

The Influence of Temperature and Frequency on Dielectric Properties of *p*-CuO/*n*-ZnO Nano Composite

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Abstract: The nanocomposite of *p*-CuO and *n*-ZnO was prepared by mechanical milling of CuO and ZnO analytical grade powder taken in 1:1 weight percentage. The structural properties of nanocomposite were studied by X-ray diffraction(XRD) and FTIR. The influence of temperature from 00c to 3500c on the *p*-CuO/*n*-ZnO nanocomposite dielectric properties were studied using broadband dielectric spectroscopy in the 1GHz to 3 GHz microwave frequency range. The influence of temperature from 00c to 3500c on loss tangent delta, AC conductivity, capacitance and impedance of the nanocomposite was also investigated in the 1GHz to 3 GHz microwave frequency range.

Keywords: nanocomposite, XRD, FTIR, dielectric, loss tangent, AC conductivity.

INTRODUCTION

Nanomaterial now a days are of great interest since they have unique electronic, optical and mechanical properties [1-7].

Semiconductor nanoparticles have special properties such as large surface to volume ratio, special electronic properties as compared to those of bulk materials [8, 9].Copper oxide (CuO) is a *p*-type semiconductor material with narrow band about 1.2 -1.9 eV. It has unique physical properties.

It has great potential for electronic and photonic applications. ZnO is a semiconductor material of II-VI compound of the periodic table.

ZnO is wurtzite type semiconductor with band gap 3.37eV at room temperature. It has very large excitation binding energy of about 60mV [10, 11]. The CuO has high hole mobility and having low lattice mismatch with ZnO. This property is useful to form *p*-CuO/*n*-ZnOnano composite junction with ZnO [12, 13].

The CuO/ZnO nano composite junction was formed by mechanical milling of CuO and ZnO analytical grade powder taken in 1:1 weight percentage.

It was then undergone the heat treatment for three hour. The synthesized nano composite was characterized by XRD and FTIR. This work is published in my earlier paper [14, 15].

The dielectric properties of *p*-CuO/*n*-ZnOnao composite were investigated by broadband dielectric spectroscopy in 1GHz to 3GHz frequency range under 0^oc to 350^oc temperature [16].

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EXPERIMENTAL

XRD study

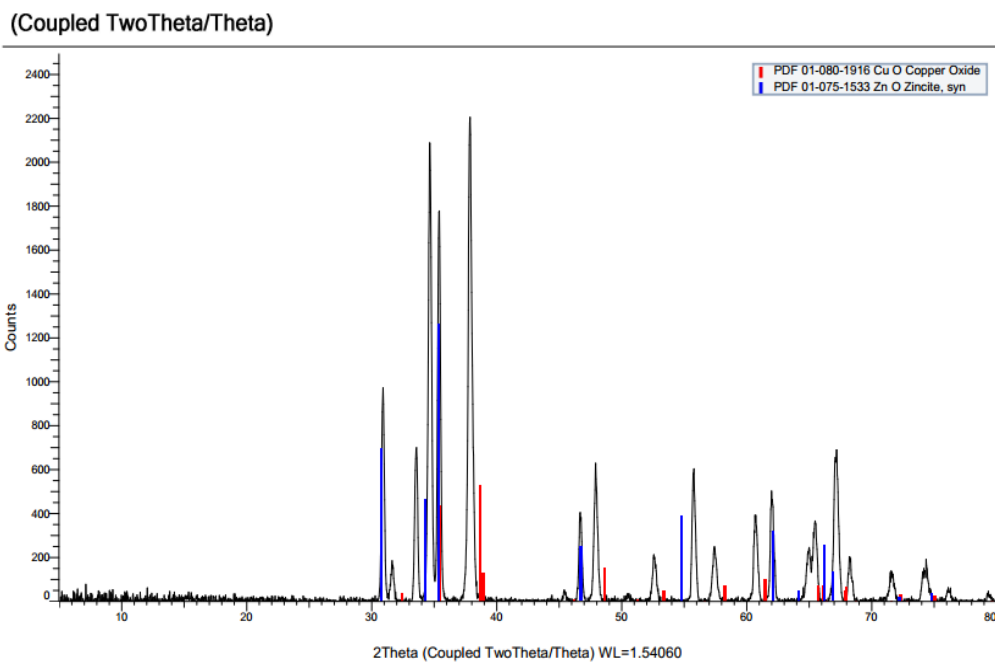


Fig. 1: XRD of *p*-CuO/*n*-ZnO nanocomposite

Figure 1 shows the XRD of *p*-CuO/*n*-ZnO nanocomposite. The XRD study showed that it is crystalline in nature with crystal size well in nanomaterial range. Figure shows the presence of CuO and ZnO in it.

FTIR

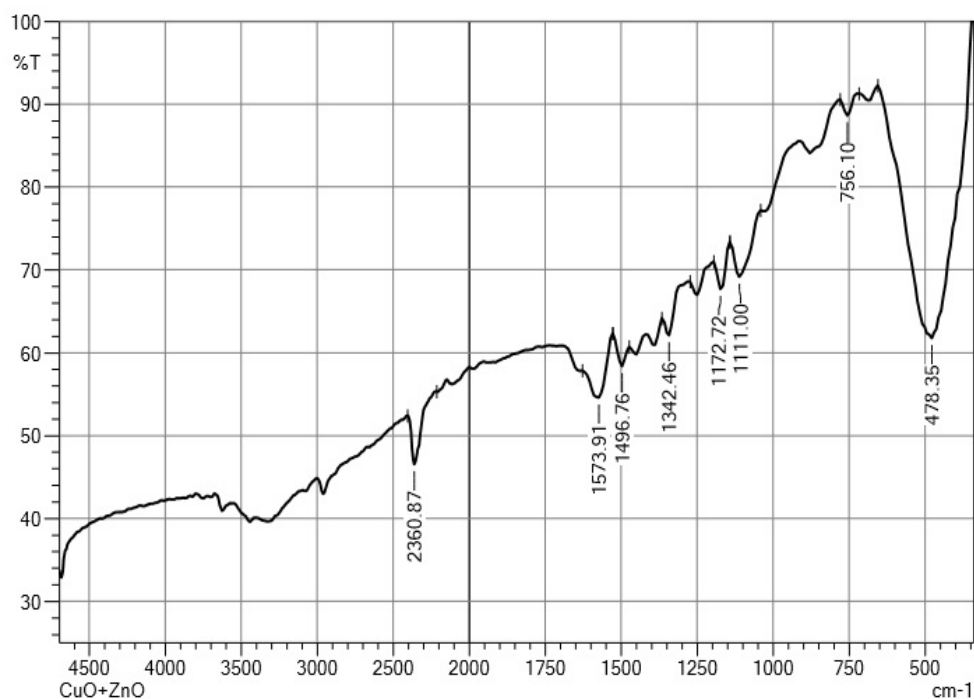


Fig. 2 FTIR spectra of *p*-CuO/*n*-ZnO nanocomposite

Figure 2 presents the FTIR spectra of *p*-CuO/*n*-ZnO nanocomposite. It shows the absorption peak at 478.35cm^{-1} .

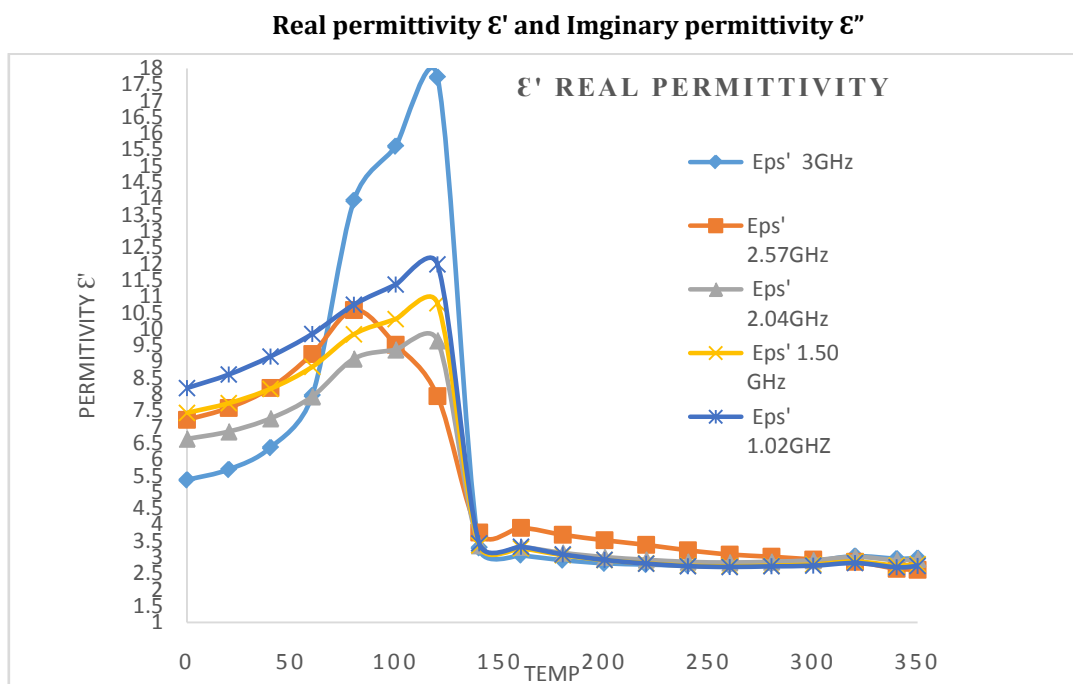


Fig.3 Real permittivity ϵ' of *p*-CuO/*n*-ZnO nanocomposite as a function of temperature

The above figure 3 shows the variation of real permittivity ϵ' of *p*-CuO/*n*-ZnO nanocomposite in the 1GHz th 3GHz frequency range at 0°C to 350°C temperature. The permittivity increases with increase in temperature at a certain critical value gradually. Then it rises suddenly at 120°C temperature and the fall down with increase in temperature and remains steady. The *p*-CuO/*n*-ZnO nanocomposite has low value of permittivity at higher frequency at lower temperature and high value of permittivity at lower temperature and frequency.

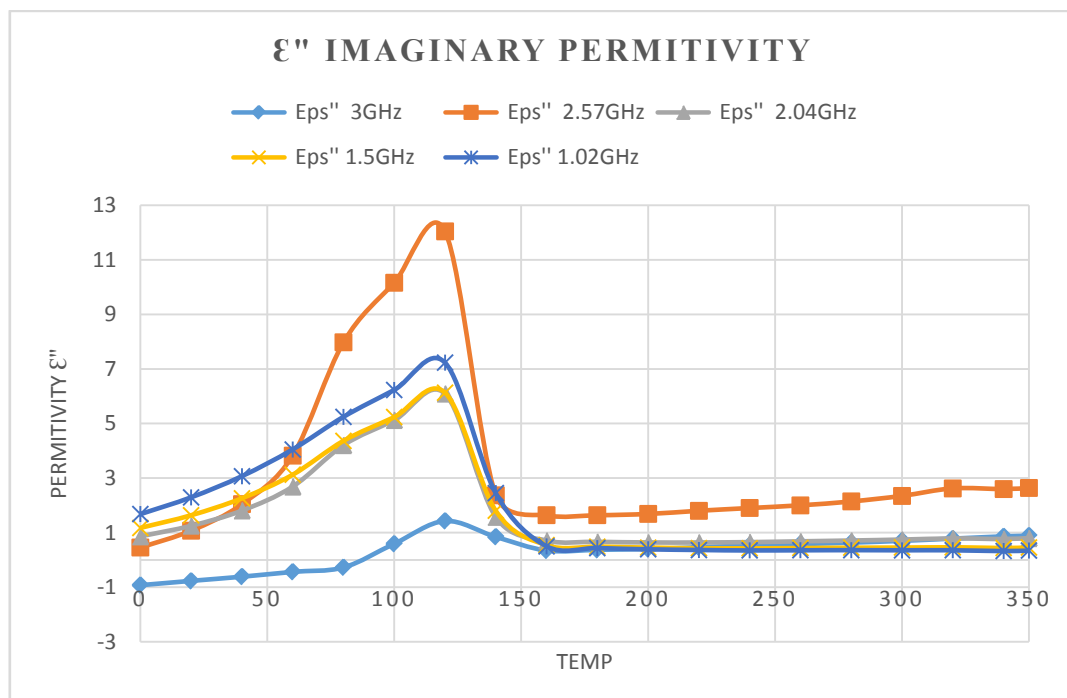


Fig.4: Imaginary permittivity ϵ'' of *p*-CuO/*n*-ZnO nanocomposite as a function of temperature

The imaginary permittivity ϵ'' of *p*-CuO/*n*-ZnO nanocomposite as a function of temperature is shown in the figure 4. It is lowest (negative) at 3GHz frequency and high for 1 GHz frequency at low temperature. The imaginary permittivity ϵ'' increases with increase in temperature and is high at 120°C temperature value. After this, it drops down and remains steady.

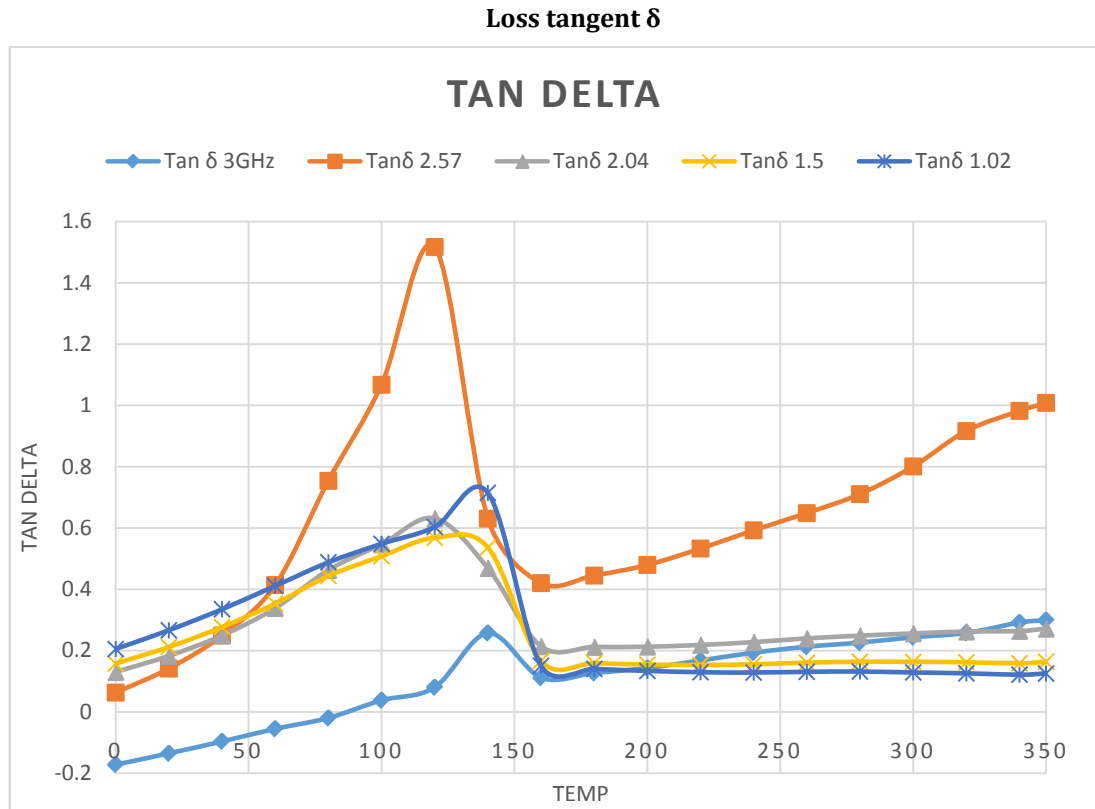


Fig.5 Loss tangent δ of *p*-CuO/*n*-ZnO nanocomposite as a function of temperature

Figure 5 shows the loss tangent δ as a function of temperature. Its value increases with increase in temperature and is maximum at 120°C temperature for 2.57GHz frequency. After this, it decreases with increase in temperature.

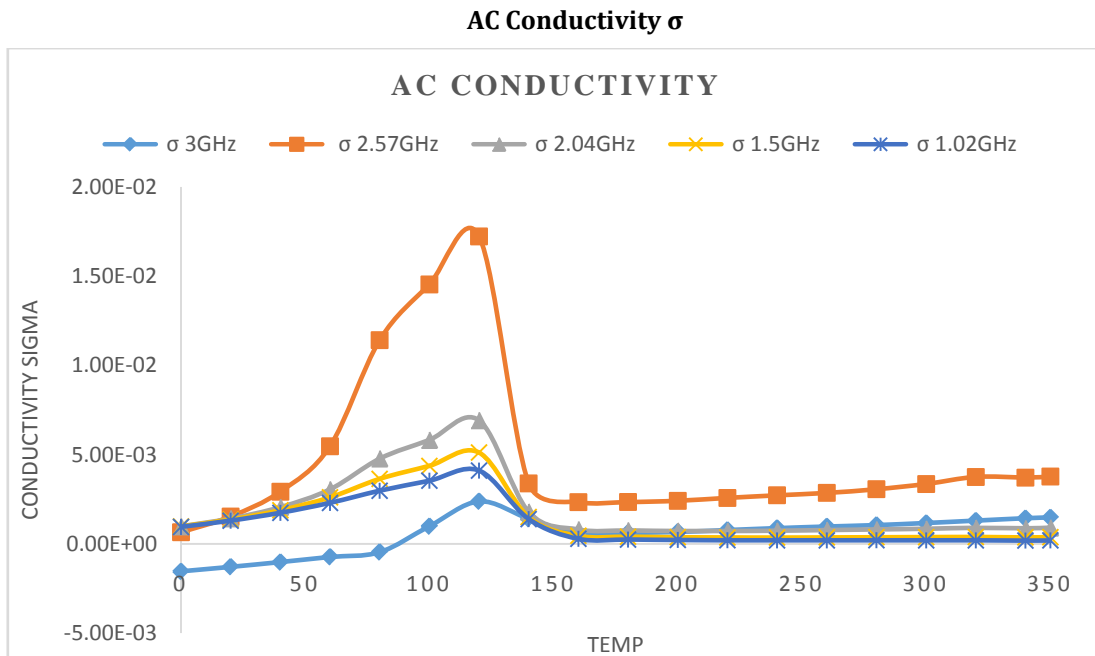


Fig.6: AC Conductivity σ of *p*-CuO/*n*-ZnO nanocomposite as a function of temperature

The figure 6 shows the AC conductivity of nanocomposite as a function of temperature. It is negative at 3GHz frequency at low temperature. As temperature rises, The AC conductivity of nanocomposite increases and is maximum at 120°C temperature at 2.57 GHz frequency. After this, as temperature increased, AC conductivity drops down and then remains almost constant for higher temperature value.

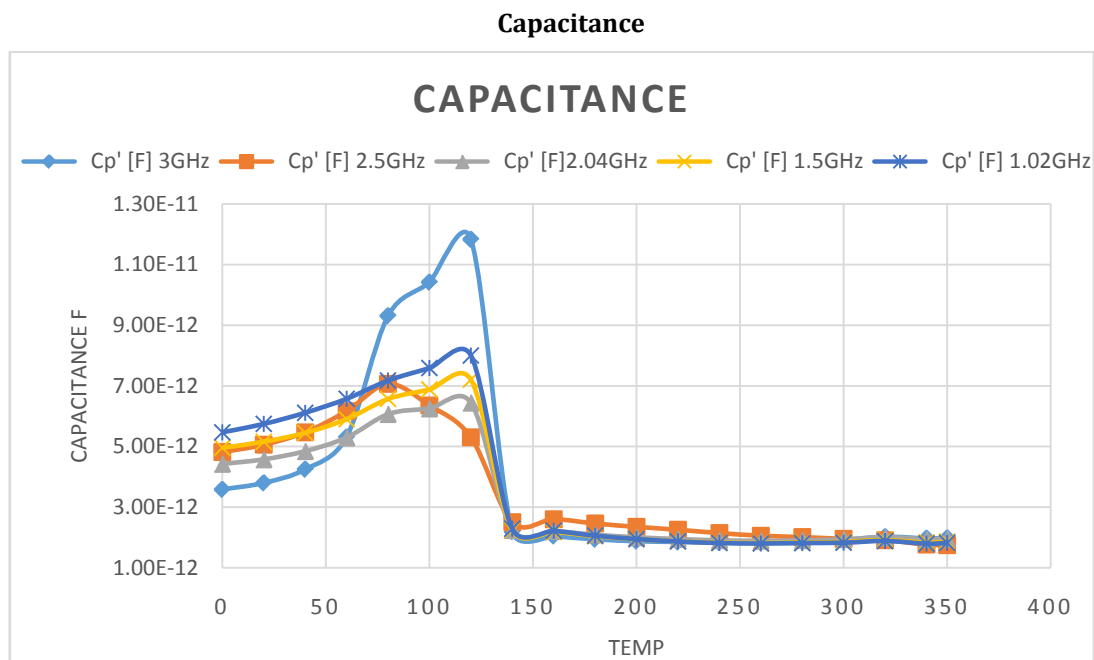


Fig.7: Capacitance of *p*-CuO/*n*-ZnO nanocomposite as a function of temperature

Figure 7 represents the capacitance of *p*-CuO/*n*-ZnO nanocomposite as a function of temperature. The capacitance increases with increase in temperature initially up to 120°C temperature and then drops down.

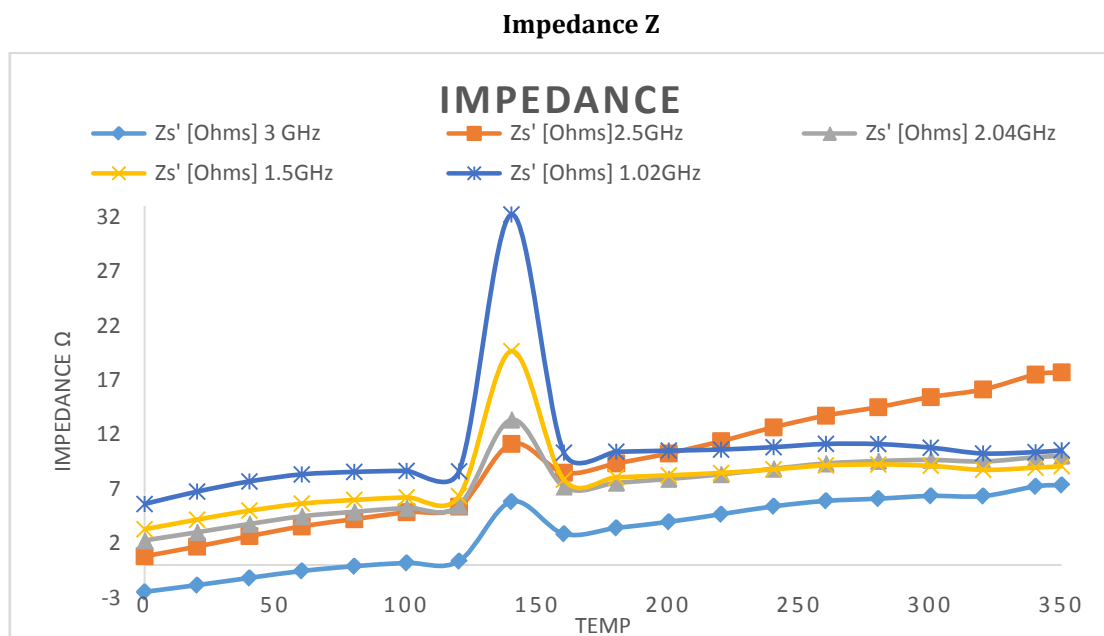


Fig.8: Impedance Z of *p*-CuO/*n*-ZnO nanocomposite as a function of temperature

Impedance Z of *p*-CuO/*n*-ZnO nanocomposite as a function of temperature is shown in figure 8. Impedance Z increases with increase in temperature upto 120°C. At 140°C, it rises suddenly and then drops down. The Z is high for 1GHz frequency and low for 3GHz frequency as obtained in the figure.

RESULT AND DISCUSSION

The XRD and FTIR confirms the formation of nanocomposite. The dielectric properties, loss tangent, AC conductivity, capacitance and impedance of *p*-CuO/*n*-ZnO nanocomposite junctions studied in the frequency range 1GHz -3GHz under the influence of temperature between 0°C to 350°C [17-19]. The influence of temperature and frequency is observed on *p*-CuO/*n*-ZnO nanocomposite.

CONCLUSION

The *p*-CuO/*n*-ZnO nanocomposite synthesized by mechanical milling method and characterized by XRD and FTIR. It is well in agreement with earlier study. The temperature and frequency has a significant impact on dielectric properties as well as, loss tangent, AC conductivity, capacitance and impedance value of *p*-CuO/*n*-ZnO. All these parameter value increases with increase in temperature upto a certain critical value(120°C) and the drops down and remains almost constant with increase in temperature.

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