Electrode Tortuosity Tester& Separator Ion Conductivity Tester

A Model and Parameters

Model	EIC1400K	EIC1400M	EIC2400K	EIC2400M
Channels number	4		4	
Auxiliary equipment	Glove box		No additional auxiliary equipment required	
EIS test range	1500~0.1 Hz	100k~0.01 Hz	1500~0.1 Hz	100k~0.01 Hz
Pressure range	10~50kg	10~50kg	10~50kg	10~50kg
Applicable samples	positive and negative electrodes	positive and negative electrodes、separator	positive and negative electrodes	positive and negative electrodes、separator
Mold Size	Φ60*61mm (W×H)		Φ45*20mm (W×H)	
Test parameters	ionic conductivity、MacMullin number		Air pressure, dew point, ionic conductivity, MacMullin number, etc.	
Features	◆ Testing of separator ionic conductivity and electrode MacMullin number under different pressures. ◆ The software interface displays test curves and allows for fitting of EIS curves to obtain parameters such as ionic conductivity and MacMullin number.		◆ Automatic ventilation to ensure a high-purity argon gas environment inside the chamber. ◆Automatic liquid injection ◆Assemble multi-channel symmetric batteries rapidly and test EIS. ◆The software interface displays test curves and can fit the EIS curve to obtain parameters such as ion conductivity and MacMullin number.	

Note: IEST is committed to continuous product improvement. Any changes to technical specifications will be made without prior notice.

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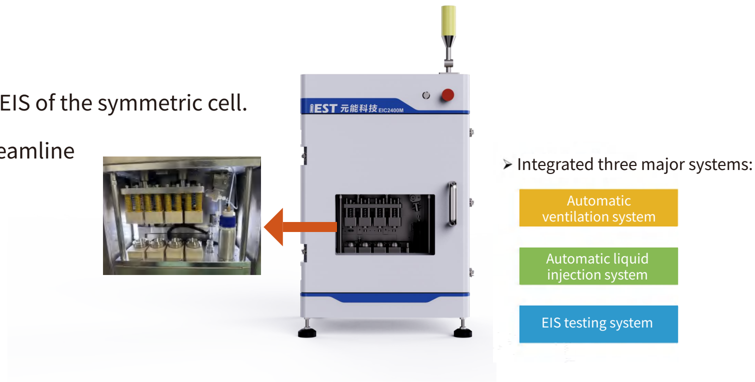
IEST 3 Major Business

- Special Testing Instruments
- Third-party Testing Service
- R&D Solutions

IEST Linkedin

B Creative Solution One



Creative Solution:

1.Calculate the MacMullin number of the electrode by testing the EIS of the symmetric cell.

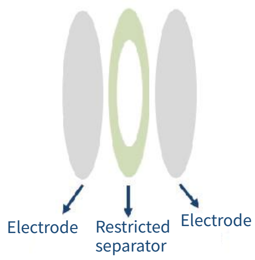
2.Simplify assembly, automate testing and analysis processes, streamline operation steps, and enhance testing efficiency.

3.Synchronous testing across four channels.

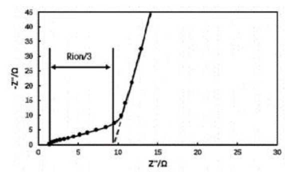
Testing Principle:

1. Assemble symmetric batteries and conduct EIS testing.
2. As shown in the figure below, linearly fit the high-frequency and low-frequency segments of the EIS spectrum separately. The difference between the intersection of the fitting curves and the X-axis multiplied by 3 is the ionic resistance of the electrode coating
3. Using the following formula, the MacMullin number can be calculated. This allows for the pre-evaluation of the electrochemical performance of the electrode after it is assembled into a cell. Therefore, characterization and comparison of the ionic conductivity of the electrode coating are particularly important.

Symmetric cell



Computing method of MacMullin number



(Test value) (Known value)

$$\tau = (R_{ion} \cdot A \cdot \varepsilon \cdot \sigma)/2d \quad \text{(MacMullin number) } N_m = \frac{k_{int}}{k} = \frac{\tau}{\varepsilon} \quad \frac{\text{(Tortuosity)}}{\text{(Porosity)}}$$

τ :Tortuosity

Rion:Ionic resistance

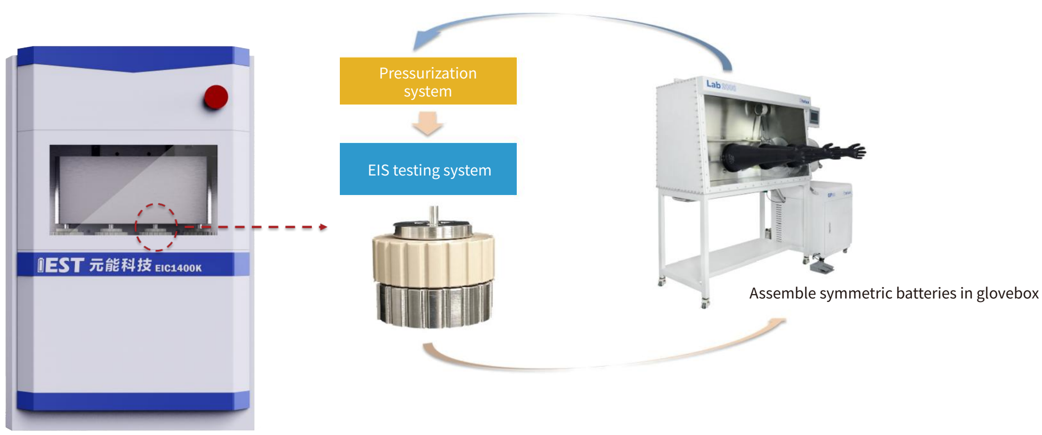
A :Electrode area

ε :Electrode porosity

σ :Electrolyte conductivity

d :Electrode thickness

C Creative Solution Two

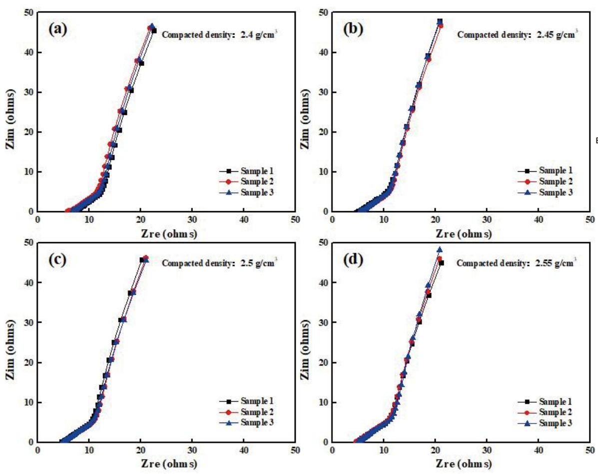


Multi-channel testing | Variable pressure testing | Fast EIS testing | Data fitting and analysis

D Application case

(1) Different compaction density of positive electrodes

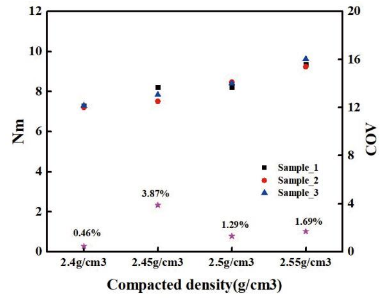
EIS spectra of positive electrodes with different compaction density(NCM)



$Nm = (R_{ion} \cdot A \cdot \sigma)/2d$

(Nm: MacMullin number R_{ion}: Ionic Resistance A: Electrode Area σ: Electrolyte Conductivity; d: Electrode Thickness)

MacMullin number of positive electrodes with different compaction density



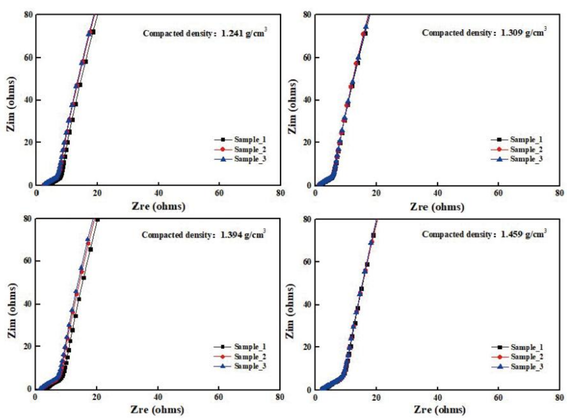
Summary:

① The consistency of EIS testing for symmetric battery of electrodes is generally good.

② Within a certain range of compaction density, as the compaction increases, the ionic resistance/MacMullin number also increases.

(2) Different compaction density of negative electrodes

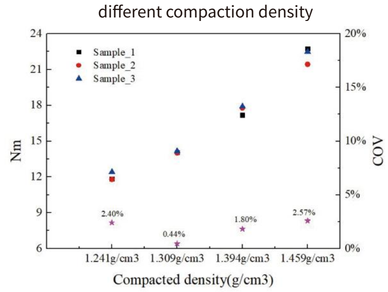
EIS spectra of negative electrodes with different compaction density (Gr)



$Nm = (R_{ion} \cdot A \cdot \sigma)/2d$

(Nm: MacMullin number R_{ion}: Ionic Resistance A: Electrode Area σ: Electrolyte Conductivity; d: Electrode Thickness)

MacMullin number of negative electrodes with different compaction density



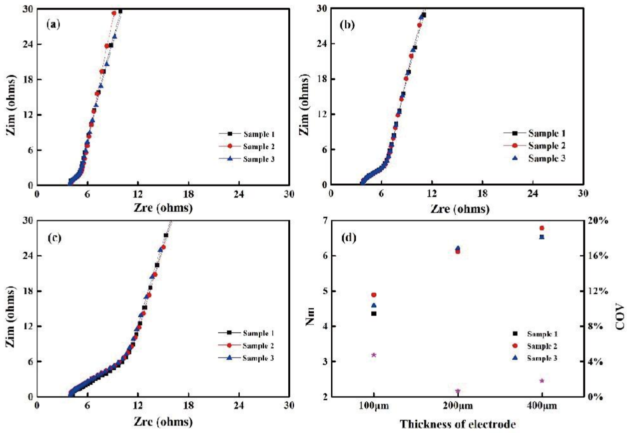
Summary:

① The consistency of EIS testing for symmetric battery of electrodes is generally good.

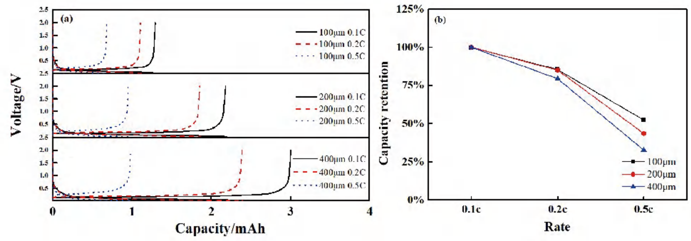
② Within a certain range of compaction density, as the compaction increases, the ionic resistance/MacMullin number also increases.

(3) The correlation between electrode tortuosity and electrochemical performance (Gr negative electrodes of different thicknesses)

Tortuosity testing of negative electrodes with different thicknesses

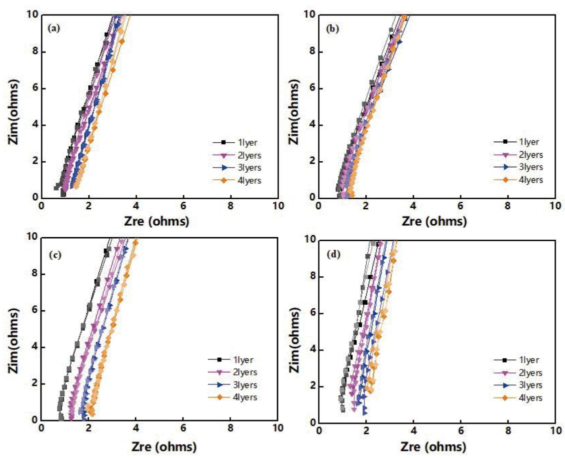


Rate performance testing

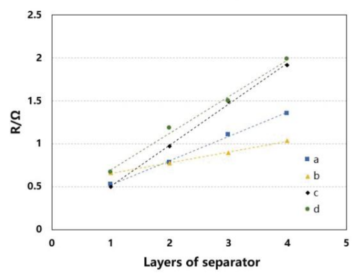


Summary: As the thickness of the electrode increases, its tortuosity also increases. However, the rate performance of the battery decreases with increasing thickness. This indicates that the rate performance of the battery decreases with increasing tortuosity. There is a certain correlation between electrode tortuosity and rate performance of battery.

(4) Different coated separators (Ionic conductivity testing of four different coated separator)



R-value fitting



$\sigma = d/(R*S)$

σ: Ionic conductivity

d: Membrane thickness

R: Resistance of single-layer separator

Separator	The fitting formula	R^2
a	y = 0.2804x + 0.2414	0.9969
b	y = 0.1234x + 0.5306	0.9976
c	y = 0.477x + 0.0273	0.9986
d	y = 0.4266x + 0.2661	0.9921

Separator	σ/ S/cm
a	0.0018
b	0.0048
c	0.0019
d	0.0014

Summary :

1、Test the EIS of 1-4 layers of separators to obtain R1, R2, R3, R4.

2、Plot a curve with the number of separator layers as the x-axis and separator resistance as the y-axis. Calculate the slope and linear fitting degree of the curve, with the linear fitting degree ≥0.99.

3、Calculate the separator ionic conductivity according to the formula.