# 2. Highway TA

- Highway TA is a thermal analysis technique with the added simulation function that converts data measured at one heating rate to measurement data at another heating rate.

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| Example: Data measured at 50ºC/min can be converted to measurement at 10 or 1ºC/min. |

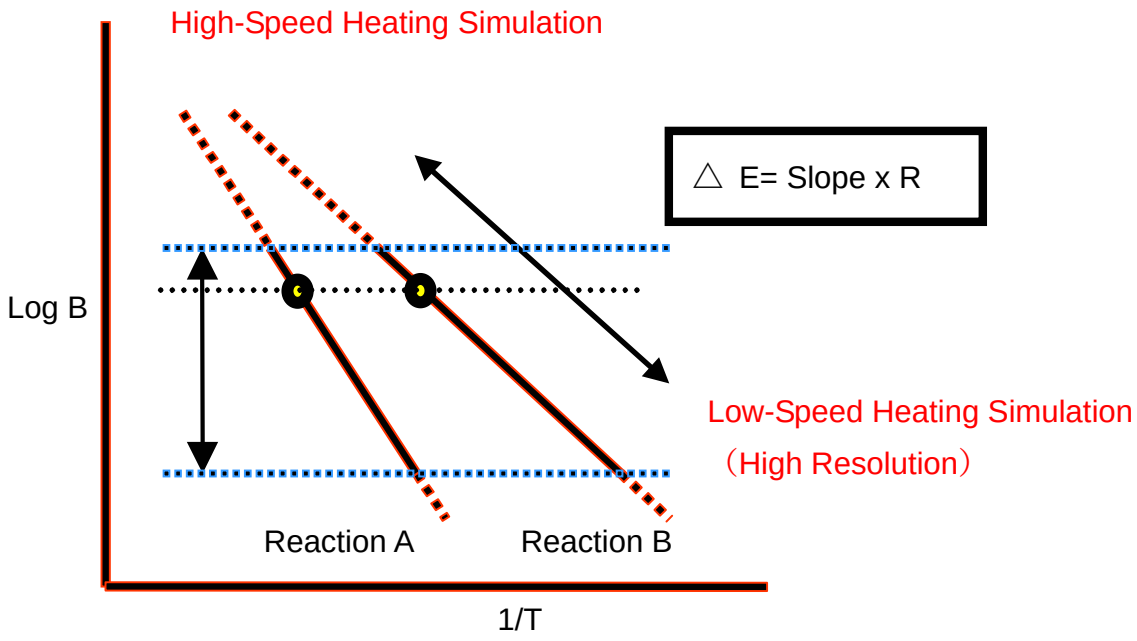
⇨ Shorter measurement time

⇨ Improved resolution

Highway TA is a thermal analysis technique with the added simulation function that converts data measured at one heating rate to measurement data at another heating rate, and can be applied to TG and DSC.

Highway TA consists of 1) standard measurement, 2) separation of each reaction, 3) calculation of activation energy and 4) temperature conversion according to the Arrhenius equation.
This helps achieve shorter measurement time and the improved TG signal resolution.

# Principle of Highway TG



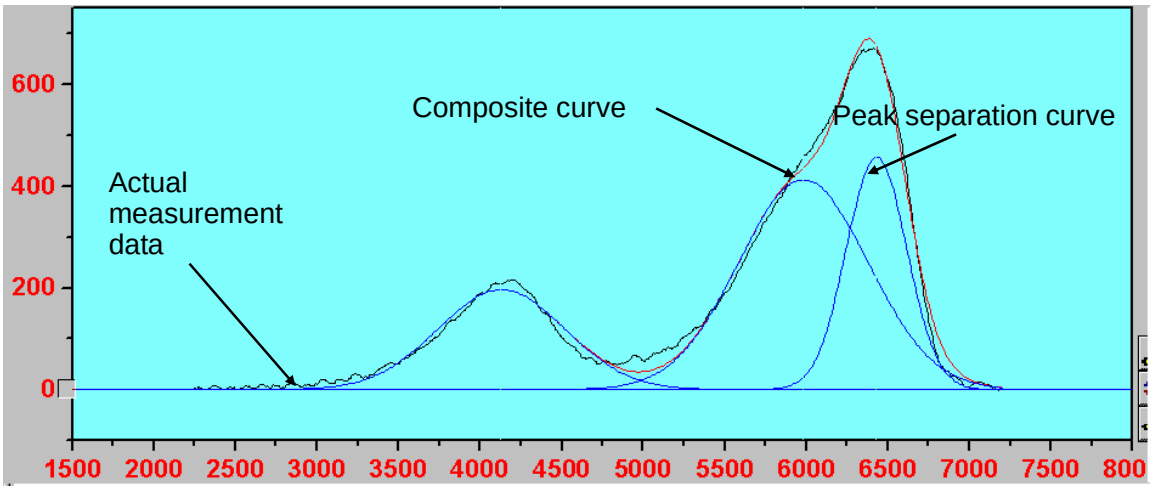

The above diagram shows Arrhenius plots that demonstrate the principles of Highway TA.

The horizontal axis represents the inverse of the temperature and the vertical axis represents the logarithm of the heating rate.

The reaction temperature (A) at one heating is plotted as above. When the heating rate changes, the temperature changes across a line at a certain slope. This slope is dependent on the activation energy. Therefore, if the activation energy of the reaction is calculated, then it is converted to a temperature at a different heating rate.

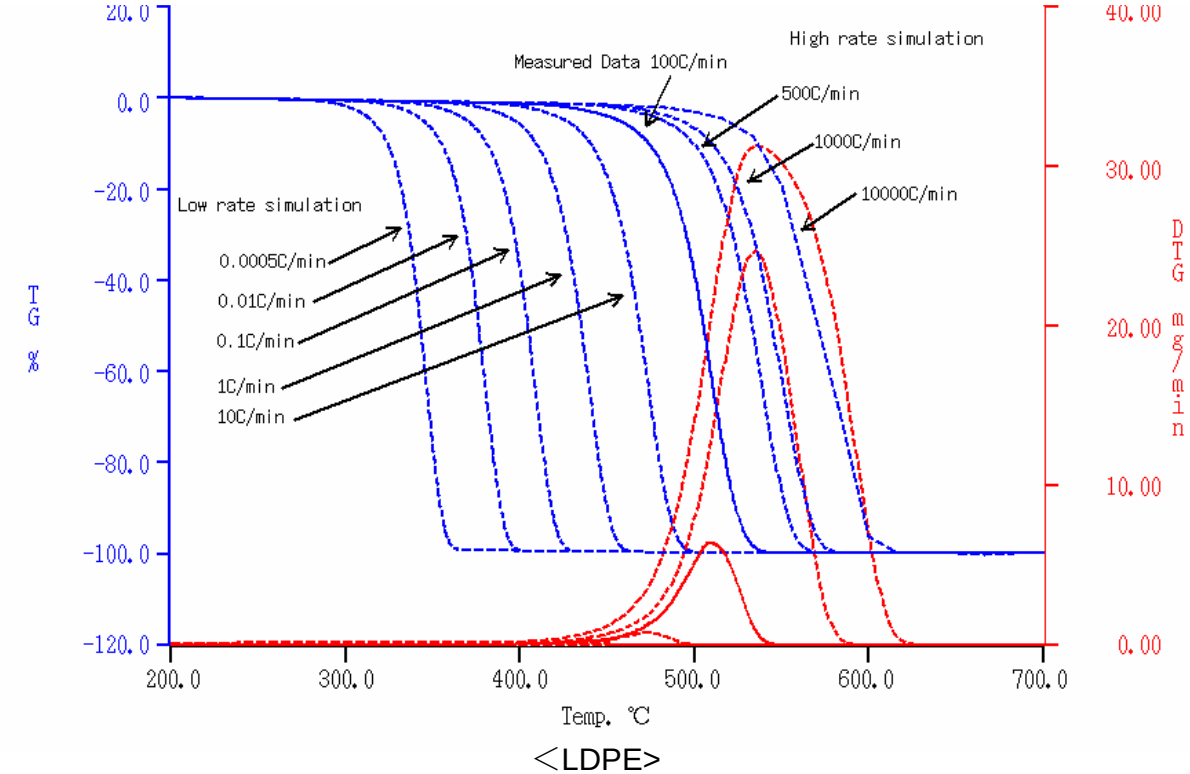
Also, activation energy tends to be small as the temperature is low (B). Therefore, the two reactions will tend to separate further as the temperature goes down. This is why there is better separation at lower heating rate.

# Peak Separation Handling Example




The above diagram shows DTG (differential signal of the TG signal). 3 peaks appear in the measurement data and each peak is separated. Activation energy is calculated for each peak and heating rate conversion is conducted.

# Super-High heating rate &
# Super-Low heating rate Simulation

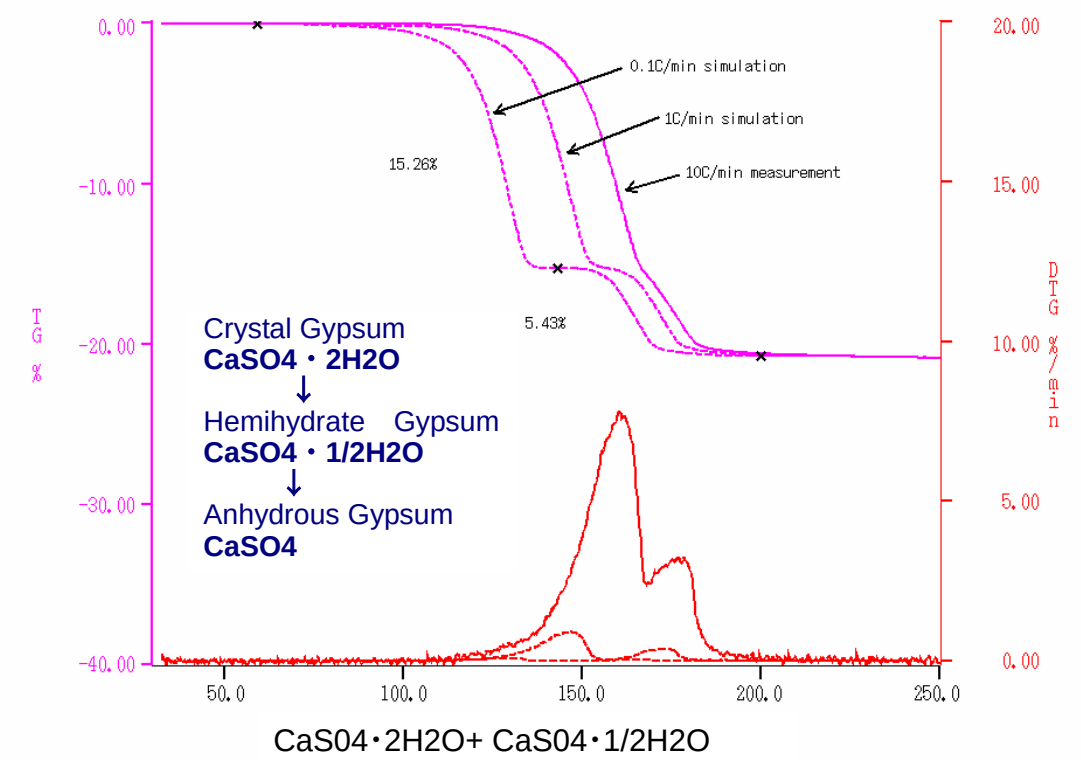



＜LDPE>

The diagram shows an example in which low-density polyethylene is measured at 100ºC/min and converted to 0.0005ºC/min to 1000ºC/min.

Using Highway TA, estimates may be gathered in ranges where actual measurements are impossible.

# Quantity determination of dihydrate/hemihydrate gypsum with Highway Simulation



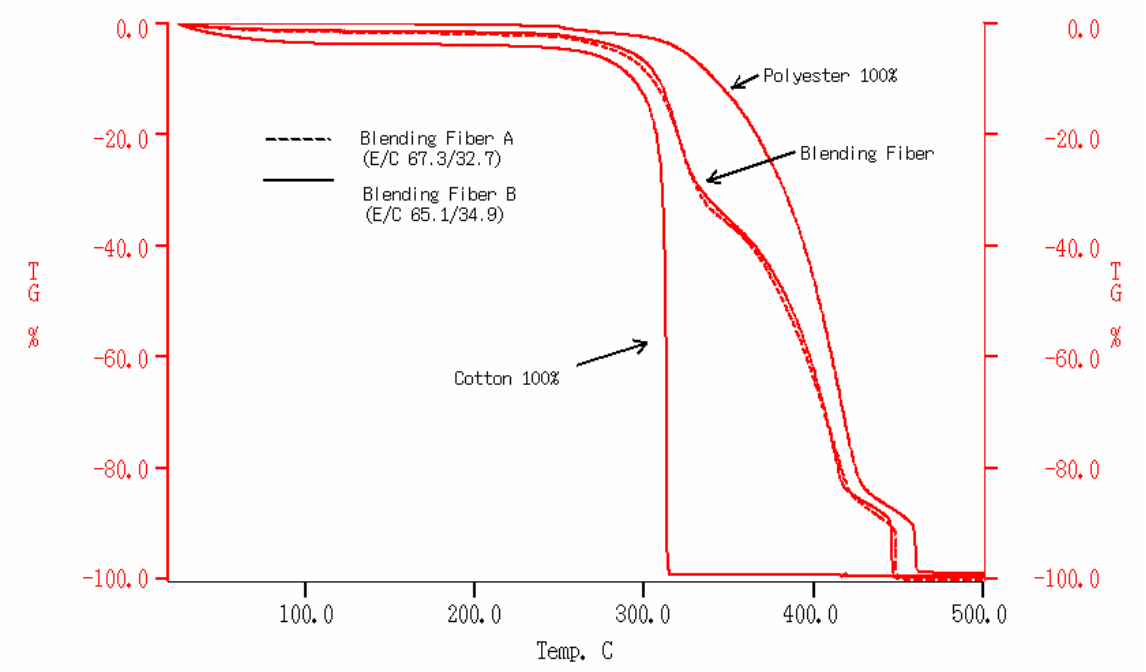

CaS04･2H2O+ CaS04･1/2H2O

The diagram shows the results from measuring calcium sulfate dihydrate (dihydrate gypsum) at 10ºC/min converted to data at 1 and 0.1ºC/min data with highway TA.

First, 3/2 of water evaporated from dihydrate gypsum, and then 1/2 of water evaporates. But because water evaporation occurs continuously, separation is poor at 10ºC/min.

But if this is simulated, data with good separation can be acquired.

# Blend Ratio Measurement of Fiber



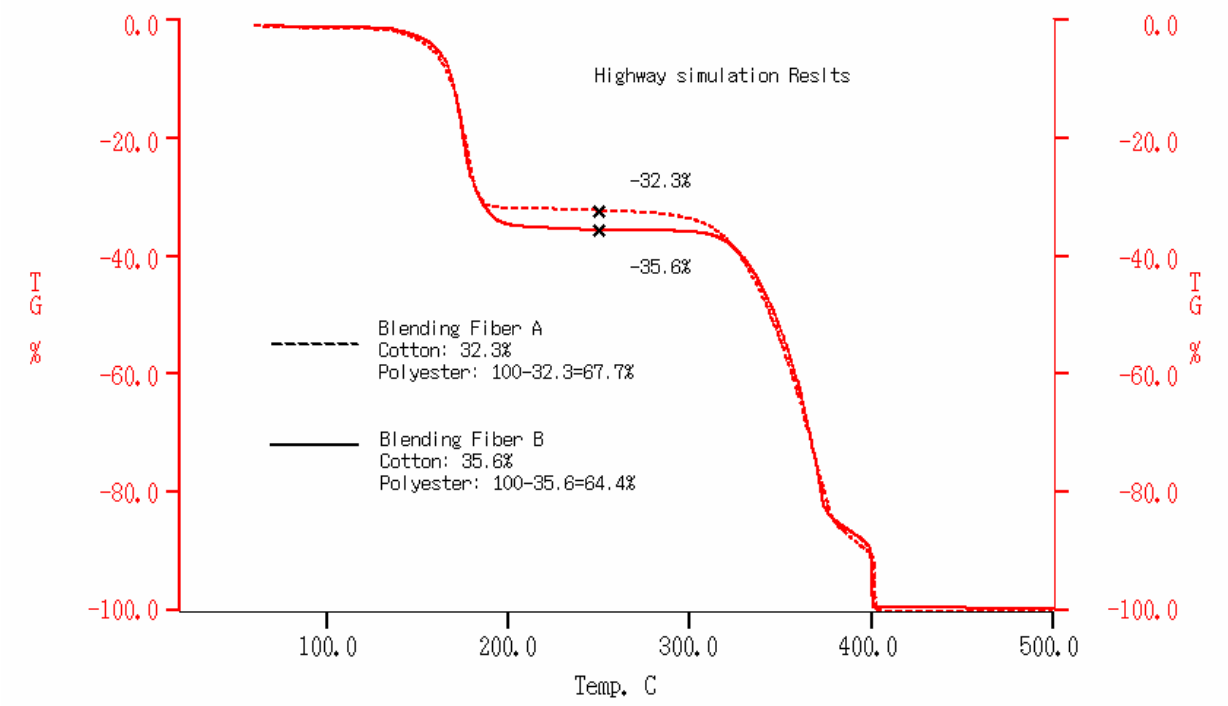

＜Cotton/polyester blended fiber>

The above diagram shows the results when two samples of cotton/polyester blend fiber measured at 10ºC/min. It shows the result when blend ratio was found using wet process and the difference in ratio is 2%.

Also, the measurement results of 100% cotton and polyester are shown as reference. From these results, it is apparent that the initial mass reduction in the blended fiber was caused by cotton and the mass reduction in the second half resulted from polyester.

However, it is difficult to determine the mass reduction amount of each material from the blended fiber result.

# Blend ratio determination with Highway Simulation

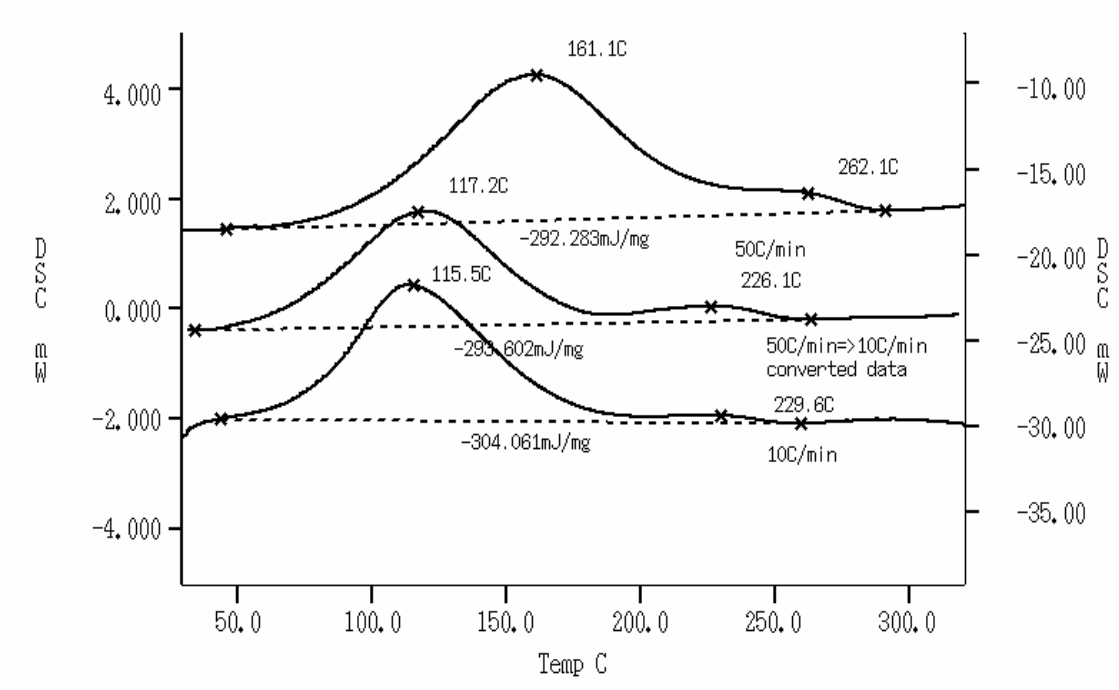



＜Cotton/polyester blended fiber>

The above diagram shows the blended fiber measurement result converted to 0.1ºC/min data. The separation of the two resolution reactions improved and it is possible to calculate the two component ratios.

Using Highway TA like this, it is possible to simulate data with bad TG signal separation to a data with good separation, and from this measurement result, we were able to find the 2% difference in blend ratio.

# Epoxy Resin Cure




<Epoxy Resin Cure>

Highway TA can be applied to DSC as well.

The chart shows epoxy resin cure measured at 50ºC/min (top line) and the result converted to 10ºC/min (middle line). Also, actual measurement data at 10ºC/min is shown (bottom line).

The simulated data and the actual measurement data match well and the validity of the conversion is apparent.

Also, Highway TA can be applied to reactions according to the Arrhenius equation and it should be noted that dissolution reactions often measured with DSC cannot be converted.