Lifespan Prediction for Polypropylene (PP) using the Chemiluminescence Method

Lifespan prediction was attempted using commercially-available software on data measured using the chemiluminescence method.

Samples	200Mg W101 Sumitomo Chemical Co., Ltd. Polypropylene (PP) pellets
Measurement devices	Main unit: CLA-FS4; sample chamber: CLS-SH0; both manufactured by Tohoku Electronic Industrial Co., Ltd.
Measurement temperature	50 to 200°C
Temperature increase rate	0.2°C /min, 0.4°C /min, 0.8°C /min
Atmosphere	Oxygen (50ml/min)

● Analysis software

AKTS - Thermokinetics (a reaction kinetics analysis program using the (Friedman) differential equivalent method)

This method improves on the (Ozawa) integral equivalent method.

Sole agent in Japan: Palmetrics Corporation (http://www.palmetrics.co.jp/index.html)

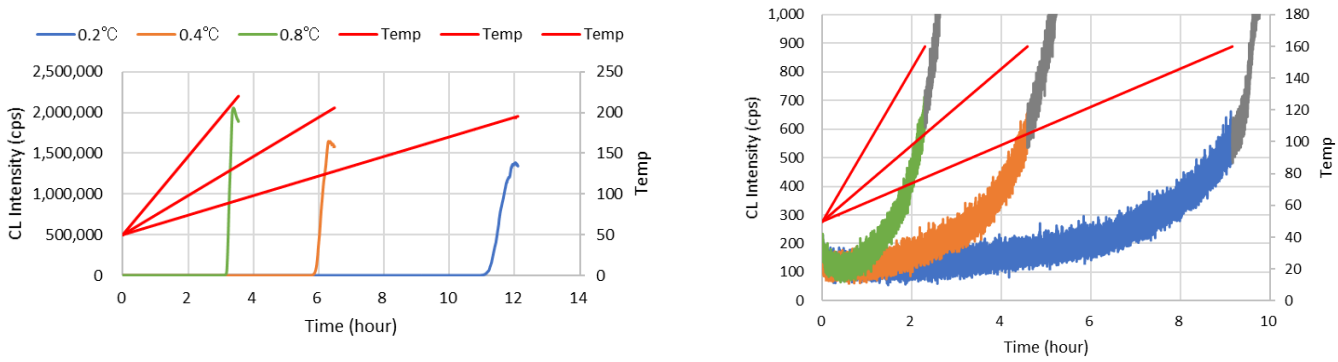

Fig. 1　CL measurement results

Measurement ends at the point when the amount of luminescence peaks and attenuates.

The graph on the right is a magnified view up to 160°C (coloured lines).

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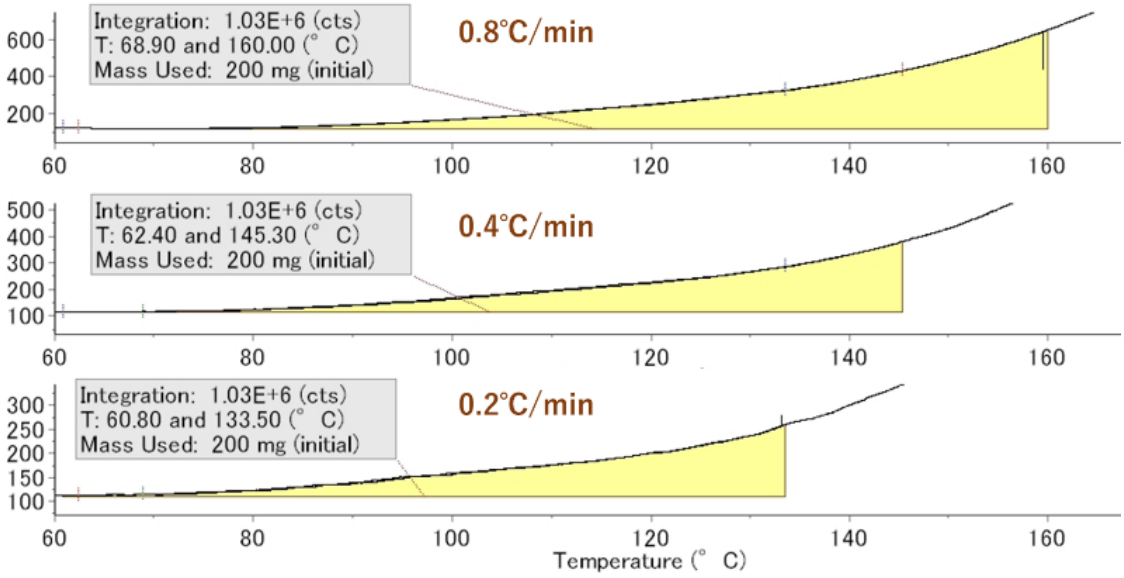

Fig. 2 Time-course graph of integrated value over time for amount of luminescence

Reaction progress is represented as an integrated value over time.

The integrated amount of luminescence at the point at which 160°C (melting point or lower) is reached, from the start of measurement at 0.8℃/min, was taken to be the reaction end point.

Integrated amount of luminescence = 1.03E + E6.

The reaction progress at this point was taken to be 1, and regarded as the lifetime.

The point at which the CL integrated value also reaches 1.03E + E6 at 0.2°C and 0.4°C /min was taken to be the reaction end point.

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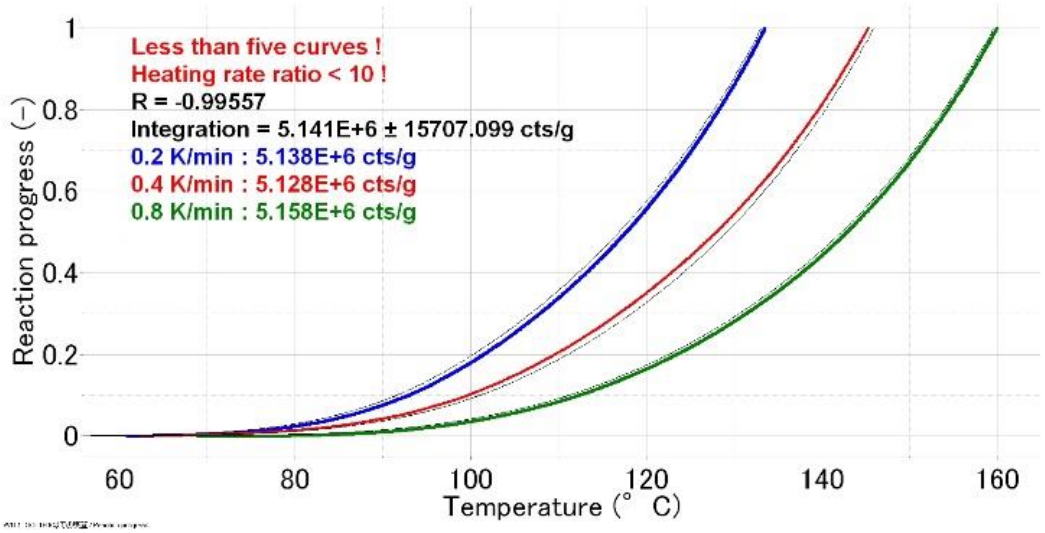

Fig.3 Graph of reaction progress and temperature up to the reaction end point

The vertical axis shows the reaction progress rate. The R value in the graph provides assurance that the analysis reliability is 0.99 or higher; in this case, the R value was 0.99557.

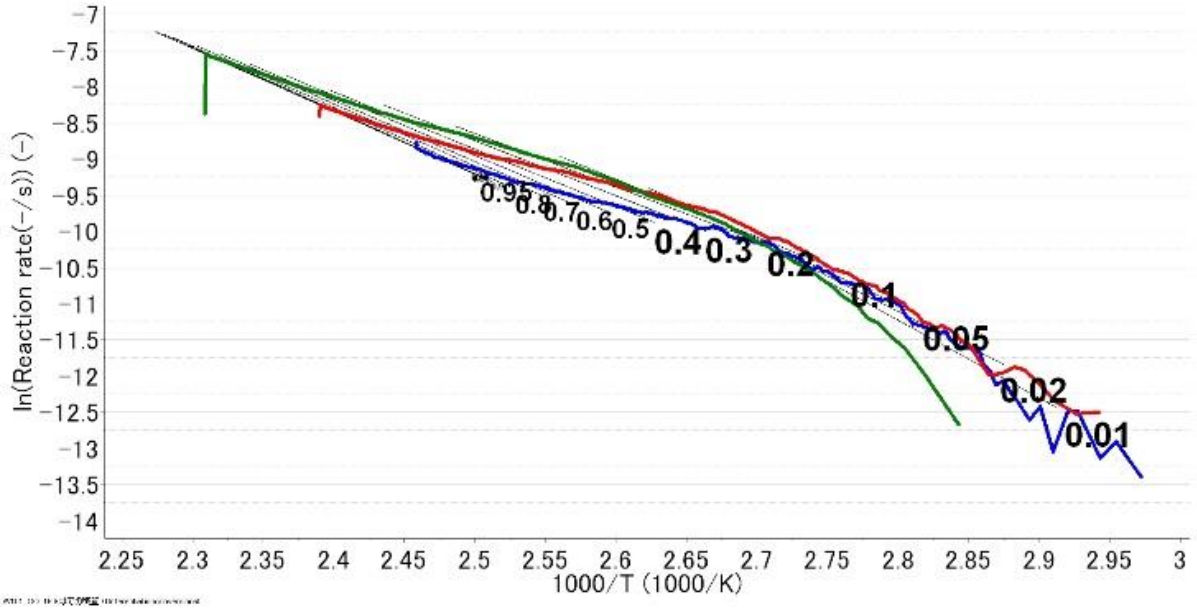

Fig. 4 The Ln (dα/dt) for α (reaction progress) is determined from a graph of the relationship between the reciprocal of each temperature and the logarithm of the reaction speed. This slope is the Ea (activation energy); the Ea for each α can be determined.

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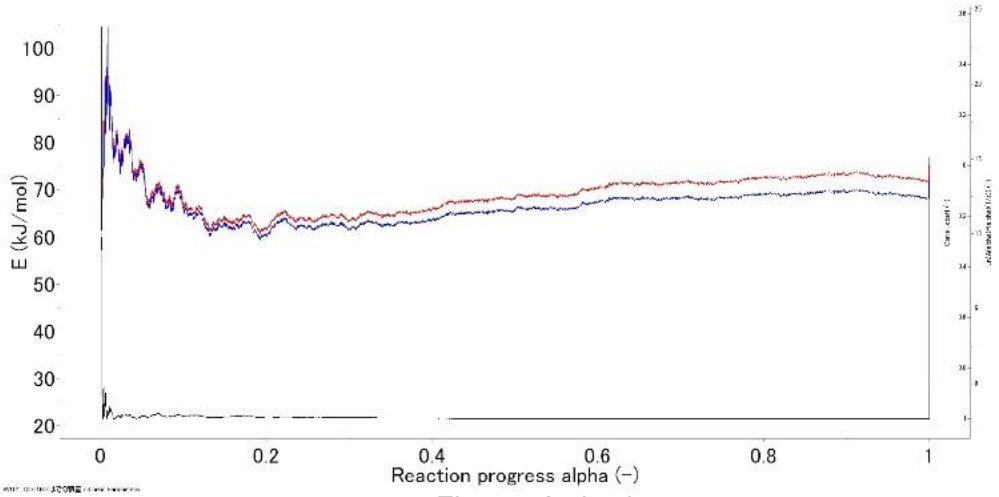

Fig. 5 Activation energy

The horizontal axis is the reaction progress from 0 to 1; in the first half of the reaction, the activation energy is high, but from 0.2 onwards, it stabilised at about 65kJ/mol.

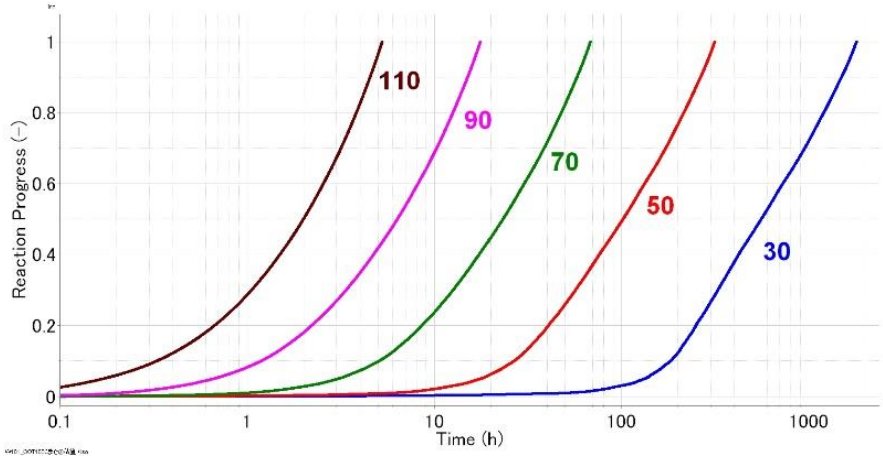

Fig. 6 Lifespan prediction

These are the lifespan predictions at constant temperatures (from 30°C to 110°C), calculated from these results. The vertical axis is reaction progress. Reaction progress 1 is when the integrated value for the amount of luminescence (CL) reaches 1.03E + E6 (the lifespan). From these results, we were able to predict the activation energy and lifespan by analysing the CL measurement results using AKTS Thermokinetics software.

This technique does not require acceleration testing, and the lifespan can be predicted rapidly using the initial samples.

Since the values calculated from the set range of the integrated values are different, it will be necessary to match the integration conditions when comparing with the actual lifespan or comparing between samples.

Samples supplied by: Petrochemicals Research Laboratory, Sumitomo Chemical Co., Ltd.