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Electrical Properties of Medicines

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ABSTRACT

Since the project is on electrical properties of medicines, they were bought directly from the market. The medicines were taken of common composition i.e, Calpol and Sinarest which have paracetamol in common. The prepared pellets were of thickness of the range of 4.19 mm and 4.94 mm and diameter of the range of 13.4 mm and 12.6 mm of Sinarest and Calpol respectively which was measured from screw gauge. Poling and Electroding was done for characterization. Poling and Electroding are required to form the capacitor. Both the plain faces of the pellets was painted for electroding, with fine silver paint (Aldrich). Sinarest was kept at 90 oC and Calpol was kept at 75oC in oven for one hour. Its conductivity was checked by a multimeter which showed conducting on each side and non-conducting when checked both sides simultaneously. Hence the pellet behaves as a capacitor. Impedance parameters (Z), phase angle (θ), capacitance (Cp) and loss tangent (tan δ) were measured as a function of frequency (100 Hz to 1 MHz) at different temperatures (36oC to 57°C for Calpol and 33oC- 68oC for Sinarest), using a impedance phase analyser along with a sample holder and heating arrangement.

Keywords: *Electroding, Impedance Phase Analyser, Poling, pellets*

INTRODUCTION

A material is classified as "dielectric" if it has the ability to store energy when an external electric field is applied. If a DC voltage source v is placed across a parallel plate capacitor, more charge is stored when a dielectric material is between the plates than if no material (a vacuum) is between the plates. The dielectric material increases the storage capacity of the capacitor by neutralizing charges at the electrodes, which ordinarily would contribute to the external field. The capacitance with the dielectric material is related to dielectric constant as

$$C = \frac{k\varepsilon_o A}{t} \qquad (1)$$

Where C and C_o are capacitance with and without dielectric, k is the real dielectric constant or permittivity, and A and t are the area of the capacitor plates and the distance between them. If an AC sinusoidal voltage source V is placed across the same capacitor the resulting current will be made up of a charging current I and a loss current δ that is related to the dielectric constant.

The dielectric properties of material are intrinsic properties expressed by the relative complex permittivity

$$,\varepsilon^* = \varepsilon' - j\varepsilon'' \quad (2)$$

Where,
ε' = dielectric constant and represents the ability of a material to store electrical energy.
ε" = loss factor and represents the loss of electric energy in the material.

Amount of loss is described by a parameter loss tangent (tanδ). The dielectric parameters are generally dependent on frequency, temperature, density and other factors such as material structure and composition (Bansal et al., 2001; Nelson, 1992, 1993). The electrical properties are often represented in terms of some complex parameters like complex impedance (Z*) and loss tangent (tanδ).

They are related to each other as follows: $Z^* = Z' - j Z'' = R_s - j/\omega C_s$, (3)

and loss tangent,

$$\tan\delta = -Z'/Z'' ; \quad (4)$$

where,
j = imaginary factor,
R_s and C_s = resistance and capacitance in series (s),
ω (=2πf) = angular frequency
ε_o = permittivity in free space (8.854 × 10-12 F/m).

The above expression offers a wide scope for graphical representation. Complex impedance spectroscopy (CIS) technique will be used to study the impedance properties/parameters of the compounds using a computer controlled LCR meter/impedance spectroscopy analyser[3] at an ac signal over a wide range of frequency and temperature.

MATERIAL AND METHODS

SINAREST Tablet/Syrup contains a clinically proven analgesic-antipyretic Paracetamol (fig. 1) with decongestant Phenylephrine and an antihistamine Chlorpheniramine maleate.
Each SINAREST Tablet contains:

Paracetamol IP	500 mg
Phenylephrine hydrochloride IP	10 mg
Chlorpheniramine maleate IP	2 mg
Caffeine (anhydrous) IP	30 mg

CALPOL contains 120 mg Paracetamol in each 5 ml.
Excipients: sucrose (contains 2.2 g of sucrose per 5 ml), sorbitol liquid (E420), methyl parahydroxybenzoate (E218), ethyl parahydroxybenzoate (E214), propyl parahydroxybenzoate (E216) and carmoisine (E122).

Paracetamol is a popular and common analgesic and antipyretic drug. It has been in use as an analgesic for home medication for over 30 years and is accepted as a very effective treatment for the relief of pain and fever in adults and children. Formula of Paracetamol: $C_8H_9NO_2$, Molecular Weight 151.2

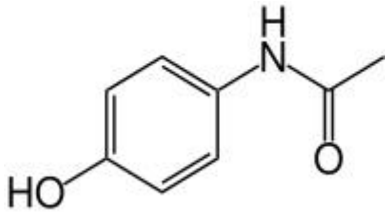

Figure1: Structure of paracetamol

It is described as 4-hydrozyacetaminophen or n-acetyl-p-aminophenol and in the US pharmacopoeia it is known as acetaminophen. The words acetaminophen and paracetamol both come from chemical names for the compound: para-acetylaminophenol.

Sample preparation

Since the project is on electrical properties of medicines, they were bought directly from the market. The medicines were taken of common composition i.e, calpol and sinarest which have paracetamol in common.

Electrical measurement

The prepared pellets were of thickness of the range of 4.19 mm and 4.94mm and diameter of the range of 13.4 mm and 12.6 mm of sinarest and calpol respectively which was measured from screw gauge.

Both the plain faces of the pellets were painted for electroding, with fine silver paint (Aldrich). Sinarest was kept at 90 ^{o}C and Calpol was kept at 75^{o}C in oven for one hour. Its conductivity was checked by a multimeter. It showed conducting on each side and non-conducting when checked both sides simultaneously. Hence the pellet behaves as a capacitor.

OBSERVATIONS

Impedance parameters (Z), phase angle (θ), capacitance (Cp) and loss tangent (tan δ) were measured as a function of frequency (100 Hz to 1 MHz) at different temperatures (36^{o}C to 57°C for calpol and 33^{o}C- 68^{o}C for sinarest), using a impedance phase analyser in conjunction with a laboratory-made sample holder and heating arrangement. The readings were noted down and the graph was plotted.

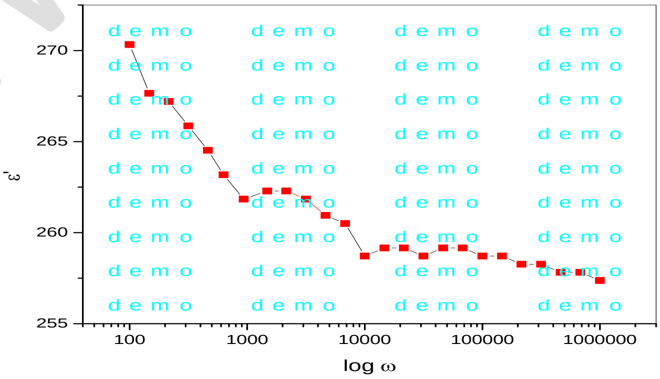

Figure 2: Graph of variation of ε' w.r.t . log of frequency at 36^{O}C

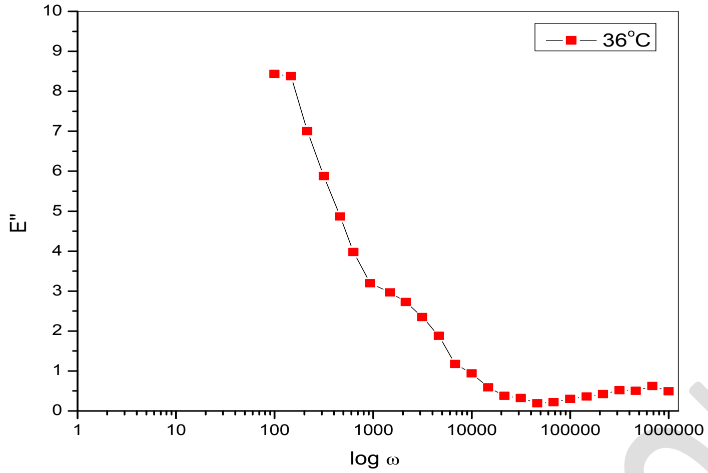

Figure 3: Graph of variation of ε'' w.r.t. log of frequency at 36^{O} C

Comparative study of calpol at temperatures (36°C and 57°C)

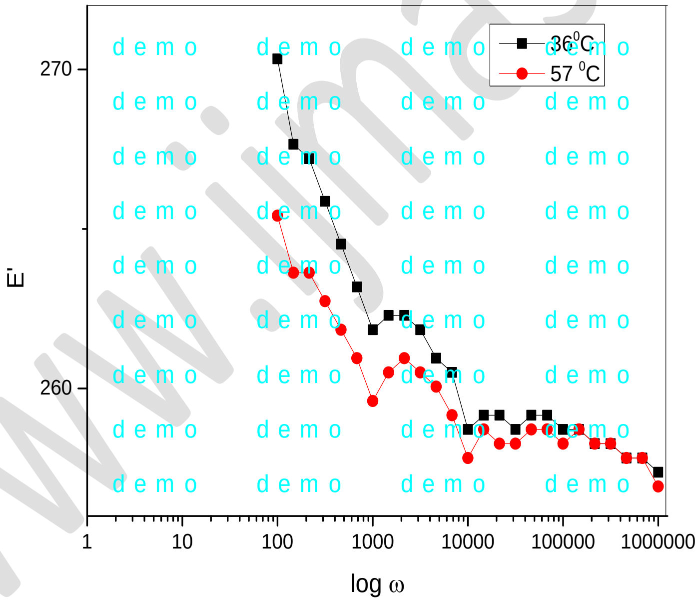

Figure 4: Graph of ε' vs log of frequency at temperature 36^{0}C and 57^{O}C

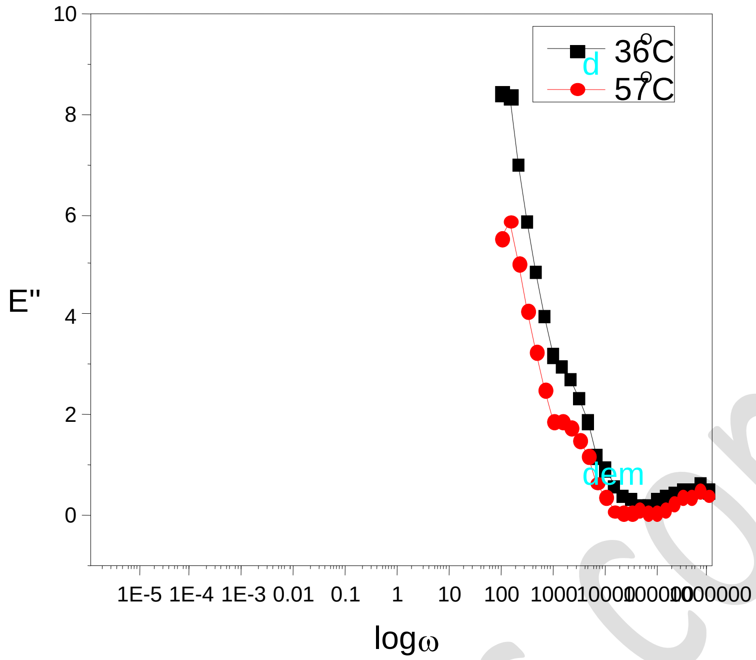

Figure 5: Graph of ε'' vs log of frequency at temperatures 36°C and 57°C

Comparative study of calpol at various frequencies (100 Hz,1000 Hz,10 kHz,100 kHz,1MHz)

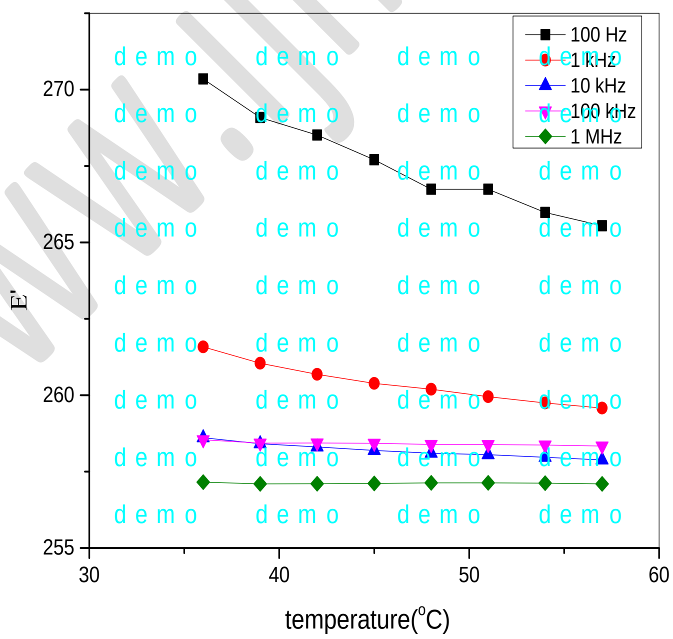

Figure 6: Graph of temperature vs ε' at various frequency

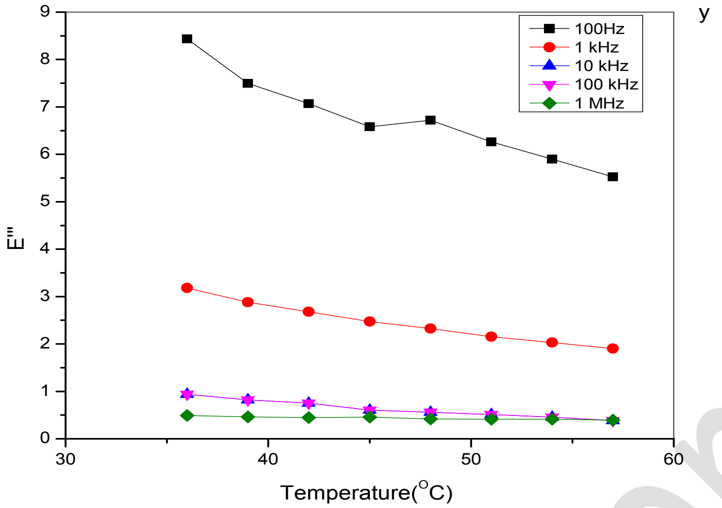

Figure 7: Graph of temperature vs ε'' at various frequency

Comparative study of sinarest at various frequencies (1Hz, 100 Hz, 10 kHz, 1 MHz)

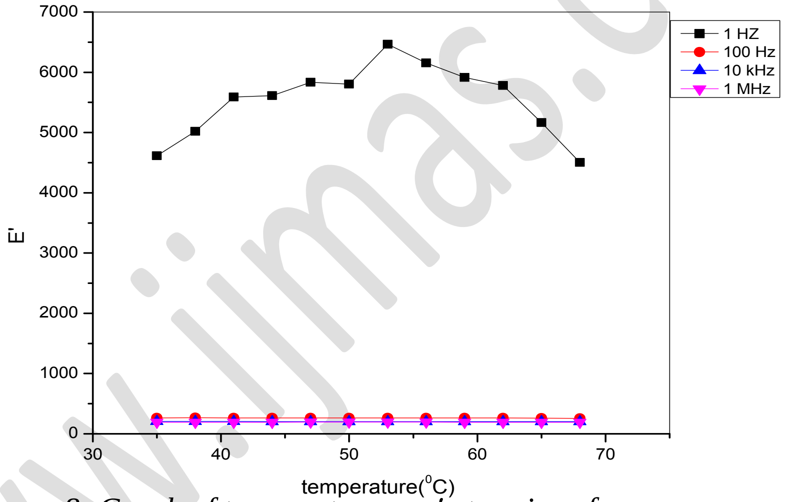

Figure 8: Graph of temperature vs ε' at various frequency

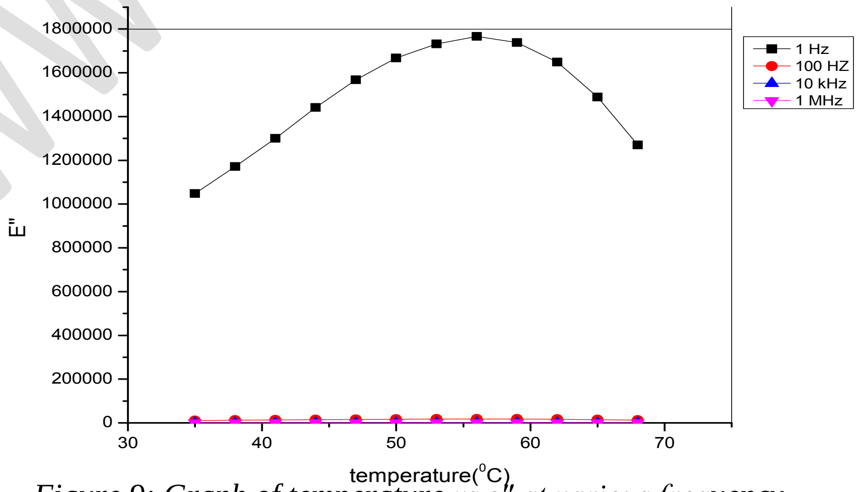

Figure 9: Graph of temperature vs ε'' at various frequency

Comparative study of sinarest at temperatures (35°C, 50°C, 65°C)

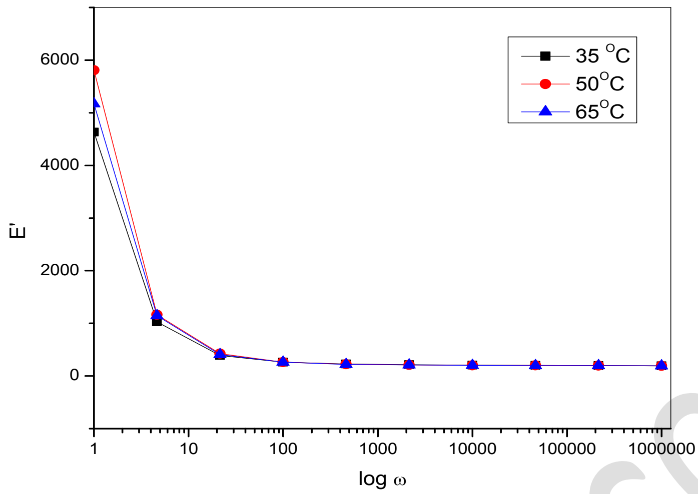

Figure 10: Graph of log of frequency vs ε' at temperatures (35°C, 50°C, 65°C)

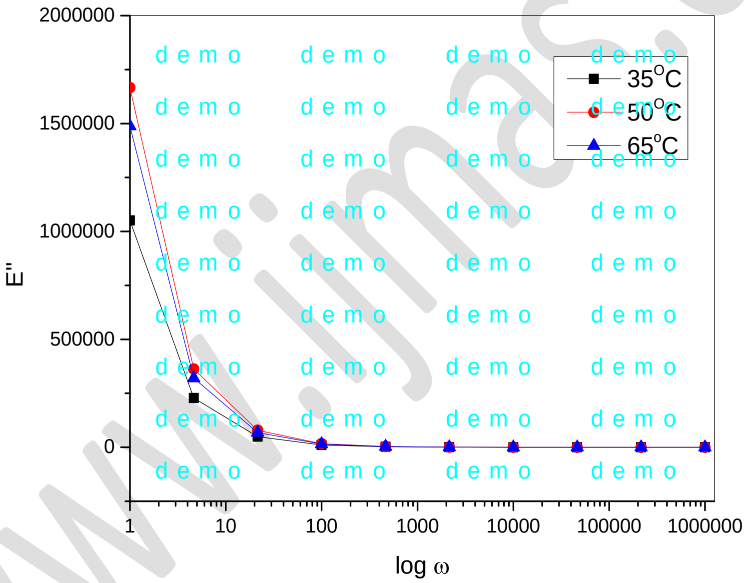

Figure 11: Graph of log of frequency vs ε"at temperatures (35°C, 50°C, 65°C)

RESULTS AND DISCUSSIONS

Dielectric studies

For Calpol (fig 2) the slope of ε' decreases with increase in log of frequency, which is a general feature of polar dielectric materials irrespective of composition. The variation of ε" relative to different log of frequency at 36°C for calpol is shown in figure 3. It shows lesser variation at higher frequencies .Hence, the real part of dielectric constant, ε' contributes more than the imaginary part, ε". At particular frequency, ε" first drops and again exponentially decreases. At room temperature there is more fluctuation. The graph of temp vs ε' at various freq for calpol (Fig. 4) (in case of lower freq range) the graph decreases exponentially. The graph is of decreasing nature in fig.6 and fig. 7. The decrease is visible in fig.6. It suggests that the dielectric constant will be almost constant at higher frequency. In the graph of temp vs ε' of sinarest (fig. 8), the graph increases linearly with rise in temperature at different frequency. No phase transition observed. Anomaly observed that is increasing frequency decreases dielectric constant. Apparent broadening around dielectric peak. The broadening and diffuseness of peak occurs mainly due to compositional fluctuations and/or substitutional disordering in the arrangement of cations in one or more crystallographic sites. The graph of frequency vs ε' (fig. 10) and frequency vs ε'' (fig. 11) was taken at less frequency range due to lack of prior knowledge of its melting points. Hence, the graph cannot be interpreted.

The fall in ε' arises from the fact that polarization does not occur instantaneously with the application of the electric field, which is further due to the inertia of the dipoles and the delay in response towards the impressed alternating electric field leads to dielectric loss and decline in ε' . At low frequencies, all types of polarization contributes and as the frequency is increased, polarizations with large relaxation times cease to respond and hence the decrease in ε' [4]. At lower frequencies ε' is maximum because the contributions from the space charge polarization is large. At higher frequencies, contributions from the polarizations having high relaxation time cease resulting in the decrease in ε' [5]. The same type of frequency-dependent dielectric behaviour is found in many other perovskite ceramic systems[6, 7].

However, work on both the dielectric and conductive properties, especially at low frequencies and low temperatures, has been rarely done and needs to be accomplished.

CONCLUSION:

The two different medicinal pellets, calpol and sinarest, of different paracetamol composition were taken. The thicknesses of two pellets were 4.19 mm and 4.94 mm and diameter were 13.4 mm and 12.6 mm respectively. The comparative electrical properties of two samples were studied. The variation of dielectric constant and loss with respect to temperature and frequency shows that at low temperatures ε′ values are frequency independent. At temperature 57˚C, ε′ increases to high values at low frequency. This is due to presence of different type of polarization in the material. The grain and grain boundary contribution have been separated using impedance spectroscopy analysis. The grain and grain boundary resistance decreases with rise in temperature.

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