AN 17–CureView Material Properties Parameters

Summary

Raw gain-phase data measured by CureView and the LT-451 or LTF-631 Dielectric Cure Monitors is converted to the dielectric properties of permittivity (ε') and loss factor (ε"). Loss factor, however, has two components—an AC component arising from dipole rotation and a DC component caused by the motion of free ions and charge carriers. DC loss factor in turn is converted into ion viscosity (resistivity ρ), which is strongly correlated to physical viscosity in most curing systems and also indicates the cure state of the Material Under Test.

Material Properties are adjustable parameters used to extract the DC component of loss factor for conversion to ion viscosity. Only derived data such as ion viscosity and resistivity are modified through the use of these material properties. The raw data is always preserved unchanged, allowing trial and error adjustment of the material properties to obtain the most useful results.

Accessing the *Material Properties* window

To view and change the ***Material Properties*** used for data processing, click on the "Data Parameters" option under "Edit" on the main menu bar as shown below:

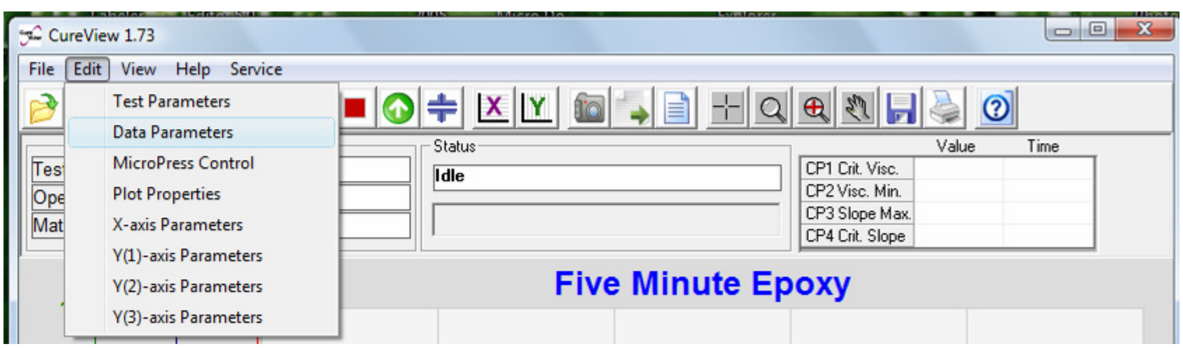

Figure 1
Main menu bar

The ***Material Properties*** window will appear.

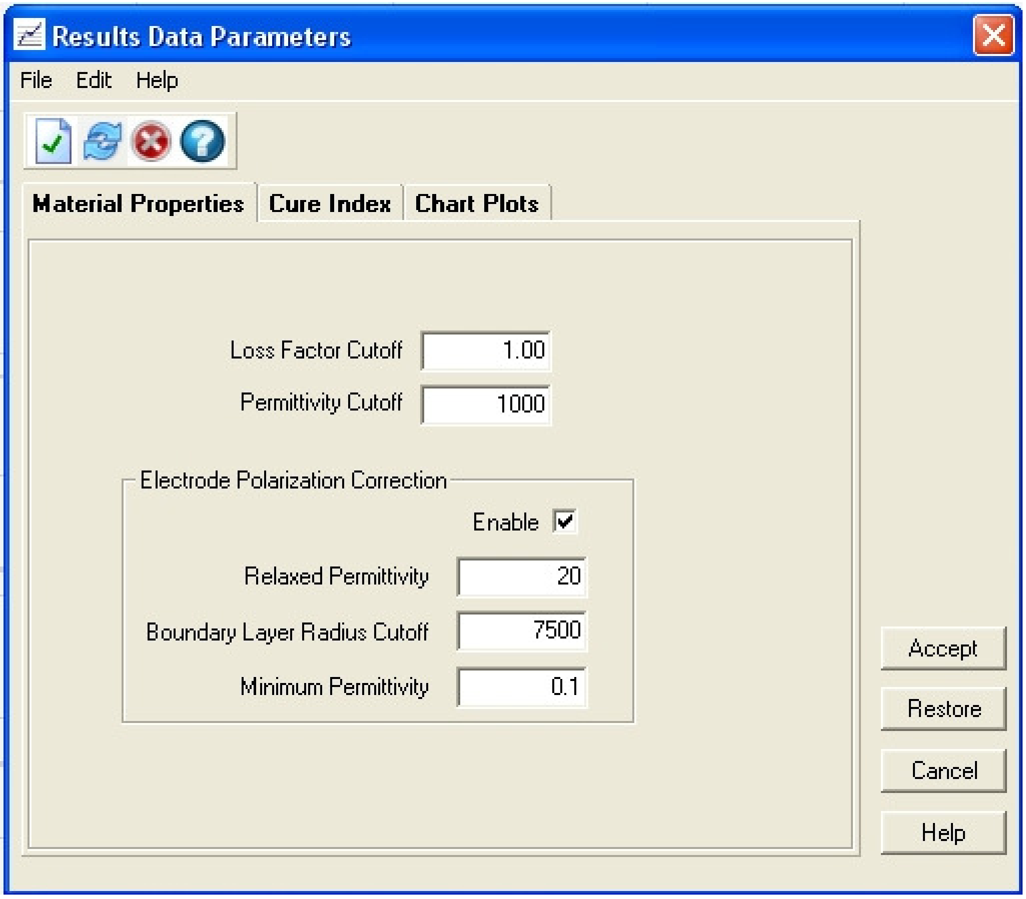

Figure 2
***Material Properties* window**

The Material Properties used when analyzing dielectric data are defined as follows:

Loss Factor Cutoff

Function: Prevents conversion of loss factor (ε") data to ion viscosity when ε" < Loss Factor Cutoff.

Default: 5 in linear loss factor units.

Loss Factor Cutoff is sometimes also called *Dipole Cutoff*. CureView assumes that dipole rotation and the AC component of loss factor dominate the dielectric response when ε" < Loss Factor Cutoff, therefore calculation of ion viscosity would produce misleading results under these conditions.

Figure 3 shows an example of multiple, non-overlapping ion viscosity curves (green traces) when the Loss Factor Cutoff is too low. In this case, the ion viscosity data is confusing because they are derived from both the AC and DC components of loss factor. The data do not give a clear indication of which curve—if any—corresponds to physical viscosity and the state of cure.

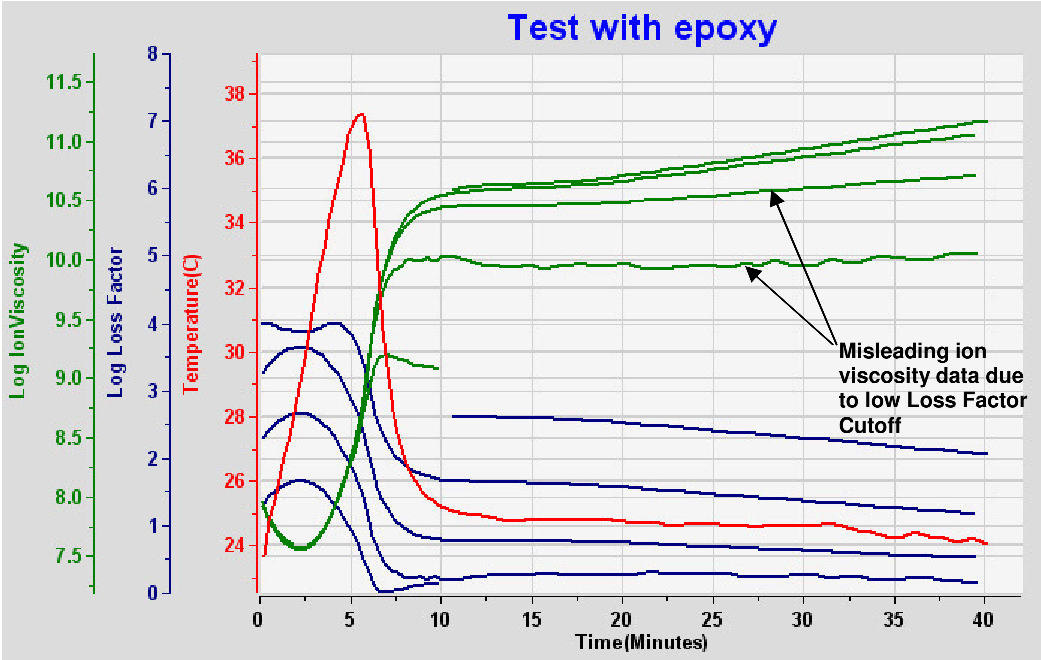

Figure 3
Plot showing ion viscosity data when Loss Factor Cutoff is too low

Results with a higher Loss Factor Cutoff are shown in Figure 4.

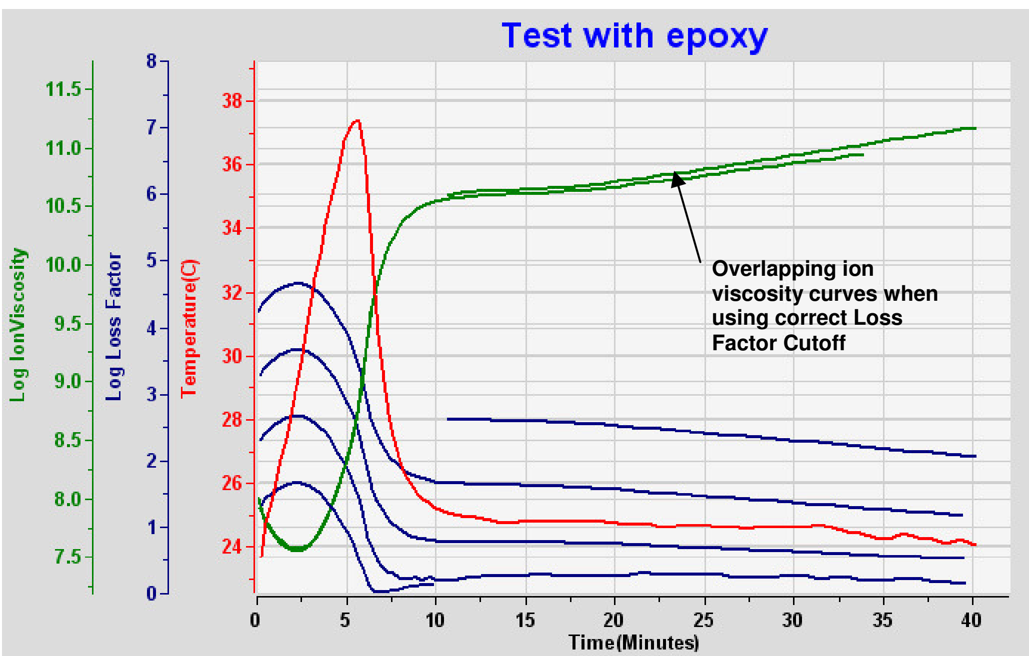

Figure 4
Plot showing ion viscosity with correct Loss Factor Cutoff

Note that the plotted ion viscosity curves overlap, indicating that the presented dielectric data is dominated by the DC component of loss factor. This result displays only information that correlates with physical viscosity and the cure state of the material under test.

Permittivity Cutoff

Function: Prevents loss factor (ε") data from being converted to ion viscosity when ε' > Permittivity Cutoff.

Default: 1000 in linear permittivity units.

CureView assumes that electrode polarization affects the dielectric response when ε' > Permittivity Cutoff. Under these conditions loss factor appears artificially low, and conversion of this loss factor to ion viscosity would produce erroneous results. Figure 5 shows the distortion in loss factor due to electrode polarization, and the deletion of misleading ion viscosity data as a result of the Permittivity Cutoff.

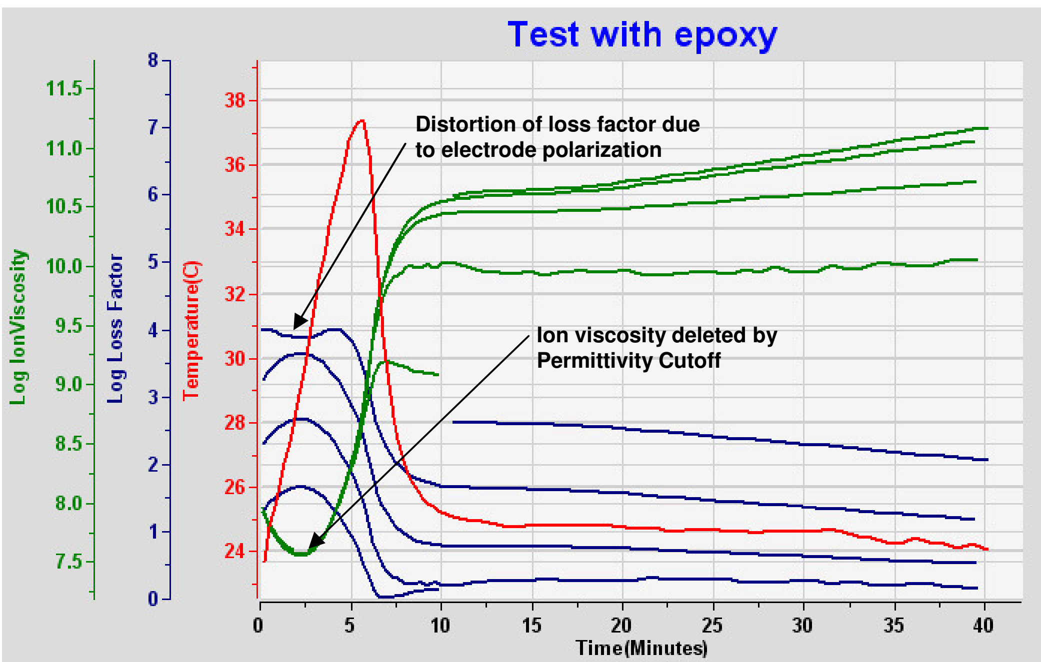

Figure 5
Plot showing effect of Permittivity Cutoff

Electrode Polarization Correction

Electrode polarization occurs when the Material Under Test is both highly fluid and highly conductive, causing the formation of an insulating boundary layer on the surface of the sensor electrodes. This boundary layer can distort the loss factor data as shown in Figure 6. CureView can correct the effect of electrode polarization with proper selection of material properties.

Clicking to insert a check (√) in the "Enable" checkbox causes CureView to correct the effect of electrode polarization. A blank in the "Enable" checkbox results in no correction for electrode polarization. Due to the need to determine the material properties by trial and error, electrode polarization correction is normally used during replotting and analysis and not during real time data acquisition.

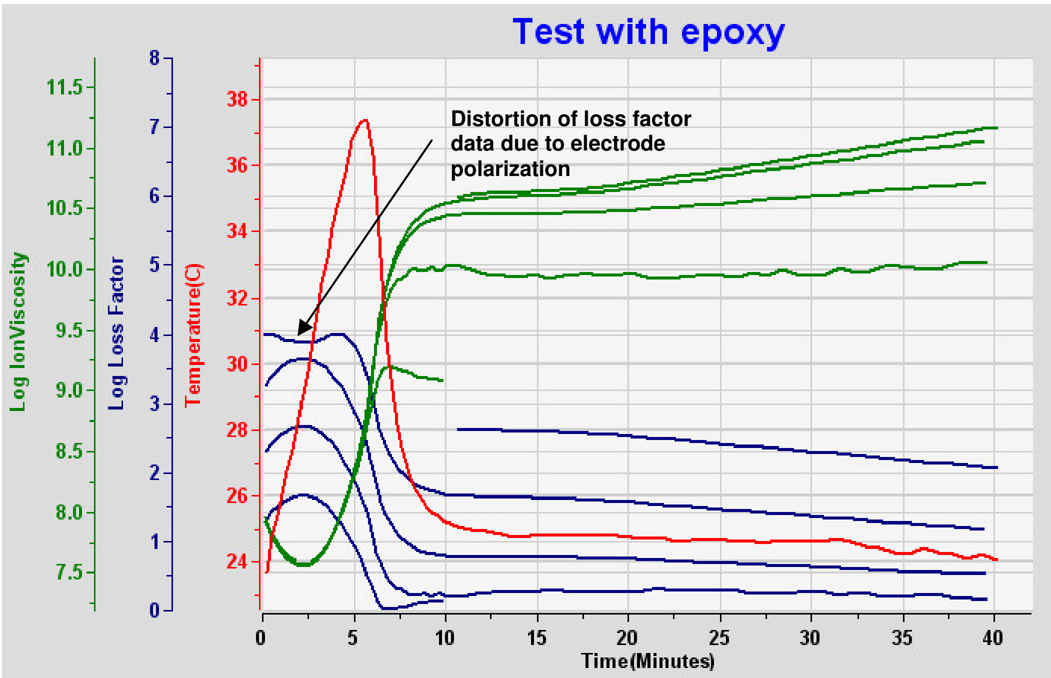

Figure 6
Plot showing distortion of loss factor due to electrode polarization

The material parameters affecting electrode polarization correction are defined below:

Relaxed Permittivity

Definition: The permittivity of the Material Under Test toward the end of cure. For most polymers it is in the range of 4 to 10.

Default: 10 in linear permittivity units.

Boundary Layer Radius Cutoff

Definition: The lower limit of permittivity used for boundary layer correction.
Default: 25 in linear permittivity units.

Electrode polarization distorts dielectric data by artificially increasing permittivity (ε') and decreasing loss factor (ε") under conditions of both high fluidity and high conductivity. When plotted against time, loss factor curves may display anomalous behavior as shown previously in Figure 6.

A Cole-Cole plot of loss factor against permittivity on linear scales is typically semi-circular when data is distorted in this way, as shown in Figure 7. The Boundary Layer Radius Cutoff determines when to apply or not apply boundary layer correction.

The default value for Boundary Layer Radius Cutoff is 25. For purposes of electrode polarization correction, the exact value of the Boundary Layer Radius Cutoff is generally not critical, but best results are obtained through trial and error until the corrected loss factor curves appear similar to those of Figure 8.

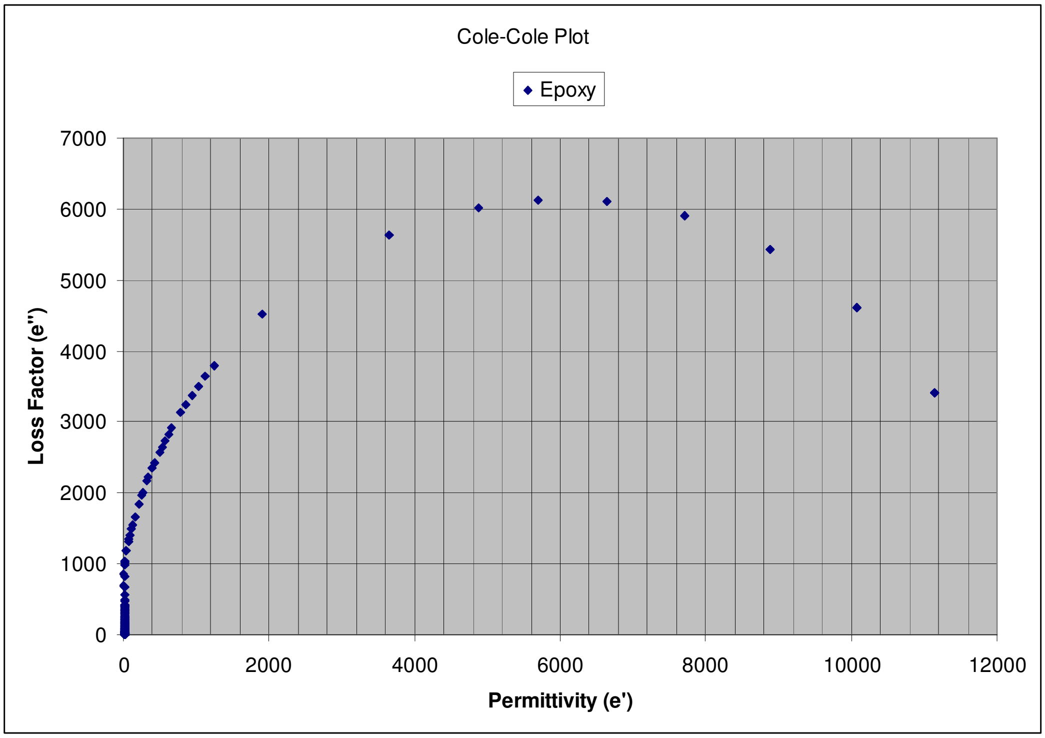

Figure 7
Cole-Cole plot of cure data distorted by electrode polarization

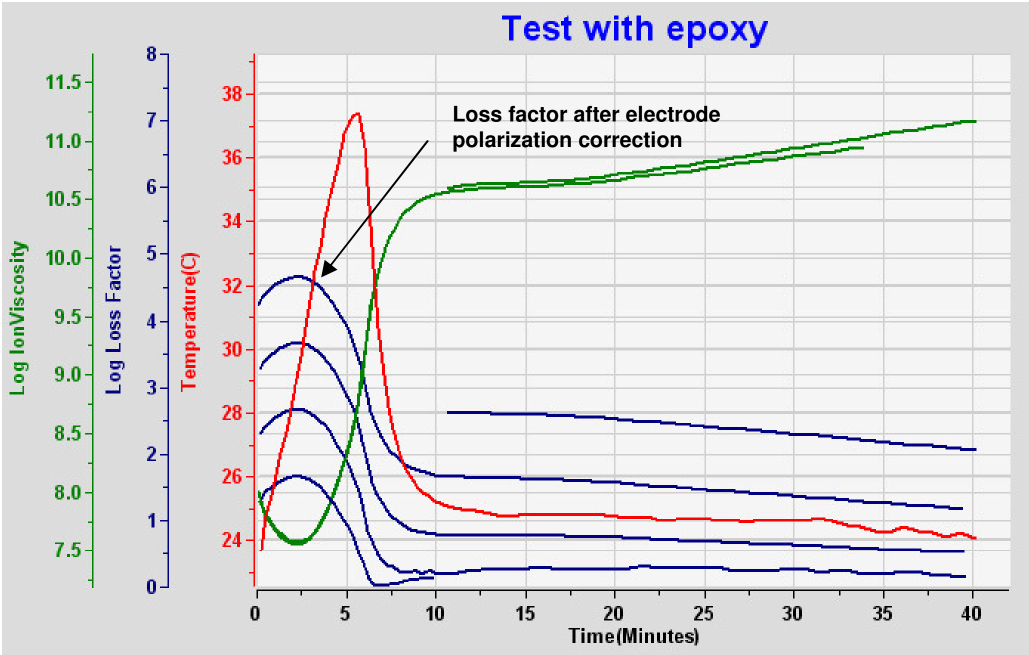

Figure 8
Plot showing data after electrode polarization correction

Minimum Permittivity

Definition: Permittivity below which CureView will not convert the associated loss factor to ion viscosity.

Default: 0.1 in linear permittivity units.

Summary of *Material Properties*

Table 1
Summary of *Material Properties*

Material Property	Action/Description	Default
Loss Factor Cutoff	CureView does not convert data to ion viscosity for loss factors below the Loss Factor Cutoff. Value is in linear units. Loss factors below Cutoff assumed to be dominated by AC conductivity.	5
Permittivity Cutoff	CureView does not convert data to ion viscosity when permittivity is above the Permittivity Cutoff. Value is in linear units. Loss factors assumed to be distorted by electrode polarization when permittivity is above Cutoff.	1000
Relaxed Permittivity	Permittivity of material under test at end of cure.	10
Boundary Layer Radius Cutoff	Low permittivity limit for application of boundary layer correction.	25
Minimum Permittivity	CureView does not convert data to ion viscosity when permittivity is below the Minimum Permittivity.	0.1

Conclusion

Many factors can cause confusing interpretation of dielectric data. Selection of appropriate ***Materials Properties*** directs CureView to process dielectric data to remove artifacts due to the effect of dipoles or electrode polarization. The result, ideally, would be ion viscosity due primarily to DC resistivity (DC conductivity), which correlates strongly with the state of cure of polymeric materials.