UPTON GROUP

Flying with your Dream, Together! To be the best of yourself!

- Enterprise Introduction
- Cases Presentation

Enterprise Introduction

Upton Automation and Technology

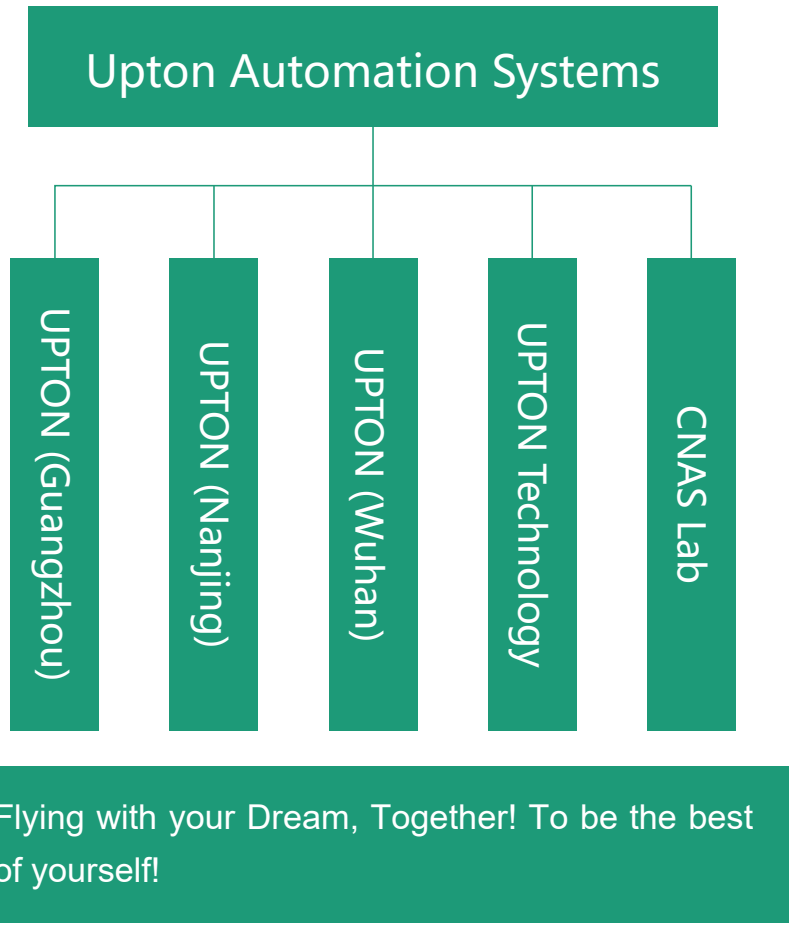
Upton Automation Systems Co., Ltd., established in 2005, is a high-tech intelligent equipment group enterprise mainly engaged in automated assembly and testing lines. We can provide complete solutions for Industry 4.0 and digital intelligent factories, and are a world-class supplier of assembly and testing solutions.

Our customers are mainly concentrated in the automotive industry. Since Upton establishment, we have successfully provided complete production line solutions for numerous automotive OEMs and component suppliers, becoming the best choice for domestic alternatives in the field of assembly and testing. At the same time, our products are also exported to Europe, America, and Southeast Asia.

The company has 11 authorized invention patents, more than 100 patent for utility model and more than 30 software copyrights currently.

Now has three factories, one CNAS laboratory and an annual revenue of more than 400 million yuan ($55 million).

In addition to providing complete industrial equipment and production lines, we also provide unique software services for major manufacturers, including a series of software products such as factory Manufacturing Execution Systems (MES), production scheduling, Andon, WMS, FMEA and production monitoring center.



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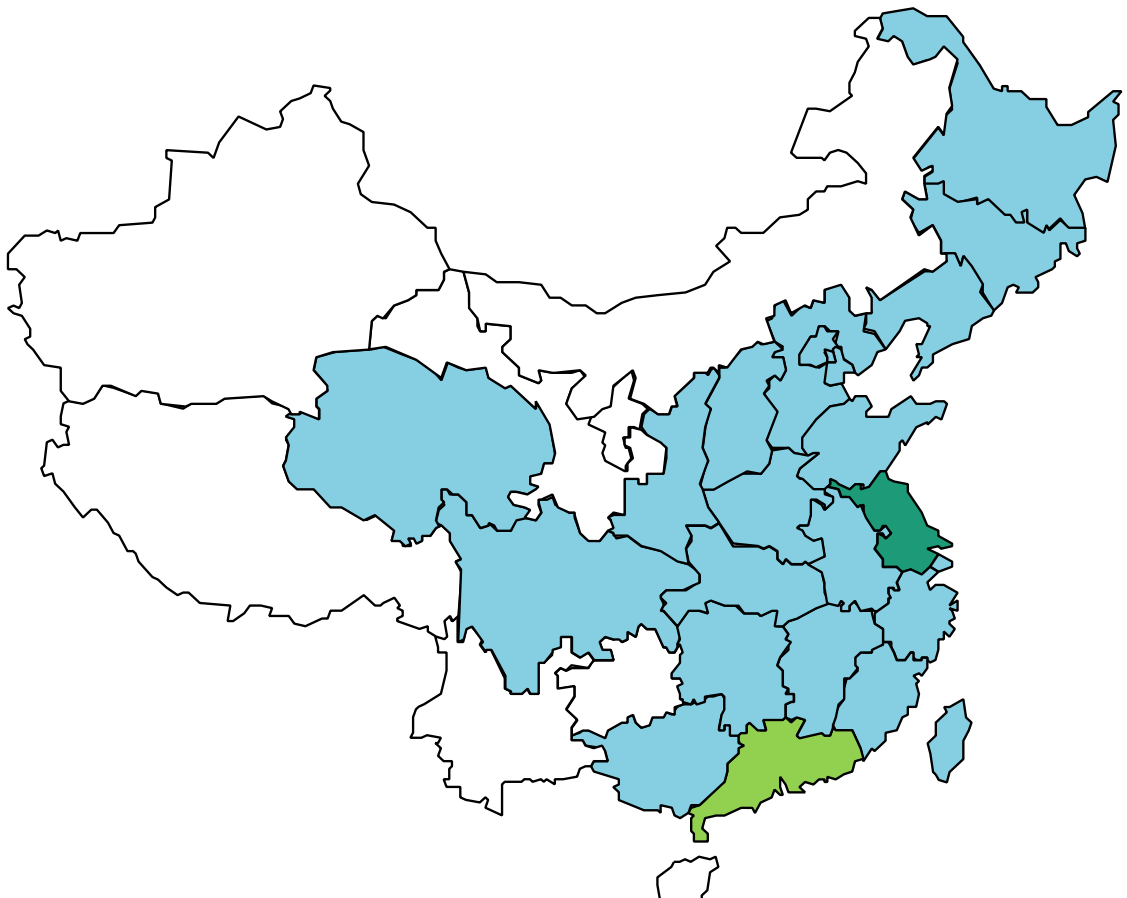
Factories Introduction

Upton Automation and Technology

Business Distribution

Upton Automation and Technology



Headquarters

Factory

Business area

Kun shan

Factory area: 17000m2 (Own factory)
Number of employees: 350+
Last year's output value: RMB280'000'000

Guang zhou

Factory area: 4000m2 (Lease)
Number of employees: 150+
Last year's output value: RMB120'000'000

Nan jing

Factory area: 11000m2 (Own factory)
Number of employees: 50+
Last year's output value: RMB30'000'000

Business Distribution

Upton Automation and Technology

Headquarters

Factory

Business area

Business Segments

Upton Automation and Technology

We have a research and development team of more than 100 people, which can meet the needs of many aspects of the factory.

Assembly and Test Production Lines	Function Test Equipment & Instruments	Software & MES Systems
Assembly and Test Line for Automobile Parts and Others	Leak/Pressure/Flow/Function Test	MES and Data Trace Systems

Business Categories

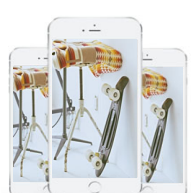
Upton Automation and Technology

Auto Parts

Engine

New Energy

Consumer Electronics



Furniture Industry

Manufacturing Execution System (MES)

MES

UPTON

Application of Leak Test for the Electrolyte of Battery by Gas Mass Spectrum Analyzer

V2.08

UPTON Automation Systems Co., Ltd.
UPTON Technology Co., Limited

DESIGN DEPT. : Marketing

Leak Test of the Electrolyte for the Battery

Upton Automation and Technology

CATALOGUE

1. Application Background
2. Solutions
3. Technology and Principle
4. Application Scenario
5. Tested Products
6. Our Products
7. Tester Performance
8. Core Competitiveness
9. Other Instruments
10. Terms

Leak Test of the Electrolyte for the Battery

Upton Automation and Technology

1. Application Background

1.1 Defects of Current Methods

Currently, there are two traditional methods used for electrolyte leak test of battery, one is VOC method, other is helium mass spectrometry method.

The common problem with VOC method is that the test results are very unstable. It has high environmental requirements, and is often interfered with by non electrolyte VOC gases, and leading to misjudgment.

Disadvantages of VOC in the application:

- It is susceptible to interference from other VOC gases (such as alcohol) and easy to cause misjudgment.
- Due to testing conditions, VOC substances may deposit and be difficult to remove.
- Pure air is needed to reduce interference and misjudgment.
- High requirements for testing environment.
- Standard gas samples are often needed to calibrate instruments.

The helium mass spectrometry test method requires pre-pressurizating with helium into the inside of cell (or pre-filling the cell with helium). However, due to the helium bubble is light, it may rise to the upper part of the electrolyte, and the leak in the bottom of the cell may not be tested.

Leak Test of the Electrolyte for the Battery

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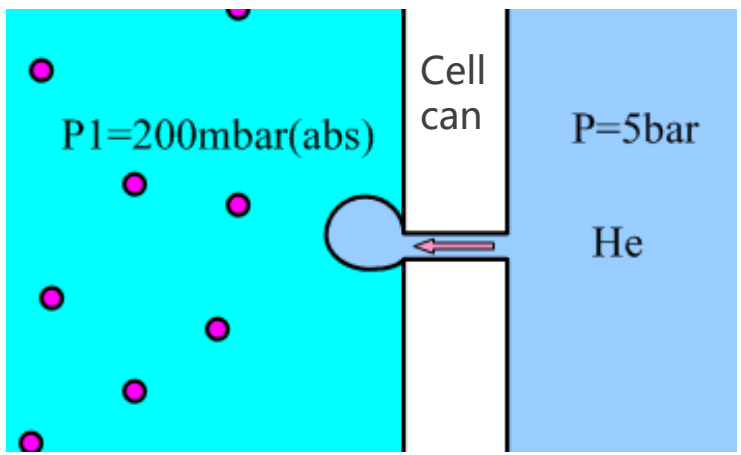
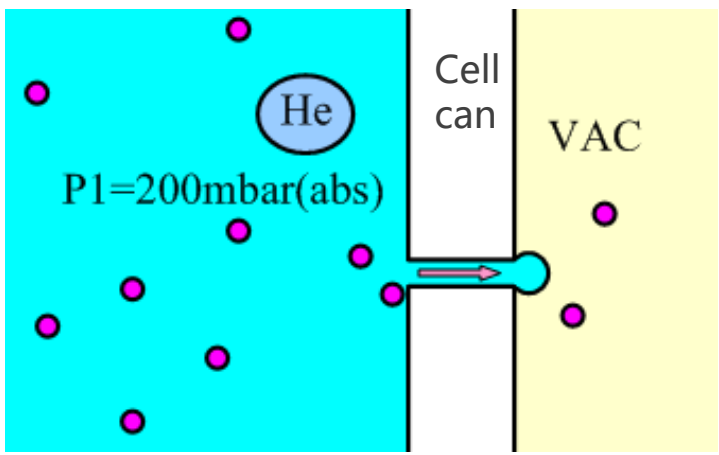
1. Application Background

1.2 Disadvantages of Helium Mass Spectrometry Leak Test



1) The usual helium leak test involves pre-pressurizing helium into the cell (or pre-filling) before testing.



2) Due to helium is light, it generally exists in the upper part of the electrolyte, If there is a leak in the bottom of cell, it can not be detected by helium mass spectrometer.

Leak Test of the Electrolyte for the Battery

Upton Automation and Technology

1. Application Background

1.3 Failure Analysis of Helium Mass Spectrometry Leak Test

- For severe leak cells, helium be pressurized or filled can be leaked out quickly from it. At this point, there is no helium present when testing.
- Due to the effect of surface tension, there is the electrolyte blocking the hole(such as the location of the injection port of cell), and helium gas cannot leak out.
- Helium is relatively light and will concentrate on the upper part of the electrolyte, and there will be no helium be leaked from the hole in the bottom.

2. Solutions

Solutions for Gas Analyzers (RGAs)

The MSQ1000 based on mass spectrometry sensor solves these problems perfectly!

Firstly, charge the sample gas molecules by ionizing them. When charged ions pass through the mass separator, only useful target ions are fed into the receiver, which greatly improves anti-interference performance!

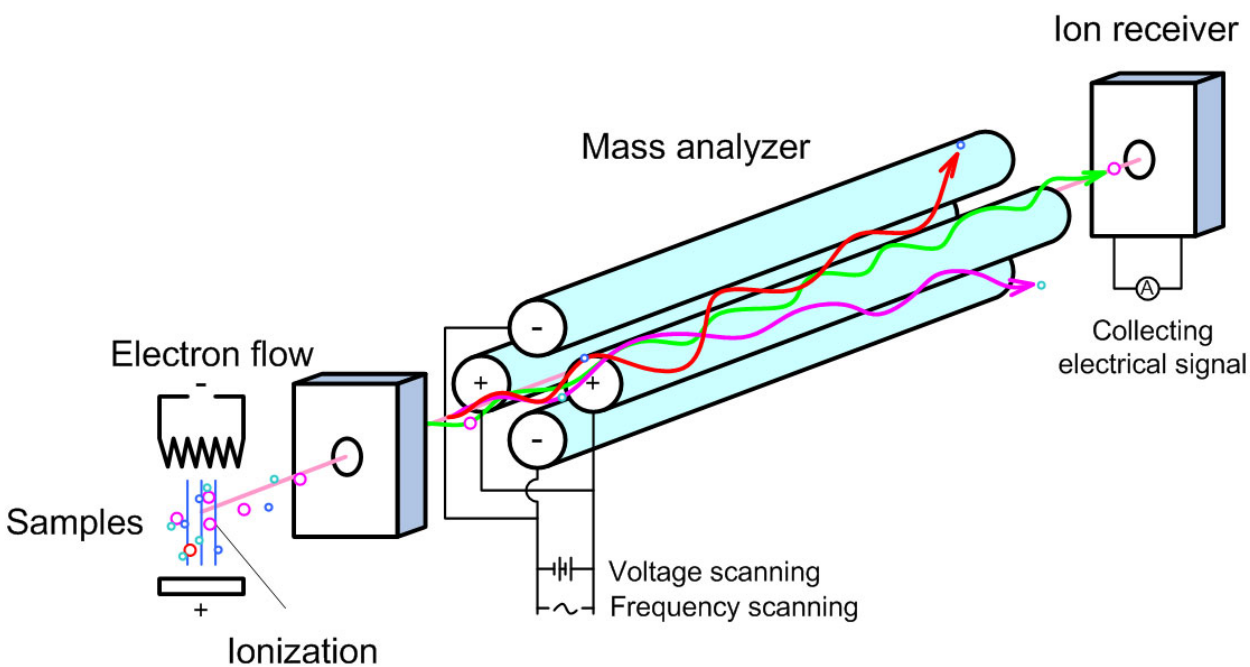
In other words, mass spectrum analyzer is used to analyze gas components, which means that substances with a mass number of 1 to 100 can be all scanned by instrument. You can test whichever you care about, or you can skip scanning for those you don't care about.

For example, assuming we want to detect the light, VOC says:" there is the light coming, and the intensity is ..." But the Mass Spectrometer says:" the light is coming, the colors are..., the order is..., the intensity of each color is..., which color or colors of light do you want to test? I can ignore the rest!"

Mass number=Molecular weight/charge number.

3. Technology and Principle

3.1 The Principle of Mass Spectrum Analysis

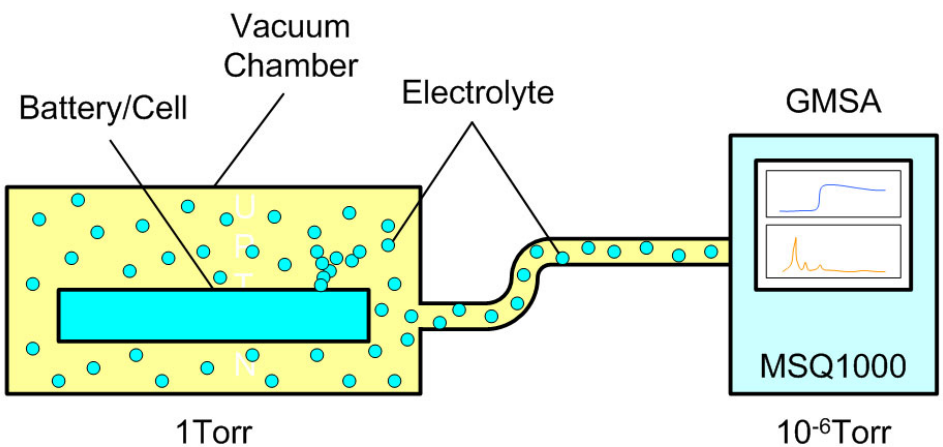


Leak Test of the Electrolyte for the Battery

Upton Automation and Technology

3. Technology and Principle

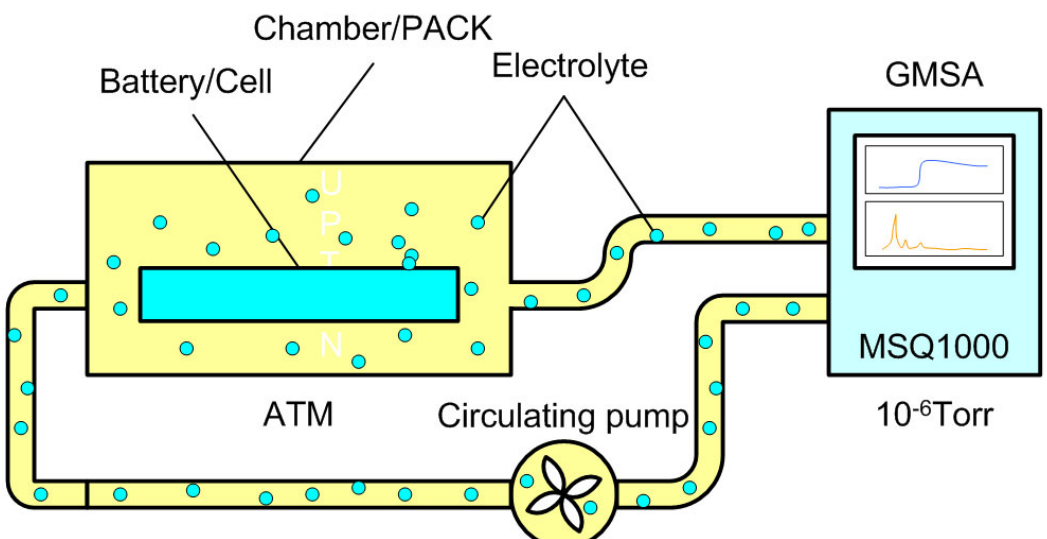
3.2 The Schematic Diagram of Test Method I



Hard Vacuum Method

3. Technology and Principle

3.3 The Schematic Diagram of Test Method II



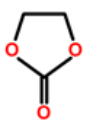
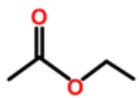
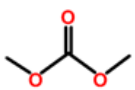
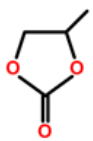
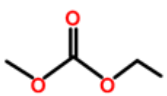
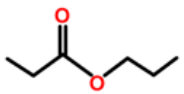
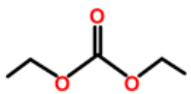
Circulating Method

Leak Test of the Electrolyte for the Battery

Upton Automation and Technology

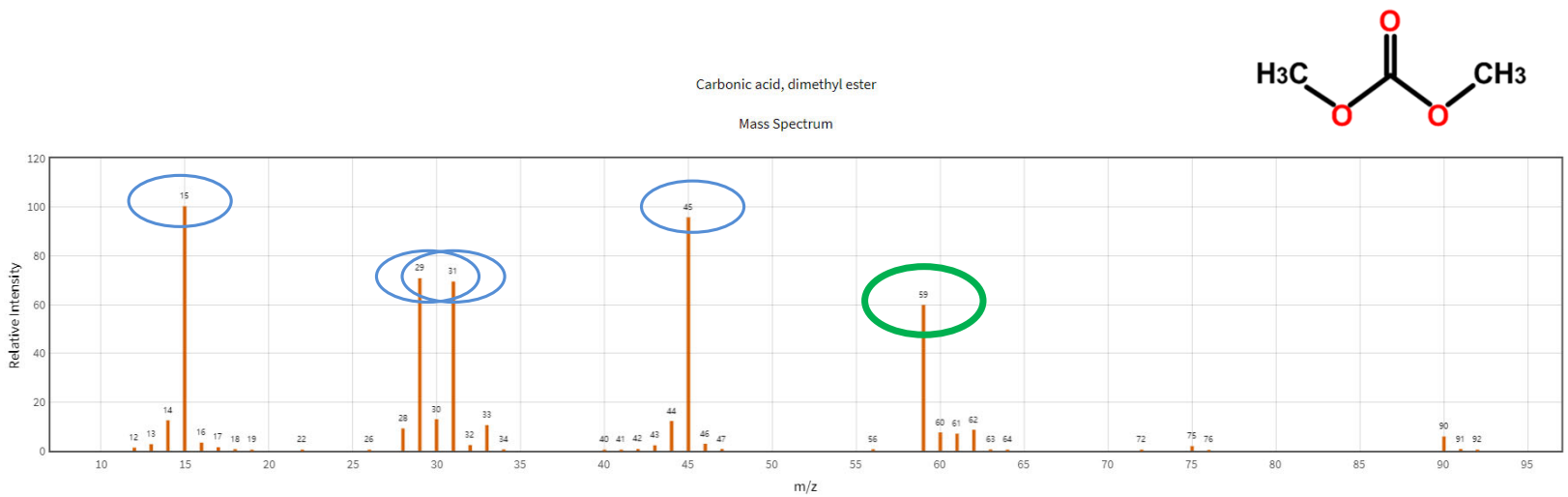
3. Technology and Principle

3.4 Typical Electrolyte

						
$EC=C_3H_4O_3$	$EA=C_4H_8O_2$	$DMC=C_3H_6O_3$	$PC=C_4H_6O_3$	$EMC=C_4H_8O_3$	$PP=C_6H_{12}O_2$	$DEC=C_5H_{10}O_3$
88	88	90	102	104	116	118
0.21mbar@20℃	96.9mbar@20℃	53mbar@20℃	0.04mbar@20℃	43mbar@20℃	14mbar@20℃	13mbar@20℃
Ethylene Carbonate	Ethyl Acetate	Ethyl Acrylate	Propylene Carbonate	Ethyl Methyl Carbonate	Propyl Propionate	Diethyl Carbonate

3. Technology and Principle

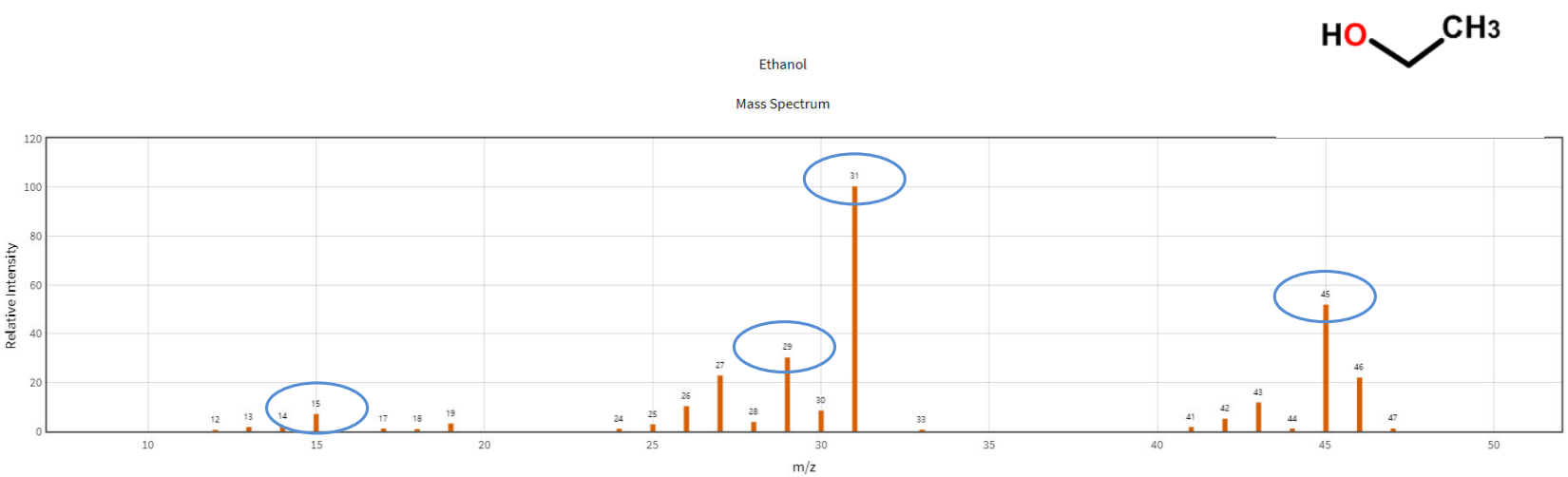
3.5 Typical Mass Spectrum (DMC, Mw=90, Dimethyl Carbonate, $C_3H_6O_3$)



The sample is ionized (EI source) to generate charged fragments. Different substances have different characteristics peak, so spectrum analyzer is not disturbed. Through the analysis of electrolyte composition and the evaluation of interference peaks, the characteristic peak of 59amu(DMC) was selected, and leak test can be carried out now.

3. Technology and Principle

3.6 Other Mass Spectrum (Ethanol, Mw=46, C_2H_6O)



In the spectrum of ethanol (alcohol), there are many peaks that are the same as DMC, especially those with small mass numbers. Therefore, it is necessary to choose peaks with large mass numbers and strong anti-interference ability as the characteristic peaks for testing.

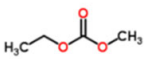
3. Technology and Principle

3.7 More Electrolyte Mass Spectrum

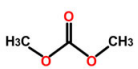
Mass Spectrum (EC=Ethylene Carbonate, Mw=88, $C_3H_4O_3$)

1,3-Dioxolan-2-one

(EMC=Ethyl Methyl Carbonate, Mw=104, $C_4H_8O_3$)

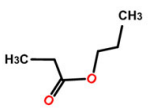


Mass Spectrum (DMC=Dimethyl Carbonate, Mw=90, $C_3H_6O_3$)



Carbonic acid, dimethyl ester

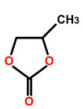
(PP=Propyl Propionate, Mw=116, $C_6H_{12}O_2$)



Propanoic acid, propyl ester

Mass Spectrum

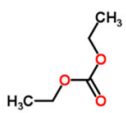
Mass Spectrum (PC=Propylene Carbonate, Mw=102, $C_4H_6O_3$)



Propylene Carbonate

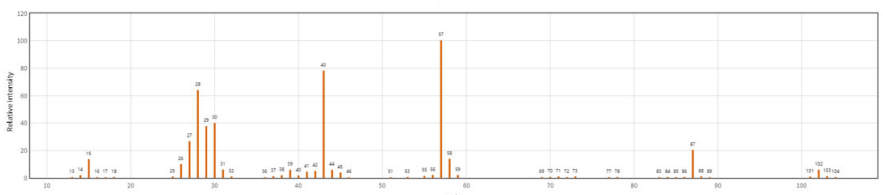
Mass Spectrum

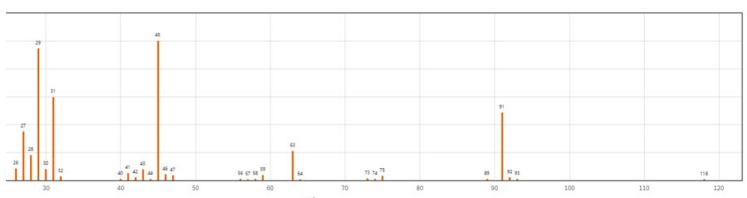
m (DEC=Diethyl Carbonate, Mw=118, $C_5H_{10}O_3$)



Diethyl carbonate

Mass Spectrum





3. Technology and Principle

3.8 How to select the characteristic peak for target signal

When a cell with unknown electrolyte composition is obtained, the following steps should be followed for analysis and verification:

Firstly, insulate the battery or cell (very important!! Especially the tabs!!).

Secondly, remove a certain amount of electrolyte from the tested cell and prepare for testing to find characteristic peaks.

Thirdly, place the electrolyte in a vacuum chamber, and insure vacuum high enough, use MSQ1000 scanning the mass number from 1 to 100, and record these characteristic peaks values.

Fourthly, confirm the target characteristic peaks. Analyze characteristic peaks and select appropriate characteristic peaks as test target peaks, and then setup the instrument.

Fifth, test these cells, compare and analyze data with the result of Leak Standard, determine approximate judgment criteria, and subsequently verify and adjust.

Finally, when testing the PACK, pay attention to analyzing the high-risk substances in the testing system that may cause misjudgment, such as alcohol, coolant, cleaning agents, etc..

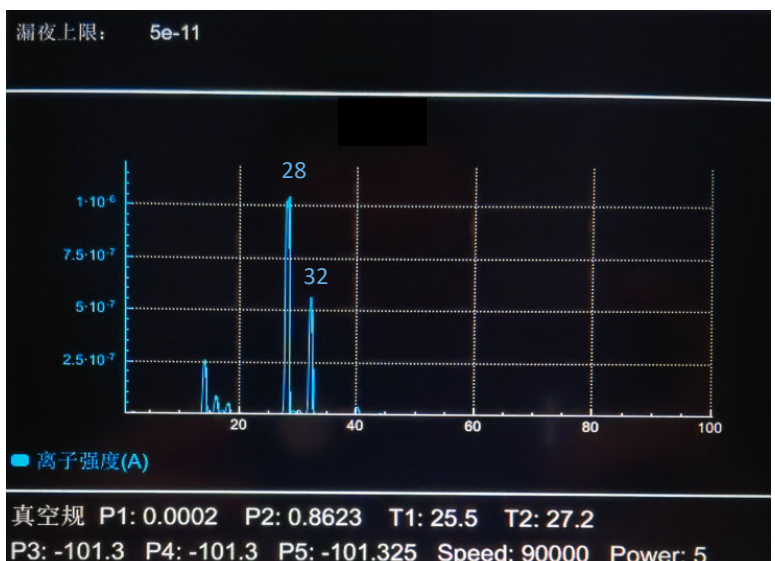
Attention: The test was conducted under high vacuum, please confirm that there will be no additional quality issues with the battery or cell under this condition!!

Leak Test of the Electrolyte for the Battery

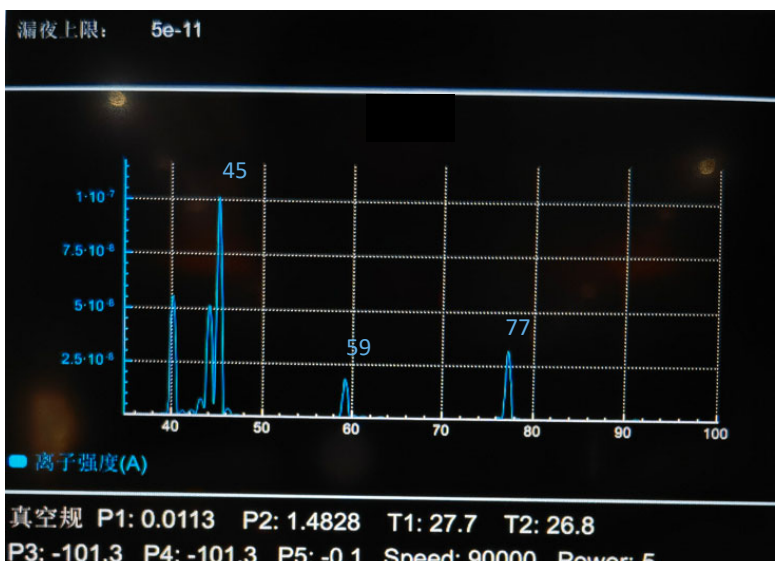
Upton Automation and Technology

3. Technology and Principle

3.8 How to select the characteristic peak for target signal



Scanning from 1 to 100 amu



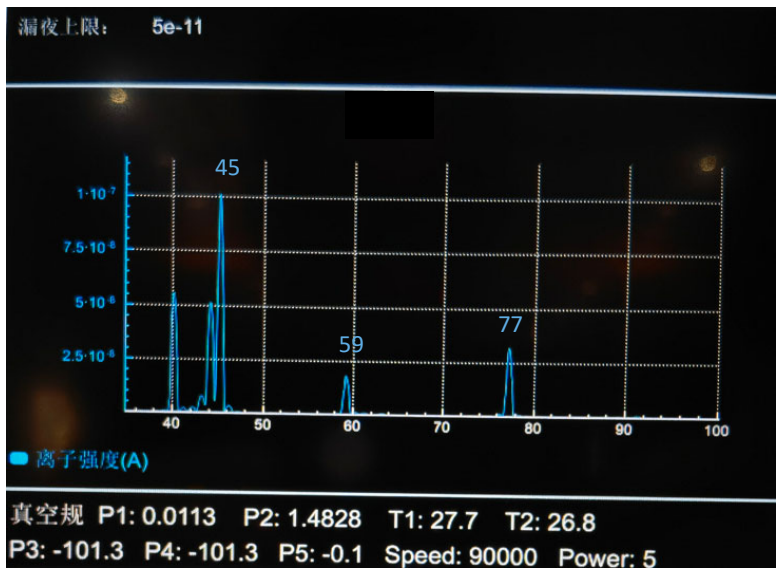
Scanning from 35 to 100 amu

Leak Test of the Electrolyte for the Battery

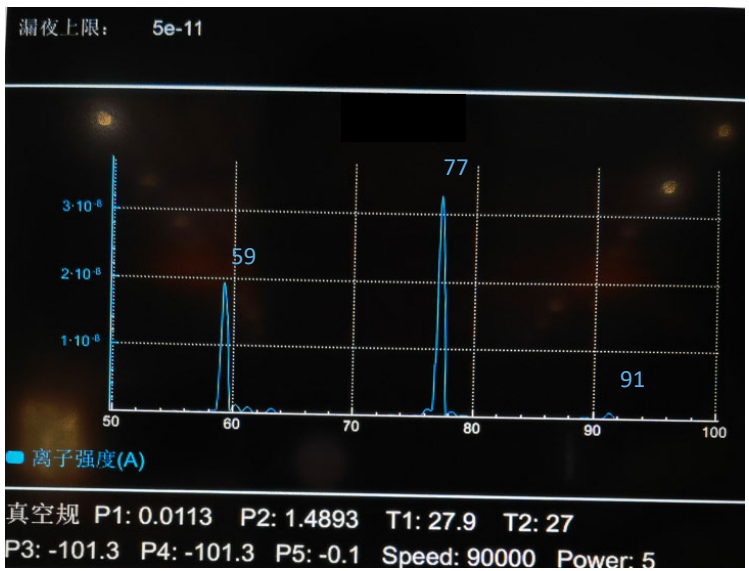
Upton Automation and Technology

3. Technology and Principle

3.8 How to select the characteristic peak for target signal



Scanning from 35 to 100 amu



Scanning from 50 to 100 amu

3. Technology and Principle

3.9 The relationship between helium leak rate and hole diameter

$$Ql = \frac{\pi}{16} * r^4 * \frac{(p_1^2 - p_2^2)}{\eta * l * p_2}$$

- The leak rate is proportional to r^4.
- The leak rate depends on the pressure difference. External pressure (vacuum)=5mbar (absolute). Internal pressure (internal pressure of the cell)=200mbar (absolute).
- The leak rate depends on the length of the hole, starting from 100μm (foil) to 3mm (thin metal).

Leak Test of the Electrolyte for the Battery

Upton Automation and Technology

3. Technology and Principle

3.9 The relationship between helium leak rate and hole diameter

Pouch Cell：

Internal Pressure=200mbar
Wall Thickness=150μm

Min detectable leakage rate
(Equivalent helium leak rate)
=1.0E-6mbar.l/s

Hole Diameter=2.8μm

Min detectable leakage rate
(Equivalent helium leak rate)
=1.0E-7mbar.l/s

Hole Diameter=1.6μm

Pouch Cell：

Internal Pressure=200mbar
Wall Thickness=150μm

Min detectable leakage rate
(Equivalent helium leak rate)
=1.31E-5mbar.l/s

Hole Diameter=5.4μm

Attention: The leak standard with pure DMC!

Pouch Cell：

Internal Pressure=200mbar
Wall Thickness=150μm

Min detectable leakage rate
(Equivalent helium leak rate)
=1.31E-4mbar.l/s

Hole Diameter=9.6μm

3. Technology and Principle

3.9 The relationship between helium leak rate and hole diameter

Prismatic Cell:

Internal Pressure=800mbar
Wall Thickness=2mm

Min detectable leakage rate
(Equivalent helium leak rate)
=1.0E-6mbar.l/s

Hole Diameter=2.7μm

Min detectable leakage rate
(Equivalent helium leak rate)
=1.0E-7mbar.l/s

Hole Diameter=1.5μm

Prismatic Cell:

Internal Pressure=800mbar
Wall Thickness=2mm

Min detectable leakage rate
(Equivalent helium leak rate)
=1.31E-5mbar.l/s

Hole Diameter=5.1μm

Attention: The leak standard with pure DMC!

Prismatic Cell:

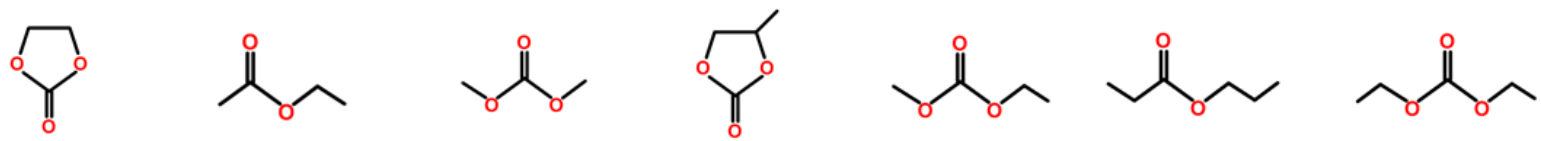
Internal Pressure=800mbar
Wall Thickness=2mm

Min detectable leakage rate
(Equivalent helium leak rate)
=1.31E-4mbar.l/s

Hole Diameter=9.2μm

3. Technology and Principle

3.10 Saturated Vapour Pressure and Vacuum

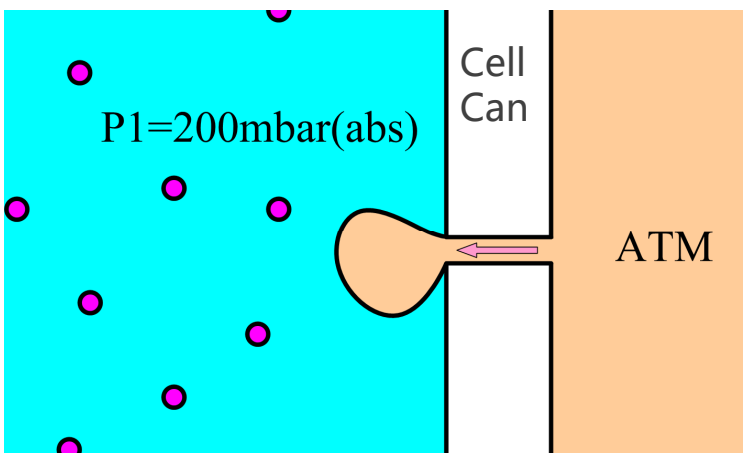


EC=$C_3H_4O_3$	EA=$C_4H_8O_2$	DMC=$C_3H_6O_3$	PC=$C_4H_6O_3$	EMC=$C_4H_8O_3$	PP=$C_6H_{12}O_2$	DEC=$C_5H_{10}O_3$
Ethylene Carbonate	Ethyl Acetate	Dimethyl Carbonate	Propylene Carbonate	Ethyl Methyl Carbonate	Propyl Propionate	Diethyl Carbonate
88	88	90	102	104	116	118
0.21mbar@20℃	96.9mbar@20℃	53mbar@20℃	0.04mbar@20℃	43mbar@20℃	14mbar@20℃	13mbar@20℃

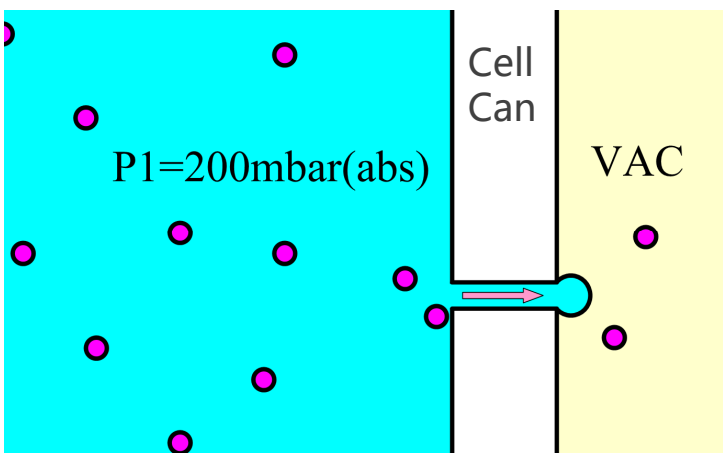
From the saturated vapor pressure (at 20 ℃) mentioned in the appeal, it can be seen that the vacuum must be sufficient high than the internal pressure of the cell, in order to allow the electrolyte into vacuum chamber and full volatilization, thereby improving the detection ability and effectiveness.

3. Technology and Principle

3.10 Saturated Vapour Pressure and Vacuum



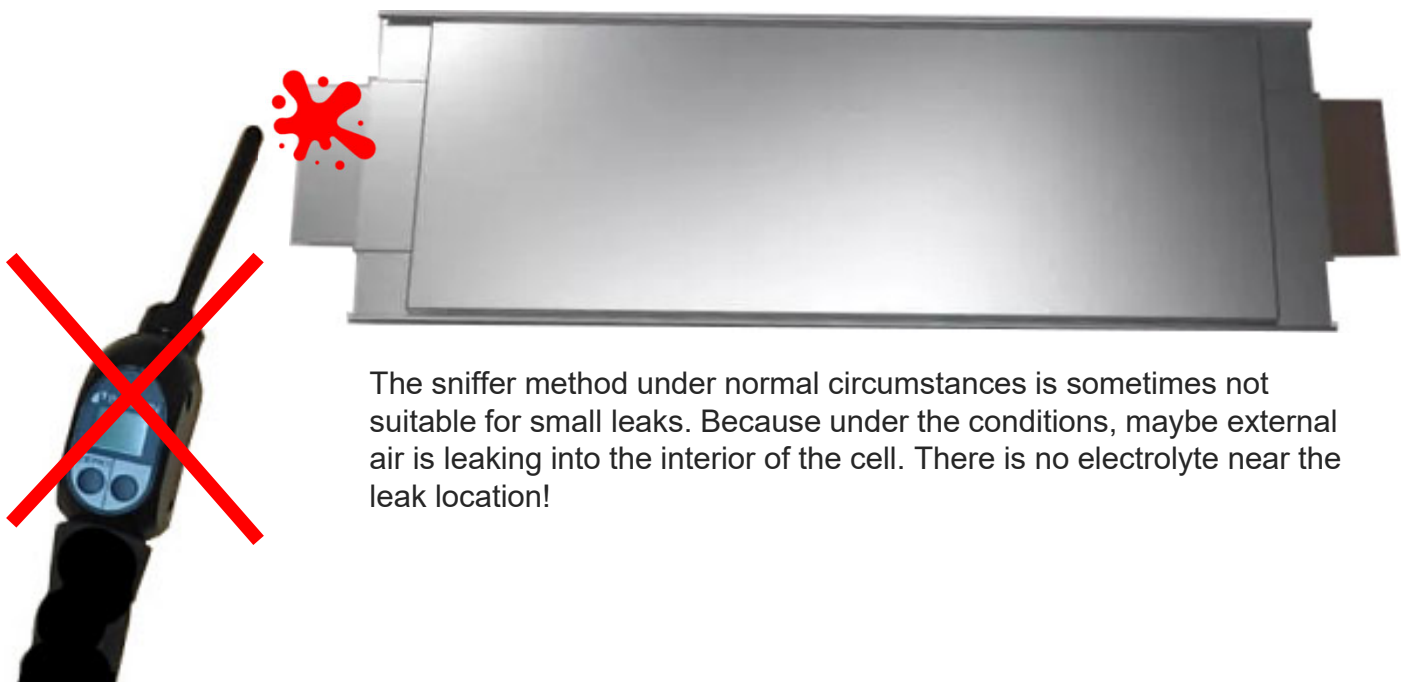
1) Under normal circumstances, the internal pressure of the cell is lower than atmospheric pressure. At the beginning, the external air leaks into the interior of the cell through the hole.



2) When we test under vacuum, the internal electrolyte leaks into the vacuum through the hole.

3. Technology and Principle

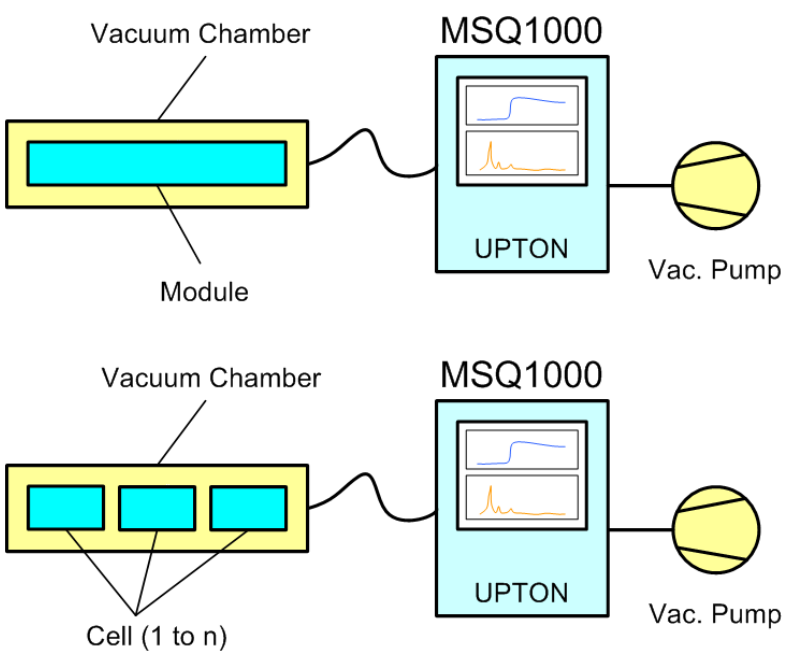
3.10 Saturated Vapour Pressure and Vacuum



The sniffer method under normal circumstances is sometimes not suitable for small leaks. Because under the conditions, maybe external air is leaking into the interior of the cell. There is no electrolyte near the leak location!

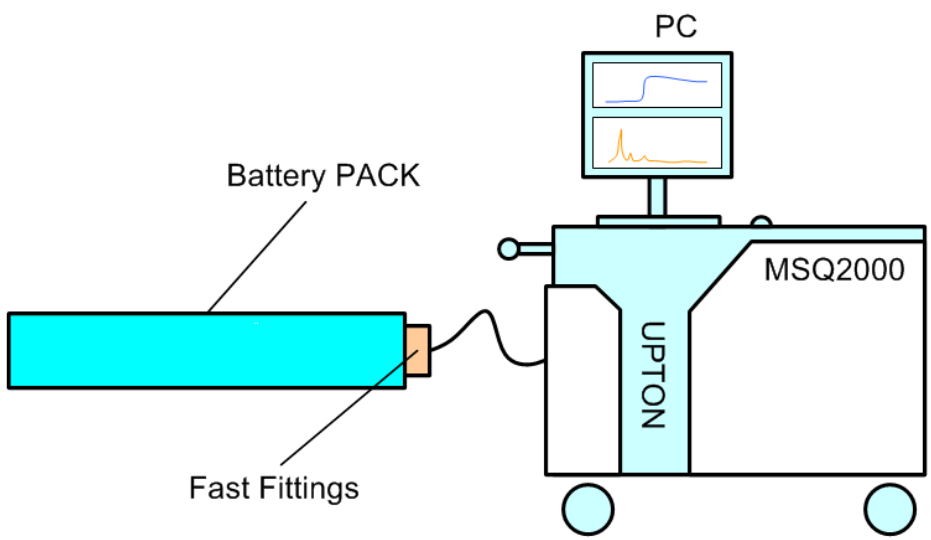
4. Application Scenario

4.1 Application Scenario I-Vacuum Chamber Mode



4. Application Scenario

4.2 Application Scenario II- Non Vacuum Chamber Mode



4. Application Scenario

4.3 Application Process

- Incoming inspection of the cell, such as pouch cell, prismatic cell, or cylindrical cells. The high vacuum mode can be used.
- Battery Module testing: Generally the battery module is not very large. The high vacuum mode can be used.
- The PACK before installing upper cap. The high vacuum or circulating method can be used. The advantage of this process is that if any leakage is found, it is more convenient for check and repair.
- The Pack before filling it with glue, it is determined to use the high vacuum mode, the circulating mode, or composite mode based on the pressurization of the battery pack.
- The PACK testing (before leaving factory). The circulating method can be used.
- The PACK testing (before it be used). The circulating method can be used.
- The PACK testing(after it be repaired). The circulating method can be used.

4. Application Scenario

4.4 The core of the application of leak test of the electrolyte

For the application of electrolyte leak testing, there are two key points:

- **Whether it is beneficial for the volatilization out of electrolyte**. So, to create all conditions for the volatilization of the electrolyte, such as high vacuum conditions.
- **Whether the electrolyte can reach the tester smoothly and quickly**. For example, to increase the diameter of the test pipeline, to circulate the air with the electrolyte inside the PACK.

Do our best to meet these two conditions!!

Leak Test of the Electrolyte for the Battery

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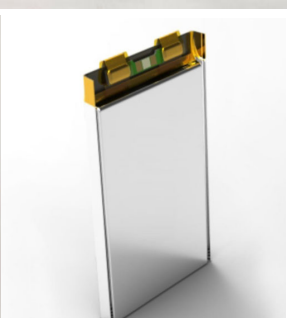
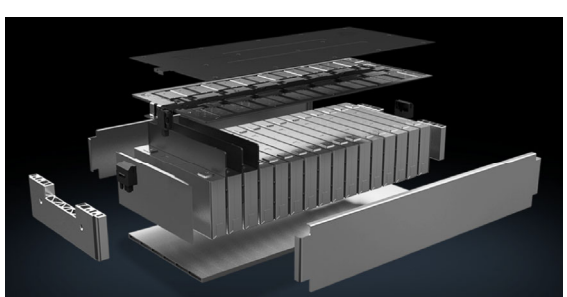
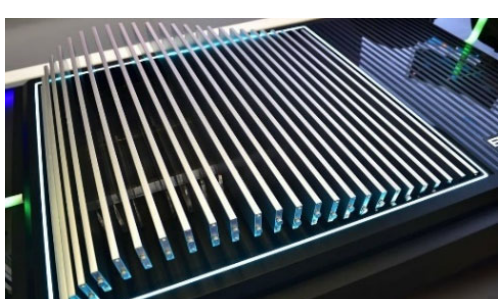
5. Tested Products

5.1 Tested Products-Cell (Pouch, Cylindrical, Prismatic Cell), Module, PACK







Leak Test of the Electrolyte for the Battery

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5. Tested Products

5.2 Other Tested Products-The Electrolytic Capacitor

Leak Test of the Electrolyte for the Battery

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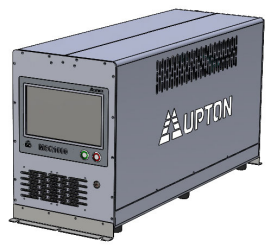
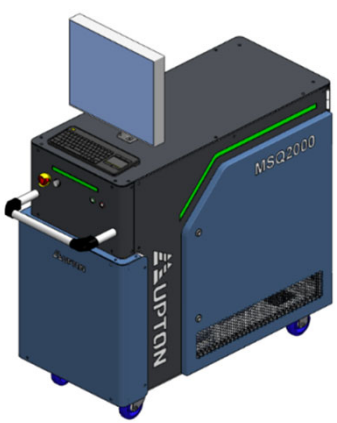
6. Our Products

Mass Spectrometer Family: MSQ=Mass Spectrometer Q Series

- MSQ1000 Series
  Standard instrument composed of MS core module + sampling system.
- MSQ2000 Series
  A customized test system consisting of MSQ1000 + external test system + backing pump + auxiliary pump + movable vehicle.
- TC01/02/05/10=10L/ (Empty=rigid test chamber + F=flexible test chamber), TC=Test Chamber
- D-MASTER, D=DMC, Model DM05=DMC leak rate 1.xE-05mbar.l/s.



MSQ1000



MSQ2000

Leak Test of the Electrolyte for the Battery

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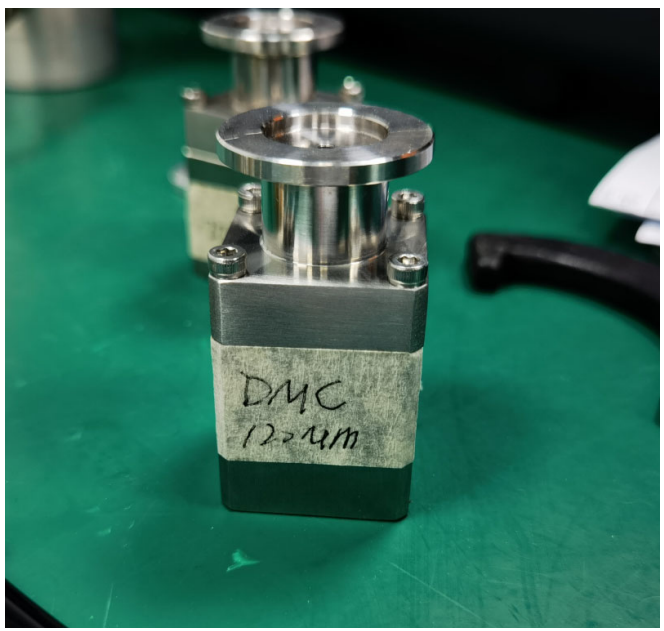
6. Our Products

6.1 Leak Standard-D-MASTER Series

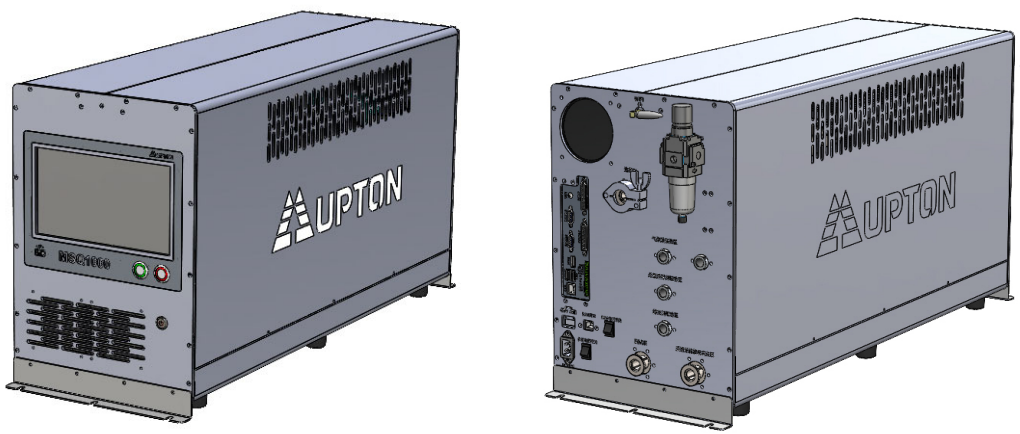
Leak Standard Plate (Permeable type)
(DMC, ≈5μm, 1.xE-5mbar. l/s)



Leak Standard (Channel type)
(DMC, 120microns hole)

6. Our Products

6.2 Standard Instrument-MSQ1000 Series



MSQ1000 Gas Mass Spectrum Analyzer (GMA)

Leak Test of the Electrolyte for the Battery

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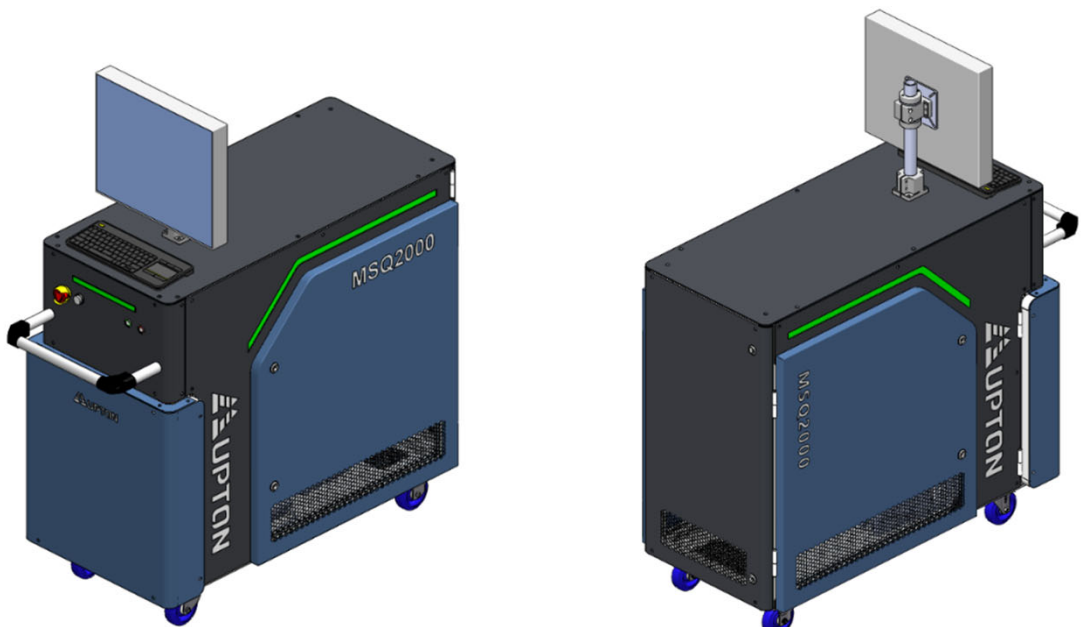
6. Our Products

6.3 Standard Equipment-MSQ2000 Series



MSQ2000 Movable Test Equipment for PACK

Leak Test of the Electrolyte for the Battery

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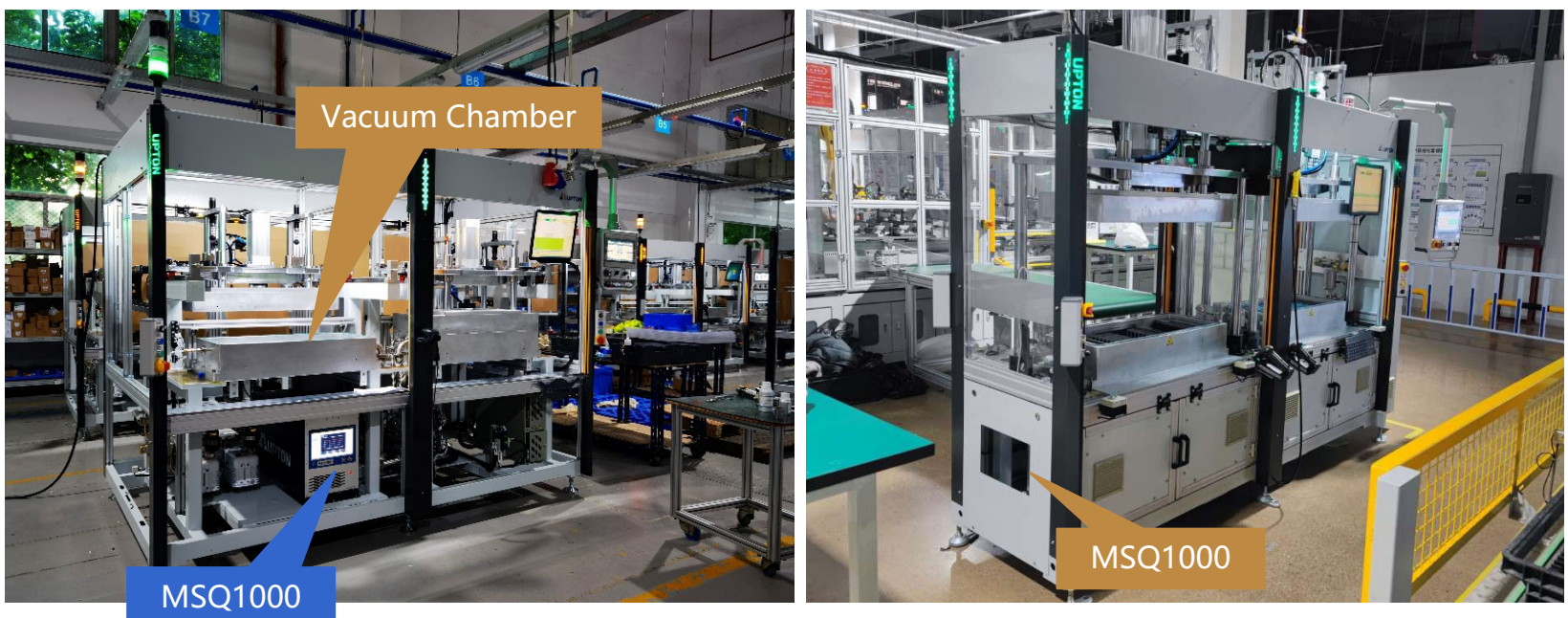
6. Our Products

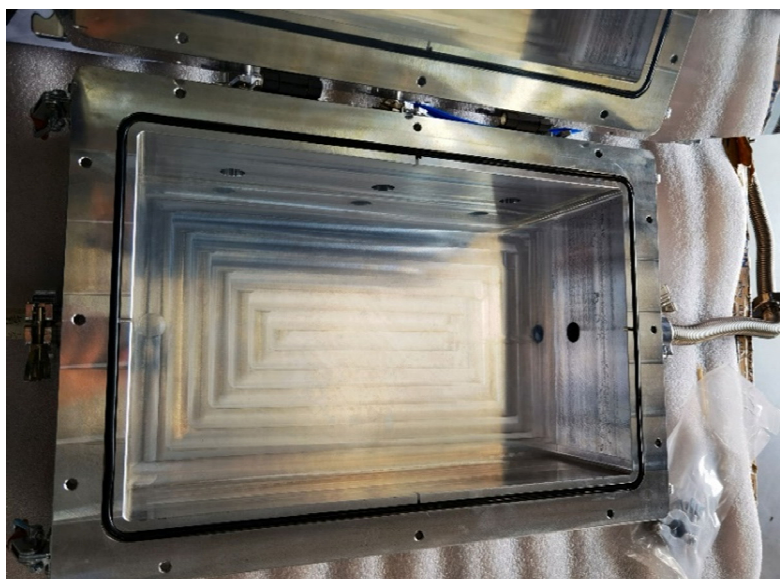
6.4 Custom Equipment-Cell/Module Test Equipment



The Electrolyte Leak Test Equipment with MSQ1000

6. Our Products

6.5 Standard Instrument-Test Information



Vacuum chamber(10.5litres), Empty

Vacuum chamber (10.5litres) + Leak Standard Plate
(Leak rate=1.xE-5mbar.l/s)

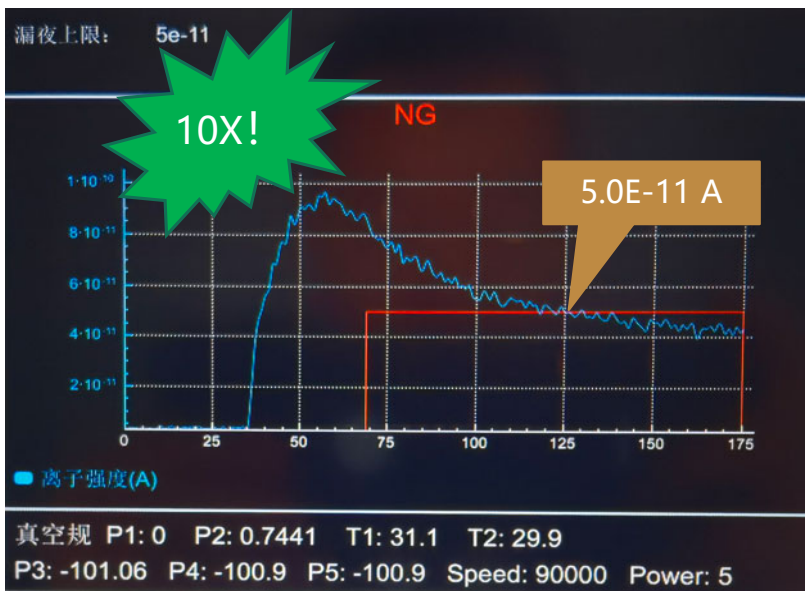
Leak Test of the Electrolyte for the Battery

Upton Automation and Technology

6. Our Products

6.5 Standard Instrument-Test Information

Vacuum chamber(10.5litres), Empty



Vacuum chamber (10.5litres) + Leak Standard Plate
(Leak rate=1.xE-5mbar.l/s)

7. Tester Performance

6.5 Standard Instrument-Test Information

Performance Parameter	Description
Min detectable leak rate	< 1.0E-7mbar.l/s helium-equivalent leak rate*
Leak rate unit	mbar.l/s
Mass number range	1 to 100 amu
Detectable electrolyte	DMC, EMC, DEC, PP, etc.
Language	CN/EN

8. Core Competitiveness

- A professional research and development team with nearly 20 years of experience in leak test, including ordinary air leak test and high-precision helium leak test.
- CNAS calibration laboratory.
- Manufacturing the calibration devices (Leak Standard with DMC).
- Having three manufacturing factories in China, Kunshan, Nanjing, and Guangzhou.
- The monthly production capacity of MSQ1000 is 30 units, and the planned monthly production capacity is 50 units.
- The monthly production capacity of testing equipment is 100 units.
- The delivery time of equipment is approximately 45 days.

9. Other Instruments-Air Leak Tester for the Box of Battery

S30 Air Leak Tester for Box of Power Battery

The S30 air leak tester, with a portable low-power consumption and high-performance design, is mainly used in new energy vehicle 4S stores and product quality monitoring on production lines. After long-term research and development, and based on massive on-site testing data, the S30 has built-in a large number of testing parameters of vehicle models (power battery packs), and can automatically complete standardized testing processes such as pressure control, testing, and data reporting. The instrument not only has a large touch screen image, which can facilitate human-machine interaction, but also has the ability to transmit data and remote control through WIFI. Engineers can also efficiently and normatively carry out on board/off board inspections of various power battery packs.

Others Standard Instruments

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9. Other Instruments-Air Leak Tester

10. Terms

VOC= Volatile Organic Compounds
RGA= Residual Gas Analyzer
GMA= Gas Mass Spectrum Analyzer
DMC= Carbonic acid dimethyl ester
M/Z=Mass-to-charge ratio
Air Leak Tester=Testing the leak by pressure/vacuum decay

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- Cases Presentation

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