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Precision Universal Testing Machines AUTOGRAPH AGS™-V

Application News

Evaluation of the Temperature Dependency of Tensile Strength of Electrode Materials for Lithium-Ion Batteries

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User Benefits

- A thermostatic chamber makes it possible to measure the tensile strength in actual temperature environments.
- Pneumatic flat grips for foil make it possible to reduce the variation in grip force and stabilizing test conditions.
- By using a load cell with a wider accuracy guarantee range than a conventional one, it is possible to perform high-accuracy tests even with a small test force.

■ Introduction

Lithium-ion batteries play an important role in various electronic devices due to their high energy density and excellent charging efficiency. To improve battery performance, battery materials and processing methods are actively being developed. One of the evaluation methods for mechanical properties is strength measurement.

The metal (current collector) used in the electrodes of lithium-ion batteries is subjected to tensile force during the manufacturing process. Evaluation of temperature dependence is required because the metal is also subjected to heat during manufacturing.

This Application News introduces a workflow consisting of tensile strength evaluation of metal foil used as lithium-ion battery electrodes. The tests were performed under various temperatures to evaluate the temperature dependence of tensile strength. The apparatus used is also described.

■ Apparatus

Table 1 shows test apparatus configuration. In this experiment, Precision Universal Testing Machine AGS™-V was used and pneumatic flat grips for foil were mounted on it. These grips reduce the swing of the grip faces and their surfaces are processed into special shapes. This reduces the risk of fracture of the specimen at the clamped portion when testing a foil specimen. These pneumatic grips make it possible to mount specimens and to make the gripping force constant for each test.

To adjust the temperature of the test space, the Compact-type Thermostatic Chamber TCE-N300A was used. It can be operated by the testing machines operation software TRAPEZIUM™X-V. This software can control both the chamber and the testing machine in the same display. This function improves the system convenience.

Fig. 1 shows the overall appearance of test apparatus, and Fig. 2 shows the grips and a foil specimen.

Table 1 Test Apparatus

Testing Machine:	Precision Universal Testing Machines AGS-V
Load Cell Capacity:	500 N
Thermostatic Chamber:	Compact-type Thermostatic Chamber TCE-N300A
Software:	TRAPEZIUMX-V (Single)
Jig:	1 kN Pneumatic Flat Grips for Foil

■ Test Conditions

Table 2 shows specimen information and test conditions. In this experiment, 3 types of metals (A1N30, A1070, C1100) were tested. Temperature conditions were room temperature, 100 °C, and 180 °C.

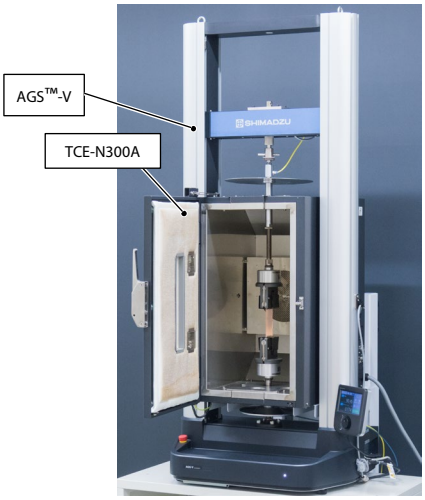

Fig. 1 Overall Appearance of Test Apparatus

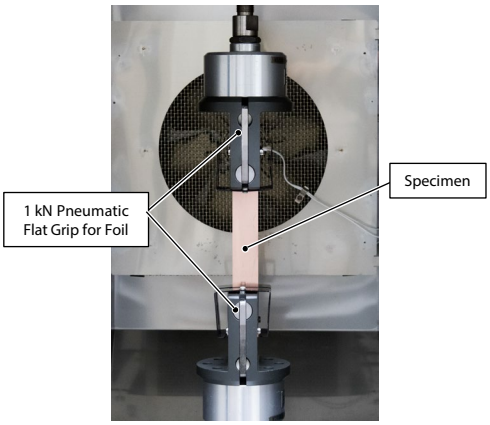

Fig. 2 Grips and Specimen

Table 2 Specimen Information and Test Conditions

Samples:	A1N30, A1070, C1100
Size (A1N30):	Thickness 0.020 mm, Width 25 mm Total Length 210 mm
Size (A1070):	Thisness 0.015 mm, Width 25 mm Total Length 210 mm
Size (C1100):	Thickness 0.016 mm, Width 25 mm Total Length 210 mm
Temperature:	Room Temperature, 100 °C, 180 °C
Test Speed:	10 mm/min
Disp. Origin:	0.5 N
Grip Distance:	100 mm
Number of Specimens:	3

■ Test Results

Table 3 and Table 4 show the test results, and Fig. 3 to Fig. 5 show the s-s curves. These curves show one representative specimen of the three. The solid line is at room temperature, the dotted line is at 100 °C, and the dash-dotted line is at 180 °C. The strain value was calculated using the distance between grips as the initial GL. The results shown in Table 3 and Figs. 3 to 5 show that the strength of all materials decreased as the temperature increased. As shown in Table 4, the elongation at failure of C1100 at 180 °C, and of A1N30 and A1070 at 100 °C and 180 °C tended to be larger than those at room temperature.

Table 3 Tensile Strength (Average of n = 3)

Temperature	A1N30	A1070	C1100
Room Temperature	179 MPa	146 MPa	499 MPa
100 °C	145 MPa	122 MPa	453 MPa
180 °C	102 MPa	89.1 MPa	134 MPa

Table 4 Strain at Failure (Average of n = 3)

Temperature	A1N30	A1070	C1100
Room Temperature	1.62 %	0.81 %	1.05 %
100 °C	2.36 %	1.22 %	1.01 %
180 °C	2.34 %	1.51 %	3.90 %

■ Conclusion

Tensile tests using the AGS-V were conducted on three kinds of metal foil used as electrodes in lithium-ion batteries in the thermostatic chamber TCE-N300A. The test results show that the strength tended to decrease with increasing the temperature in all materials. The elongation at failure tended to increase at 180 °C for C1100 and at 100 °C and 180 °C for A1N30 and A1070.

Pneumatic flat grips for foil make it possible to conduct tests without fracture nor slippage of the specimen at the clamped portion.

This measurement enables the temperature dependence of the mechanical characteristics of metal foil used as electrodes for lithium-ion batteries to be easily obtained. It is expected to be applied to solving problems such as material selection and processing methods for lithium-ion batteries.

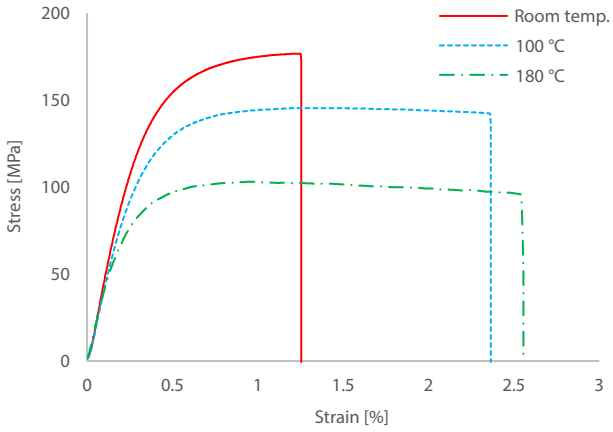

Fig. 3 Test Result (A1N30)

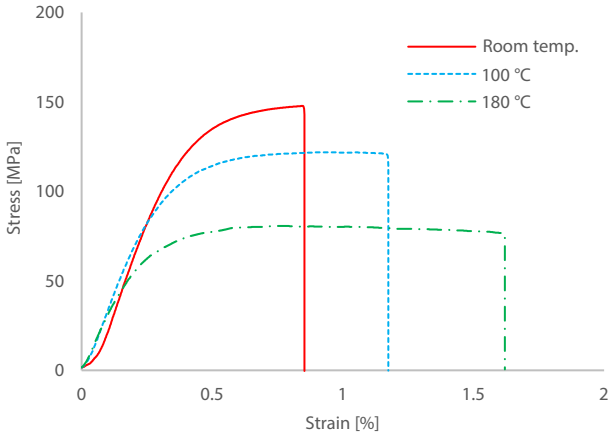

Fig. 4 Test Result (A1070)

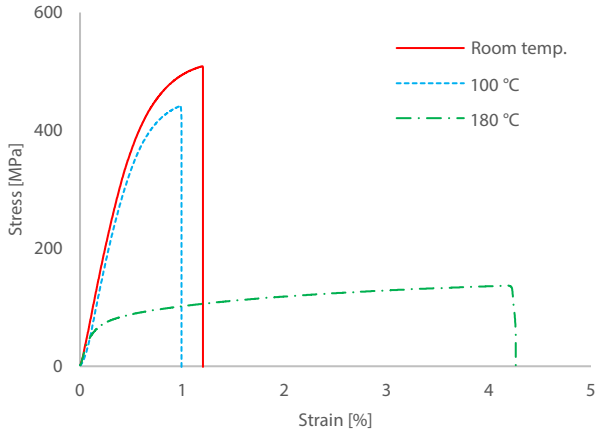

Fig. 5 Test Result (C1100)

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