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Capacitance Measurement of PVA/Zinc Acetate Fibre

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Abstract

The viscous gel of PVA/Zinc acetate composite is a focus of this investigation. The used gel has chemical pure hydrated zinc acetate $Zn(CH_3CO_2).2H_2O$ and 20% by weight of PVA (Polyvinyl alcohol). The change in dielectric properties as a function of sample thickness is measured with both Ag-electrode and Cu – electrode.

Key words: hydrated zinc acetate, Ag-electrode, dielectric properties

Introduction

Conventional glass preparation requires melting of the precursors at high temperatures, rapid cooling and subsequent verification of the glassy material, possess several useful features for optical applications such as transparency, homogeneity, mechanical sturdiness, high refractive index etc. An approach to glass and glass-like materials is offered by the so-called, sol-gel technology. The sol-gel technique is based on hydrolysis of liquid precursors and formation of colloidal sols. The precursors are usually organosilicates yielding silicate sol-gel materials. It is possible to obtain modified organosilicate precursors with direct Si-C bonds (which do not undergo hydrolysis) and possessing terminal functional groups. Such precursors, either pure or mixed with the conventional ones, yield inorganic-organic materials with mechanical (e.g elasticity) and physico-chemical properties(e.g wetability) modified by the organic components of the inorganic polymer network .The functional groups can be also mused for covalent binding of various chemicals giving specifically modified glassy-materials.

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The sol-gel process is a wet-chemical technique (Chemical Solution Deposition) for the fabrication of materials (typically a metal oxide) starting from a chemical solution that reacts to produce colloidal particles (sol). Typical precursors are metals alkoxides and metal chlorides, which undergo hydrolysis and polycondensation reactions to form a colloid, a system composed of solid particles (size ranging from 1nm to 1μm) dispersed and a solvent.

The sol evolves then towards the formation of an organic network containing a liquid phase (gel). The precursor sol can be either deposited on a substrate to form a film (e.g. by dip-coating or spin coating), cast into a suitable container with the desired shape [http://en.wikipedia.org/wiki/ Sol-gel]. The semi conducting metal oxide ZnO is a wide band gap (3.37 eV) compound semiconductor is suitable for sensor applications [Siddheswaran R *et al* 2006 Cryst.Res.Technol.41. (5) 446].

The sol –gel approach is interesting in that it is a cheap and low –temperature technique that allows for the fine control on the product's chemical composition, as even small quantities of dopants. Sol-gel derived materials have diverse applications in optics, electronics, emergency, space, (bio) sensors, medicine (e.g controlled drug release) and separation (e.g chromatography) technology [http://en.wikipedia.org/ wiki/ Sol-gel].

PVA/ Zinc acetate precursor solution is prepared by sol-gel technique. Zinc acetate is the chemical compound with the formula Zn $(O_2CCH_3)_2$ but more commly refers to the dehydrate $Zn(O_2CCH_3)_2$ $(H_2O)_2$. Both the hydrate and anhydrous formsare colorless solids that are commly used in chemical synthesis and as dietary supplements. Zinc acetates are prepared by the action of acetic acid on zinc carbonate or zinc metal [http://en.wikipedia.org/wiki/Zinc_acetate]. Zinc acetate is soluble in water and alcohol. It crystallizes from dilute acetic acid. It comes in the form of white granules, slightly efflorescent and has a faint vinegar odour [National Pollutant Inventory Substance Profile /2004 Zinc and compounds. National. htm]. In this research paper, we reported a novel and simple approach to a viscous gel of PVA/Zinc acetate composite.

Experimental

- Some grams of Zinc acetate (powder) and PVA (polyvinyl alcohol) were weighed with digital balance .

Fig .1

- Polyvinyl alcohol PVA was mixed with water and heated at 50° C.
- Then, Zinc acetate was added into it by the ratio of different values.

Fig .2

- It was stirred vigorously for 1 hr.
- At the temperature of 50° C, it was heated for about 1 hr.
- And then, it was shaped as a pellet.
- In this research, three pellets were made with different ratio in the above procedures.
- They were detected to know the capacitances of the samples with Quad Tech 1730 LCR Digit bridge.
- They are shown in Fig. 3(a ~ f).

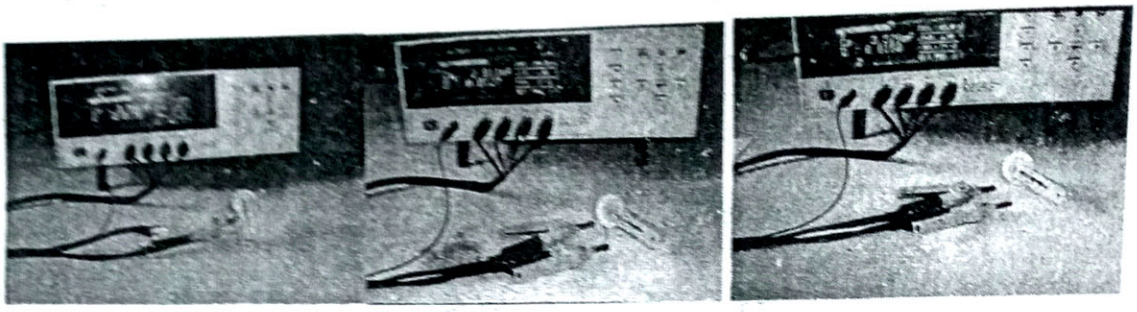

Fig .3(a) Fig .3(b) Fig .3(c)

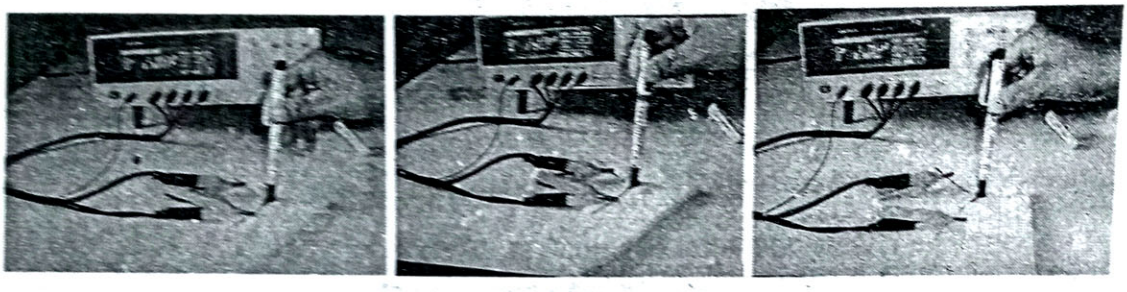

Fig .3(d) Fig .3(e) Fig .3(f)

Results and Discussion

The capacitance of the ceramic fiber capacitor was detected by LCR meter. Firstly, it was detected with silver electrode, as illustrated in Fig. 4(a ~ c).

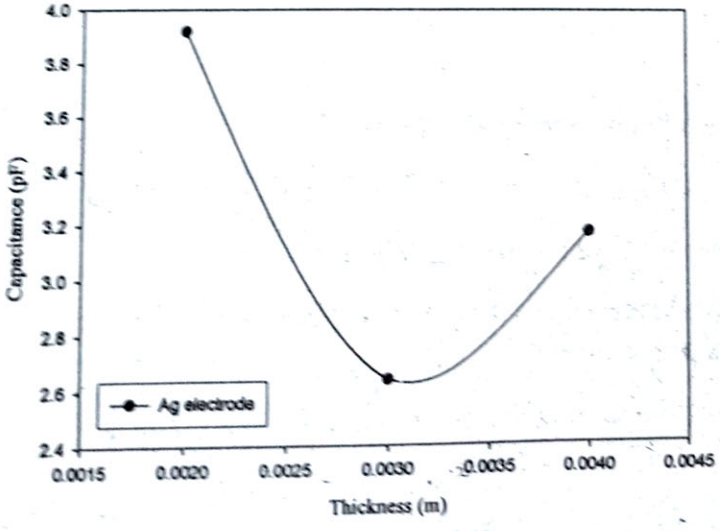

Fig .4(a) Variation of capacitance with thickness

It was found that the highest value of capacitance was caused at the smallest thickness.

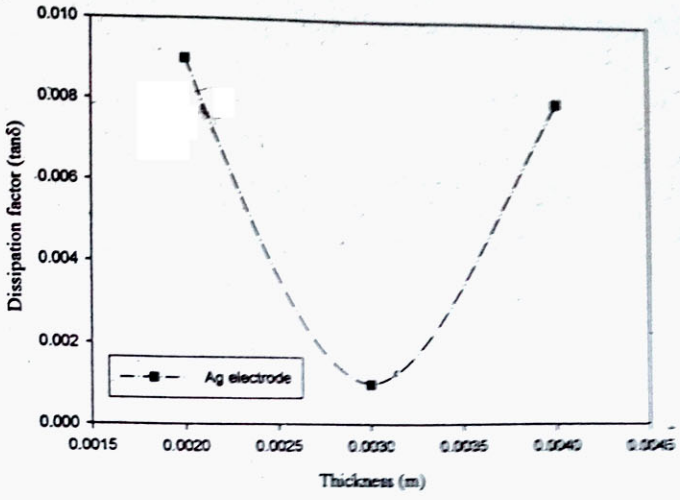

Fig. 4(b)Dependence of dissipation factor on thickness

It represents the dissipation factor reached its highest value at the smallest thickness.

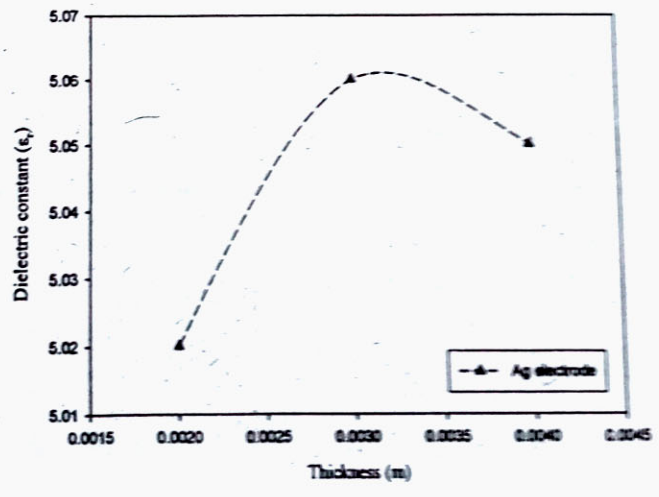

Fig.4(c) Relation between dielectric constant and thickness

It illustrates the dielectric constant ε_r increases with respect to the thickness but the value of ε_r was reduced at the larger thickness.

And then, they were measured with copper electrode as shown in Fig, 5(a ~ c).

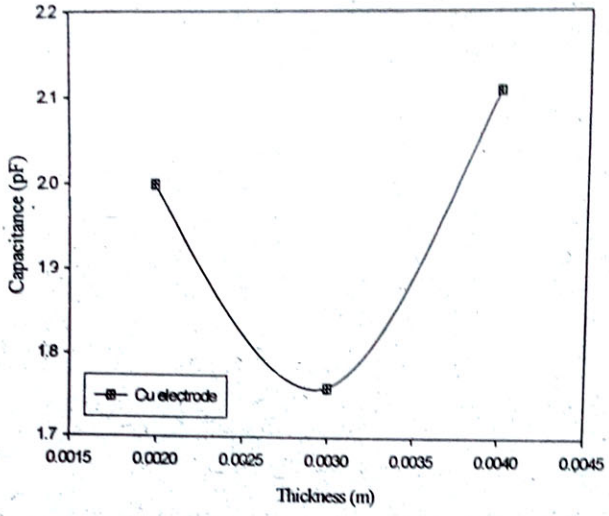

Fig. 5(a) Variation of capacitance with thickness

It was found that the value of the capacitance was the highest at the highest thickness and the highest dissipation factor was at the highest thickness in Fig. 5(b)

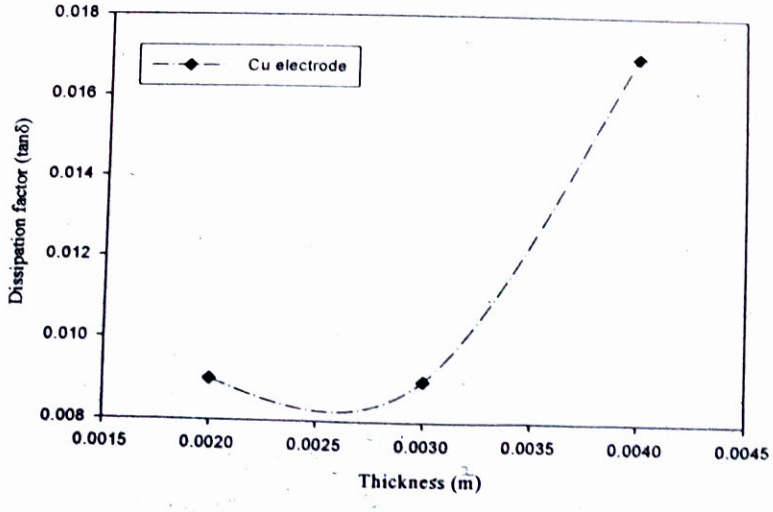

Fig. 5(b) Dependence of dissipation factor on thickness

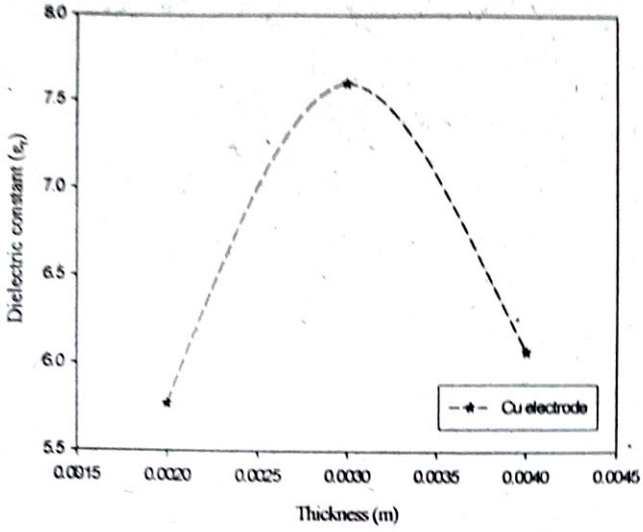

Fig.5(c) Relation between dielectric constant and thickness

ε_r increases with respect to the thickness and it decreases with larger thickness.

When the samples were measured with Ag electrode, the capacitance was the largest at the smallest thickness. When Cu electrode was used, it was found that the capacitance was the largest at the largest thickness. Therefore, it can be said that Ag was better than Cu.

According to the Fig. 4(b) and 5(b), dissipation factor D was the largest at the smallest thickness which was used with Ag electrode and D was the smallest at the smallest thickness with Cu electrode.

Dielectric constant ε_r was calculated with the following equation,

$$C = \varepsilon_o \varepsilon_r A/d$$

$$C = \varepsilon_o \varepsilon_r \pi r2/d$$

$$\varepsilon_r = C d / \varepsilon_o \pi r2$$

Where C = Capacitance of the sample(F)

ε_o = Permittivity in vacuum (8.85*10-12 F/m or C2 N-1 m-2)

ε_r = Relative Dielectric Constant (Unit less)

A=Area of the contact electrode (m2)

d = Thickness of the sample (m)

r =Radius of the contact electrode (m)

According to the Fig.4(c) and 5(c), the value of ε_r was the highest and the best at the thickness of 0.0030m. These values were assigned in the following Tables.

Table.(1) Measurements of the sample with Ag electrode (f =100 kHz)

Sr No	Thickness d(m)	Capacitance C(pF)	Dissipation Factor D	Dielectric Constant ε_r
1.	0.002	3.92	0.009	5.02
2.	0.003	2.64	0.001	5.06
3.	0.004	3.17	0.008	5.05

Table.(2) Results of the sample with Cu electrode (f=100 kHz)

Sr No	Thickness d(m)	Capacitance C(pF)	Dissipation Factor D	Dielectric Constant ε_r
1.	0.002	2.004	0.009	5.77
2.	0.003	1.758	0.009	7.60
3.	0.004	2.108	0.017	6.07

Conclusion

Preparation of PVA /zinc acetate fibre capacitor and its dielectric properties have been observed .From these observations; some remarkable conclusions could be established.

(i) As the Ag-contact , the largest capacitance and Dissipation factor were found at the minimum film thickness.

(ii) Both of the Cu- contact and Ag contact, the largest dielectric constant value was found at the 0.003 m of sample thickness.

(iii) According to these results, the growth chemistry of of PVA/ zinc acetate fiber was highly accepted for optical fiber communication system.

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