films were analyzed by using TGA curves. The TGA pattern and derivative are presented in Fig.4 &5. Two and three distinct stages weight loss were presented in the temperature range from 25 to 800 °C for pure chitosan and CS/PVA with different concentration films respectively. The weight loss values of three distinctive steps of thermal degradation for the pure chitosan and CS/PVA with different concentration films as shown in Fig.4. The vaporization of surface-adsorbed water was created the first stage weight loss (>100 °C) of all the CS/PVA nanocomposite films. This stage was found in the temperature range from 26 to 104 °C, 36 to 128 °C, 32 to 105 °C, 33 to 123 °C, 30 to 127 °C and 32 to 125 °C for pure chitosan, 1 wt%, 2 wt%, 3 wt%, 4 wt% and 5 wt% of CS/PVA films respectively. The second stage of weight loss was found in the temperature range from 104 to 383 °C for pure chitosan, 128 to 214 °C for 1 wt% of CS/PVA, 105 to 221 °C for 2 wt% of CS/PVA, 123 to 489 °C for 3 wt% of CS/PVA, 127 to 481 °C for 4 wt% of CS/PVA and 125 to 384 °C for 5 wt% of CS/PVA. The reason for this was the thermal degradation of chitosan and PVA chains from the films [Qiao et al. 2017]. The third stage of

weight loss was found in the temperature range from 214 to 386 °C, 221 to 483 °C, 489 to 549 °C, 481 to 553 °C and 384 to 507 °C for 1 wt%, 2 wt%, 3 wt%, 4 wt% and 5 wt% of CS/PVA films respectively. The reason for this was shows thermal degradation of PVA in the matrix [32]. Fig.6 depicts the DSC thermogram of CS/PVA films with different concentration. The melting temperature of all the films were observed and the values as 457, 515, 531, 526, 526 and 493 °C for pure chitosan, 1 wt%, 2 wt%, 3 wt%, 4 wt% and 5 wt% of CS/PVA films respectively. It is indicated the thermal stability of CS/PVA films were improved. The temperatures values of Pure CS and CS/PVA with different concentration films corresponding weight loss of 10, 50 1nd 75% were presented in Table.3.

Table 2 Temperatures corresponding weight loss of 10, 50 and 75%

Film concentration	Temperatures (°C)		
	Weight loss of 10 %	Weight loss of 50 %	Weight loss of 75%
Pure CS	52	298	353
1 wt% CS/PVA	171	337	427
2 wt% CS/PVA	107	370	524
3 wt% CS/PVA	219	365	490
4 wt% CS/PVA	250	388	507
5 wt% CS/PVA	239	352	493

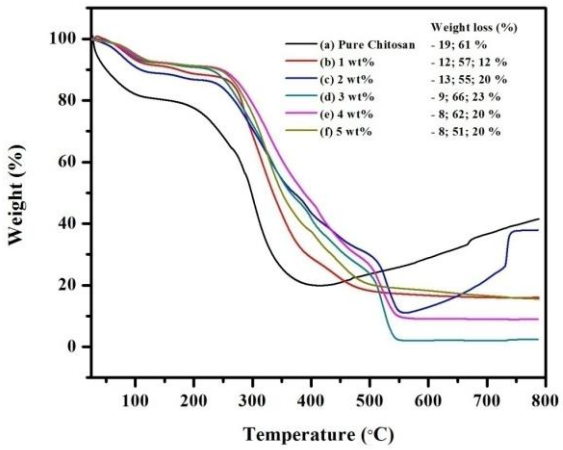

Fig. 4 TGA curves of CS/PVA nanocomposite films with different concentration

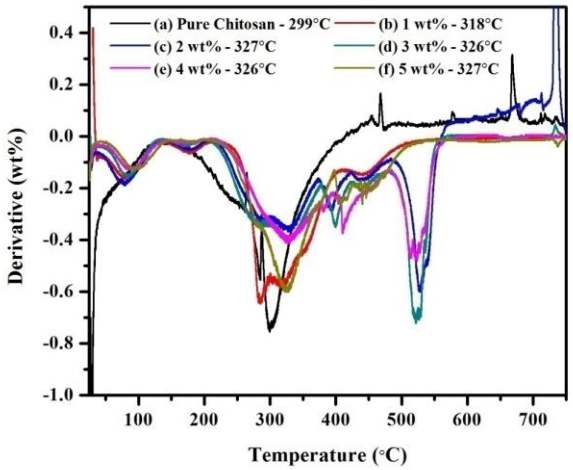

Fig. 5 TGA derivative curves of CS/PVA nanocomposite films with different concentration

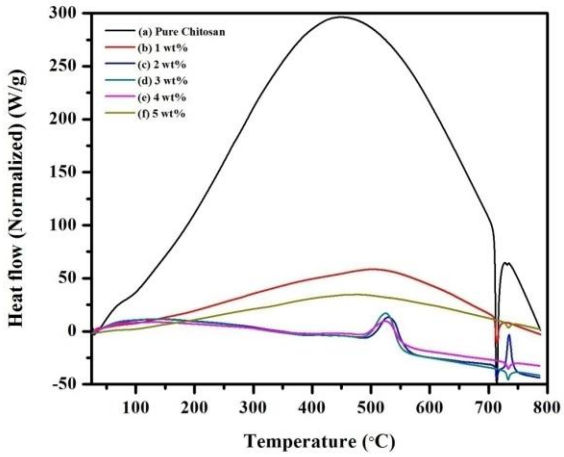

Fig. 6 TGA heat flow versus temperature curves of CS/PVA nanocomposite films with different concentration

IV.CONCLUSION

The Polymer membrane based on Chitosan and PVA has been prepared by Solution Casting Method. The Polymer membrane was subjected with Improved Structural, Vibrational and Optical properties FTIR , SEM, DGA and impedance analysis for various concentration.

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Cite this article as :

G. Jeya Jothi, P. Kanchana, R. Vinotha, "Chitosan/PVA Nanocomposite Films with Improved Structural, Vibrational and Optical Properties", International Journal of Scientific Research in Science, Engineering and Technology (IJSRSET), Online ISSN : 2394-4099, Print ISSN : 2395-1990, Volume 11 Issue 1, pp. 18-22, January-February 2024. Available at doi : https://doi.org/10.32628/IJSRSET2310664
Journal URL : https://ijsrset.com/IJSRSET2310664