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Investigation of Dielectric Constant of PVC-PMMA Thin Films Doped with Salicylic Acid at Different Frequency, Dopant and Temperature[1]

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ABSTRACT

This research study examines the influence of frequency and salicylic acid dopant and temperature on the dielectric constant of PVC-PMMA thin films. The thin films were prepared using the isothermal evaporation technique, and their dielectric constants were measured using an LCR meter over a frequency range of 20 Hz to 200 KHz at 303 k and 323 k. The ln f vs dielectric constant plots were analyzed to investigate the effects of frequency and salicylic acid dopant concentration and temperature on the dielectric properties of the films.

Keyword: PVC; PMMA; Salicylic Acid; Dielectric Constant.

INTRODUCTION

Dielectric materials find extensive applications in various electronic devices and capacitors due to their ability to store and transmit electrical energy. Polymer blends, such as PVC-PMMA, have gained significant attention for their potential in dielectric applications. The dielectric properties of such blends can be modified by incorporating dopants, offering opportunities for enhanced electrical performance.

EXPERIMENTAL PROCEDURE

The PVC-PMMA thin films were prepared by the isothermal evaporation technique. Two sets of films were fabricated: one with a 6% salicylic acid dopant and the other without any dopant. The dielectric constants of the films were measured using an LCR meter over a frequency range of 20 Hz to 200 kHz at 303 k and 323 k. The natural logarithm of frequency (ln f) and dielectric constant values were recorded and tabulated for further analysis.

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GRAPH RELATED FOR DIELECTRIC CONSTANT

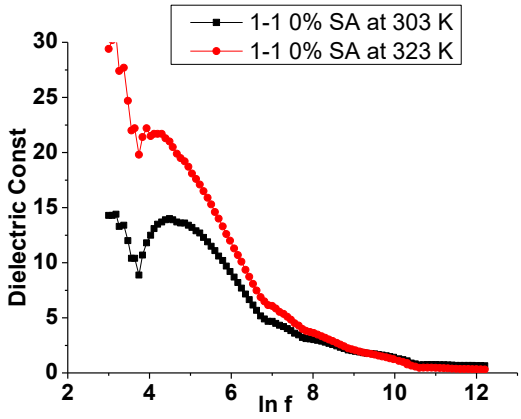

Fig 1.1 Variation of ln f vs Dielectric constant

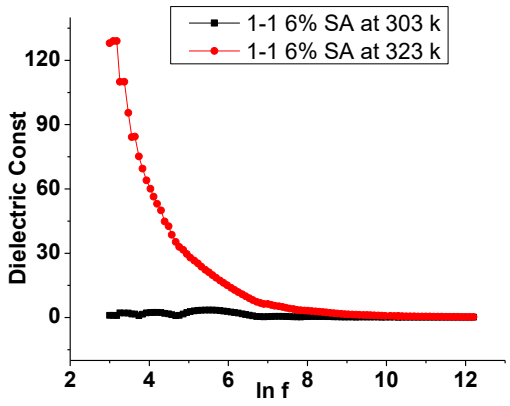

Fig 1.2 Variation of ln f vs Dielectric constant

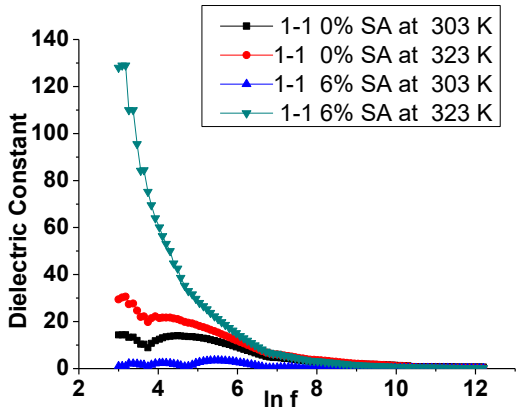

Fig 1.3 Variation of ln f vs. Dielectric constant doped and undoped SA

RESULTS AND DISCUSSION

The ln f vs. dielectric constant (fig1.1, 1.2, 1.3) plots were examined to analyze the effects of frequency and salicylic acid dopant on the dielectric properties of the PVC-PMMA thin films.

Effect of Frequency

The dielectric constant of the PVC-PMMA films exhibited a frequency-dependent behavior. As the frequency increased, the dielectric constant decreased for both the film with 6% salicylic acid dopant and the film without any dopant. This behavior is consistent with the characteristics of dielectric materials, where the dielectric constant decreases with increasing frequency.

The behavior of the dielectric constant of a material in response to varying frequencies of an electric field provides valuable insights into its electrical and structural properties. The observed trends in the dielectric constant of the PVC-PMMA thin film can be explained through the interaction of the polymer matrix with the electric field, as well as the inherent characteristics of the system.

1. **High Dielectric Constant at Lower Frequencies:**
In the lower frequency range, it is observed that the dielectric constant of the PVC-PMMA thin film is relatively high. The high dielectric constant can be attributed to the presence of charges that are able to respond to the electric field. In the case of the PVC-PMMA thin film, the presence of localized charge carriers, such as polarons, might contribute to this behavior. These charges can align and respond to the field, leading to an enhanced dielectric constant.

2. **Decrease in Dielectric Constant at Higher Frequencies:**
As the frequency of the applied electric field increases beyond 100 Hz, the dielectric constant of the PVC-PMMA thin film is observed to decrease. This decrease can be attributed to the interplay between the ordered structure of the material and the mobility of ions within the polymer matrix. At higher frequencies, the mobility of ions becomes significant, allowing them to move and oppose the effect of the applied electric field.

The decrease in dielectric constant could be explained by considering the following factors:

i. Ordered Material Characteristics:

In materials with an ordered structure, such as crystalline regions within the PVC-PMMA thin film, the alignment of charges in response to the electric field can be hindered by the organized arrangement of molecules. This leads to a lower dielectric constant as the material becomes less responsive to the field.

ii. Ionic Mobility:
As the frequency increases, the mobility of ions within the polymer matrix becomes more pronounced. These ions are not tightly bound to the polymer chains and can move in response to the field, counteracting its effect. This ion movement contributes to a decrease in the overall dielectric constant.

The findings presented in Migahed et al.'s work (reference [24]) further support the observed trend of decreasing dielectric constant with increasing frequency in ordered materials.

Influence of Temperature on Dielectric Constant in PVC-PMMA Films

The dielectric constant of the PVC-PMMA films was also affected by temperature. As the temperature increased from 303 k to 323 K , the dielectric constant values for both the film with 6% salicylic acid dopant and the film without any dopant generally increased. This temperature-dependent behavior indicates that the dielectric constant of the films is influenced by thermal effects.

Temperature is a critical parameter that can significantly impact the electrical properties of materials, including the dielectric constant. In this study, the effect of temperature on the dielectric constant of PVC-PMMA films was investigated. The dielectric constant was analyzed across a temperature range, and the results reveal a clear correlation between temperature and dielectric constant values

Influence of Salicylic Acid Dopant on Dielectric Constant in PVC-PMMA Films

The presence of salicylic acid dopant influenced the dielectric constant behavior of the PVC-PMMA films. Comparing the two sets of films, it was observed that the film with 6% salicylic acid dopant consistently exhibited higher dielectric constant values compared to the film without any dopant at all frequencies and temperatures. This suggests that the addition of salicylic acid as a dopant increases the dielectric constant of the PVC-PMMA films.

The dielectric constant of a material is a key parameter that characterizes its electrical response to an applied electric field. In this study, the impact of salicylic acid as a dopant on the dielectric constant behavior of PVC-PMMA films was investigated. The dielectric constant was examined across a range of frequencies and temperatures to elucidate the effects of the dopant on the electrical properties of the films.

CONCLUSION

In conclusion, the observed frequency-dependent behavior of the dielectric constant in the PVC-PMMA thin film is a result of the interplay between the presence of charges, the ordered or disordered nature of the material, and the mobility of ions within the polymer matrix. The high dielectric constant at lower frequencies can be attributed to the response of charges to the electric field, while the decrease in dielectric constant at higher frequencies is influenced by the ordered structure of the material and the mobility of ions. These insights contribute to a deeper understanding of the electrical properties of the PVC-PMMA thin film.

The presence of 6% salicylic acid dopant in the PVC-PMMA films leads to a consistent increase in the dielectric constant values across frequencies and temperatures. This effect can be attributed to enhanced polarization, dipole alignment, and possibly improved charge carrier mobility within the polymer matrix due to the presence of the dopant. These findings underscore the potential of salicylic acid as a dopant to tailor the dielectric properties of PVC-PMMA films for specific applications requiring higher dielectric constants. Further investigations could delve into the underlying molecular interactions that drive this enhanced dielectric behavior.

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