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Article

Fluorescence and Antimicrobial Properties of Modified Polyvinyl Alcohol Conjugates with some Carboxylic Acid

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ABSTRACT

It is found that the fluorescence intensity of the modified polyvinyl alcohol (MPVA) and complexes of MPVA (CMPVA) is higher than that of pure PVA. The increase of the intensity of the emission peak may be due to the strong interaction between the dopant and the polymer. Antibacterial activities of the test samples are expressed by measuring the zone inhibition observed around the area. The result obtained from PVA, MPVA and CMPVA, it is clear that the MPVA and CMPVA are more microbial than that the free metal ion or PVA. From this observation, it concluded that MPVA and CMPVA antimicrobial agent.

Key words: Fluorescence and antimicrobial properties, Conjugate, Carbonyl compounds, Carboxylic acids.

1. INTRODUCTION

Fluorescence sensing of chemical and biochemical analytes is the dominant analytical approach in medical testing, biotechnology, and drug discovery [1-3]. This method has become one of the most sensitive and is often used for different bioanalytical purposes applying fluorescence dyes and quantum dots as labels [4]. Some bioanalytical systems such as real-time polymerase chain reaction [5] and some fluorescence sensors [6] are successfully exploiting combinations of fluorescence agents and quenching materials. The combination of a quencher with fluorescence agents may allow a decrease of analysis time as well as an increase in selectivity and sensitivity of the methods. As well as polyaromatic hydrocarbons, ruthenium(II) complexes with ligands such as bipyridyl (Rubipy), 1,10-phenanthroline (Ruphen), and 4,7-diphenyl-1,10-phenanthroline (Ru-dpp) were also successfully applied as oxygen probes due to their relatively long decay times and good photostability [3,7-9]. Over recent years, polyvinyl alcohol (PVA) polymers have attracted attention due to their variety of applications. PVA is a potential material having high dielectric strength, good charge storage capacity, and dopant-dependent electrical and optical properties. It has a carbon chain backbone with hydroxyl groups attached to methane carbons/these OH groups can be a source of hydrogen bonding and hence assist the formation of polymer complexes [10]. On the other hand, titanium is interesting in terms of optical, electronic, and ultraviolet (UV)-absorbing properties and shows promise for a variety of applications including self-cleaning, UV blocking, purification, and antibacterial applications [11]. Therefore, titanium compounds have many scientific and industrial applications [12,13]. The study of dielectric relaxation in polymeric films is a powerful approach for obtaining information about the characteristics of ionic and molecular interactions. The dielectric parameters associated with relaxation processes are of particular significance in ion-conducting polymers. The frequency-dependent conductivity and dielectric relaxation are both sensitive to the motion of charged species and dipoles of the polymer. Many workers reported that the dielectric parameters are strongly influenced by the nature of additives and temperature. PVA doped with different types of elements was reported [14-17], but until now, few physical studies on PVA doped with titanium complex have been available. Incorporation of CH to PVA provoked a reduction of the UV light transmission of the films, associated to the polymer interactions, which could suppose and advantage to their use in food packaging at the same time that provides to the film antimicrobial activity. The blending of chitosan into PVA films seems to be a promising strategy to obtain antimicrobial, biodegradable packaging for food products [18-23]. Fluorescence properties of modified PVA (MPVA) conjugates and doped MPVA conjugates are already performed in our previous research [24].

Literature survey demands improvement of different properties of various forms of MPVA materials. In this research, the fluorescence properties and antimicrobial properties of MPVA and complex MPVA were studied.

2. MATERIALS AND METHODS

All the chemicals are used of AR grade. In the present study, fluorescence properties are studied using Fluoromax-2 spectrofluorophotometer. For fluorescence emission spectra and antimicrobial study, the following MPVAs and complexes of MPVA (CMPVA) were used. These are PVA-dimethylaminobenzaldehyde (PDB), PVA-p-formylpyridine (PFP), PVA-p-formylbenzoic (PFB) acid, PVA-p-formylbenzene sulfonic acid, and CMPVA, with transition metal salts such as Co(II), Zn(II), Cu(II), and Fe(II) which are used.

2.1. Fluorescence Emission Spectra of MPVA

To understand the fluorescence properties of MPVA, the fluorescence emission spectra of all the MPVA samples were recorded at room temperature as shown in Figure 1. The wavelength of excitation chosen for all samples is 350 nm. The emission spectra of the MPVAs exhibit

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obvious main one peak centered at different wavelengths as shown in Table 2. The Fluorescence Emission Spectra of MPVA is obtained at same spectral position. The similar bands appear in the emission spectrum of PVA. These bands may be assigned to the recombination of free charge carriers at the defects in PVA and MPVA. Fluorescence intensity of peaks increases with modification.

2.2. Fluorescence Emission Spectra of CMPVA

To understand the fluorescence properties of CMPVA, the fluorescence emission spectra of all the CMPVA samples were recorded at room temperature as shown in Figure 2. The wavelength of excitation chosen for all samples is 270 nm. The emission spectra of the CMPVA exhibit obvious main two peaks centered at different wavelengths as shown in Table 3. It can be seen that the emission peaks are at different spectral positions in CMPVA. These bands may be assigned to the recombination of free charge carriers at the defects in CMPVA. Fluorescence intensity of peaks increases with CMPVA. The peak wavelength of PFB-Cu(II) and PFB-Cu(II) is the same indicating less interaction between metal ions and polymer [25].

It is found that the fluorescence intensity of the MPVA and CMPVA is higher than that of pure PVA. The increase of the intensity of the emission peak may be due to the strong interaction between the dopant and the polymer. This observation is in agreement with previous works [26,27].

2.3. Antimicrobial Study of MPVA

An antimicrobial is an agent that kills microorganisms or stops their growth. Antimicrobial medicines can be grouped according to the microorganisms they act primarily against. For example, antibiotics are used against bacteria and antifungals are used against fungi. They can also be classified according to their function. Agents that kill microbes are called microbicidal, while those that merely inhibit their growth are called biostatic. The use of antimicrobial medicines to treat infection is known as antimicrobial chemotherapy, while the use of antimicrobial medicines to prevent infection is known as antimicrobial prophylaxis.

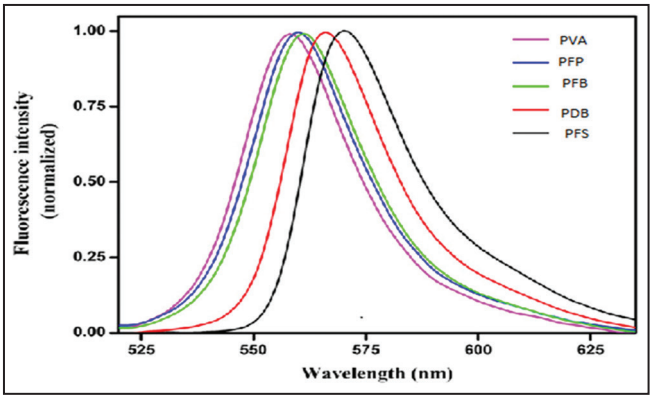

Figure 1: Emission spectra of polyvinyl alcohol (PVA) and modified PVA.

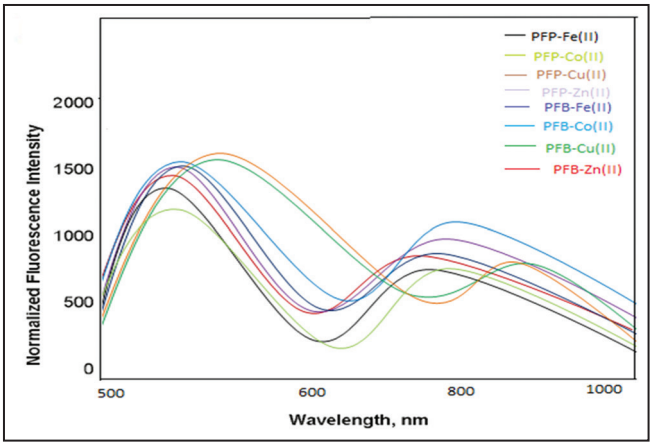

Figure 2: Emission spectra of modified polyvinyl alcohol (MPVA) and complexes of MPVA.

Antimicrobial use is known to have been common practice for at least 2000 years. Ancient Egyptians and ancient Greeks used specific molds and plant extracts to treat infection. In the 19th century, microbiologists such as Louis Pasteur and Jules Francois Joubert observed antagonism between some bacteria and discussed the merits of controlling these interactions in medicine. In 1928, Alexander Fleming became the first to discover a natural antimicrobial fungus known as *Penicillium rubens* and named the extracted substance penicillin which, in 1942, was successfully used to treat a Streptococcus infection.

2.4. Antimicrobial Activity Tests

The antibacterial activity of functionalized MPVA and CMPVA was evaluated against *Staphylococcus aureus* (+ve),

Table 1: Wavelength of emission peak of PVA and MPVA.

Samples	Peak wavelength (nm)	
	1	2
PVA	560	-
PFP	570	-
PFB	572	-
PDB	575	-
PFS	580	-

PVA: Polyvinyl alcohol, MPVA: Modified polyvinyl alcohol, PFP: Polyvinyl alcohol-p-formylpyridine, PFB: Polyvinyl alcohol-p-formylbenzoic, PDB: Polyvinyl alcohol-dimethylamin obenzaldehyde, PFS: Polyvinyl alcohol-p-formylbenzene sulfonic

Table 2: Wavelength of emission peak of CMPVA (PFP).

Samples	Peak wavelength (nm)	
	1	2
PFP-Fe (II)	580	760
Co (II)	582	767
Cu (II)	585	780
Zn (II)	589	785

CMPVA: Complexes of modified polyvinyl alcohol, PFP: Polyvinyl alcohol-p-formylpyridine

Table 3: Wavelength of emission peak of CMPVA (PFB).

Samples	Peak wavelength (nm)	
	1	2
PFB-Fe (II)	595	790
Co (II)	596	795
Cu (II)	602	905
Zn (II)	605	910

CMPVA: Complexes of modified polyvinyl alcohol, PFB: Polyvinyl alcohol-p-formylbenzoic

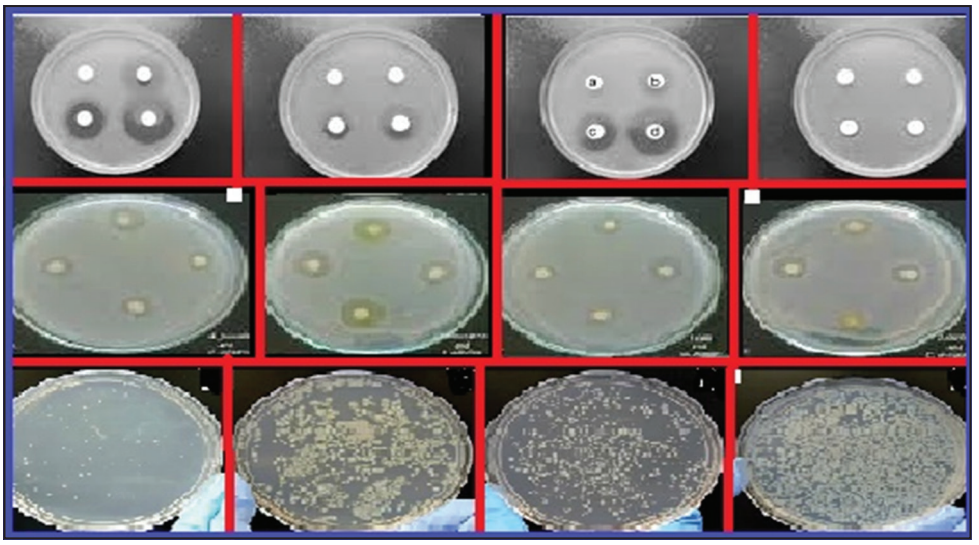

Figure 3: Antibacterial activity of the modified polyvinyl alcohol (MPVA) and complexes of MPVA.

Table 4: Antibacterial activity of the MPVA and CMPVA.

Sample Name	Diameter of zone inhibition of mycelial growth (mm)			
	S. aureus (+ve)	*B. megaterium* (+ve)	*S. dysentry* (−ve)	*Salmonella* (−ve)
PVA	-	-	-	-
PFP	-	-	-	-
PFB	-	-	-	-
PDB	-	-	-	-
PFS	-	-	-	-
PFP-Fe (II)	-	-	-	-
Co (II)	-	-	-	-
Cu (II)	25	31	27	30
Zn (II)	23	23	23	21
PFB-Fe (II)	-	-	-	-
Co (II)	-	-	-	-
Cu (II)	-	-	-	9
Zn (II)	21	24	17	15

S. aureus: *Staphylococcus aureus*, *B. megaterium*: *Bacillus megaterium*, *S. dysentry*: *Shigellosis dysentery*, PVA: Polyvinyl alcohol, MPVA: Modified polyvinyl alcohol, PFP: Polyvinyl alcohol-p-formylpyridine, PFB: Polyvinyl alcohol-p-formylbenzoic, PDB: Polyvinyl alcohol-dimethylaminobenzaldehyde, PFS: Polyvinyl alcohol-p-formylbenzene sulfonic, CMPVA: Complexes of modified polyvinyl alcohol

Bacillus megaterium (+ve), *Shigellosis dysentr*y (−ve), and *Salmonella* (−ve) bacterium. The sensitivity or resistance of the bacteria to functionalized PVA cations and anions was determined using a Kirby–Bauer disk diffusion susceptibility test-like method. A 6-mm disk of nanofiber was cut and sterilized under UV light (15 min on each side) to avoid any contamination. Mueller Hinton agar plates were inoculated with 0.5 McFarland equivalent suspensions of fresh, 24 h growth bacteria before the placing of disks on the agar surface. For the sake of antimicrobial studies, MPVA polymers were run in triplicate on each plate along with a positive (10% Reputex™ 20 in water) and a negative control (native PVA nanowebs). Inoculated plates were incubated at 370°C for 24 h. The diameter of the zone of inhibited bacterial growth was measured. All measurements are made with the unaided eye while viewing the back of the Petri dish. The results on the antibacterial activity of MPVA and CMPVA polymers are presented in Figure 3.

In general, more susceptible test organism, the larger is the zone of inhibition, and antibacterial activities of the test samples are expressed by measuring the zone inhibition observed around the area. The result obtained from PVA, MPVA and CMPVA, it is clear that the MPVA and CMPVA are more microbial than that the free metal ion or PVA. From this observation, it concluded that MPVA and CMPVA antimicrobial agent.

The highest inhabitation of growth occurred on MPVA and CMPVA and lowest inhabitation of growth occurred on MPVA and CMPVA are shown in Table 4. It is observed from the result that only PFP-Zn (II), PFP-Cu (II), and PDB-Zn (II) show antimicrobial properties against while others are inactive. This may due to the presence of pyridine ring in MPVA [28-34].

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****Bibliographical Sketch***

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