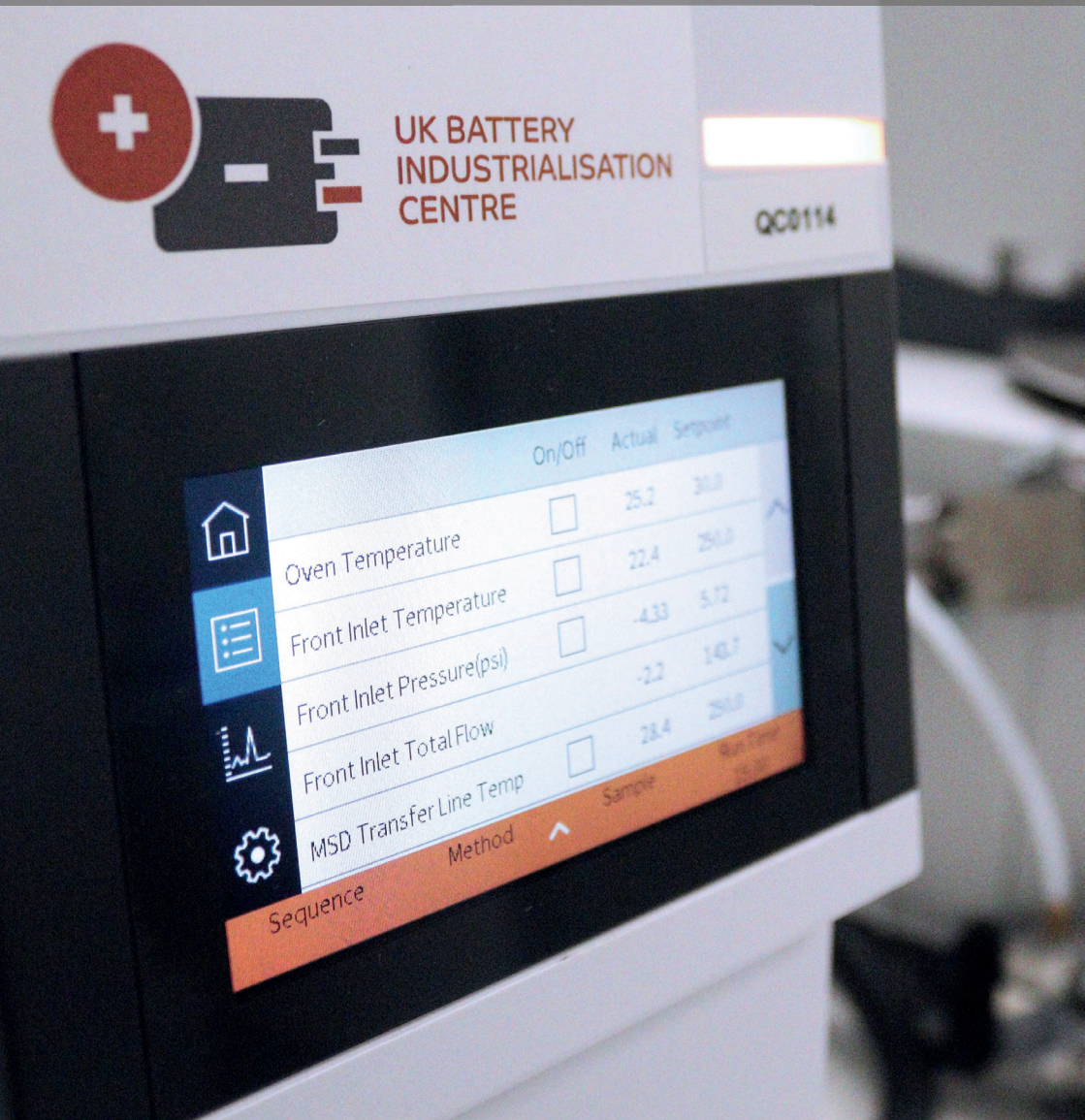
Battery Development Laboratory

Equipment and capability



Contents

Our bespoke laboratory offers state-of-the-art analytical equipment and techniques designed to support your project, meaning you benefit from short turnaround times and rapid feedback.

Forensics
For cell failure investigations, safe teardown of cells, and detailed measurement and imaging of cell components

Characterisation
Analysis of material properties such as morphology, crystal structure, and elemental composition using a range of techniques including XRD, ICP, Raman, NMR, and SEM-EDX

Chemical and physical processing
For handling of hazardous chemicals, preparation of samples for advanced characterisation, wet or chemical analyses, small scale mixing and coating, and coin cell build

Electrochemistry
Advanced electrochemical analysis of coin, pouch, and cylindrical cells using techniques such as EIS, cyclic voltammetry, GITT and PITT with the ability for different temperature testing

CT scanning
Non-destructive analysis of cells to evaluate potential assembly defects or failure modes without physical teardown

ELECTROCHEMISTRY

For bespoke and advanced electrochemical analysis of coin, pouch, and cylindrical cells, including EIS, cyclic voltammetry, GITT, and PITT

ENVIRONMENTAL CHAMBERS

Thermally-controlled chambers for ensuring consistent temperature-controlled battery cycling.

LIT MK240 (BINDER)

Temperature range:
-40°C to 110°C

PLATINOUS J PU-2J (ESPEC)

Temperature range:
-40°C to 100°C

CYCLING AND EIS

Potentiostats and cell cyclers for electrochemical testing of various cell formats including cycle life, EIS, GITT, and PITT.

VMP-300 AND VMP-3e (BIOLOGIC)

BCS-810 AND BCS-815 (BIOLOGIC)

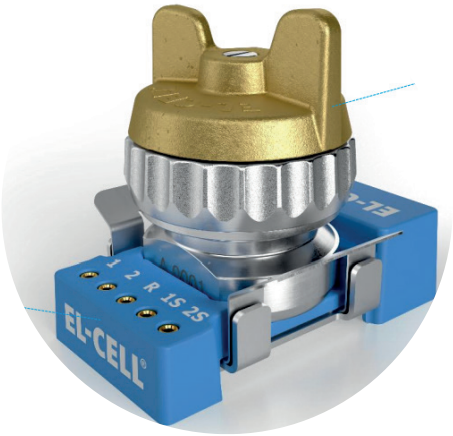
	VMP300	VMP-3e	BCS-810	BCS-815
Number of channels	8	16	8	8
Max current per channel	10 A	1 A	1.5 A	15 A
Voltage range	-1V to +6V	-10V to +10V	0V to +10V	0V to +9V
Parallel channel	1 x 80 A	-	-	1 x 120 A
EIS	10 µHz to 7 MHz	10 µHz to 1 MHz	10 mHz to 10 kHz	10 kHz to 10 kHz

ELECTROCHEMISTRY

For bespoke and advanced electrochemical analysis of coin, pouch, and cylindrical cells, including EIS, cyclic voltammetry, GITT, and PITT

3-ELECTRODE PAT CELL

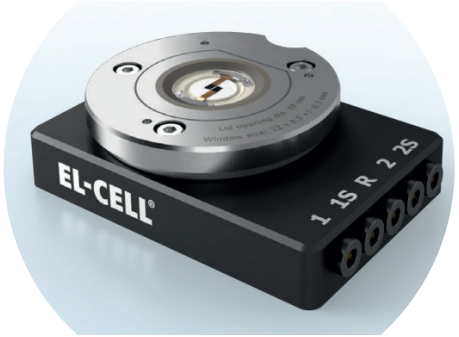
PAT-cell is a test cell for 2- and 3-electrode high-throughput battery testing for extended time periods (>1000 hours). It is designed for easy handling and fast assembly and can be used inside the glovebox. The cell is compatible with both aprotic and aqueous electrolytes.



We have six cells that can be connected to our potentiostat via the PAT-Clamp-1 docking station for electrochemical analysis (cycling testing, EIS compatible). It can also be used inside the environmental chamber and operate in temperatures from -20 to 80°C. The maximum electrode diameter is 18mm and the maximum separator diameter is 21.6mm.

Parameter	Specification
Operational temperature (°C)	-20 to 80
Electrode diameter (mm)	18
Separator diameter (mm)	21.6

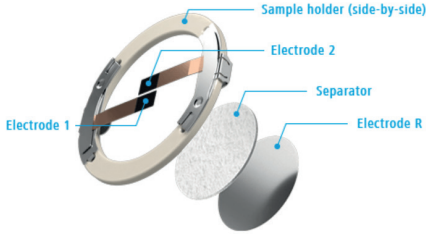
OPTICAL CELL (EL-CELL)

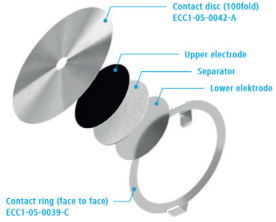


The optical cell is designed for operando characterisation of electrodes using light microscopy or Raman spectroscopy in reflection mode.

The electrodes can be assembled in side-by-side or face-to-face arrangements. The cell can also be connected to our potentiostat for electrochemical analysis such as cycling testing and electrical impedance spectroscopy (EIS).

It is compatible with our environmental chambers as it can operate in temperatures from -20 to 70°C





Parameter	Specification
Operational temperature (°C)	-20 to 70
Electrode diameter (mm)	Up to 10
Separator diameter (mm)	10

FORENSICS

For cell failure investigations, safe teardown of cells, and detailed measurement and imaging of cell components

MB200MOD GLOVEBOX (MBRAUN)

A custom designed argon-filled glovebox for teardown of battery cells for forensic analysis. It features a laminated safety glass front, reinforced frame, burst disk, and thermal camera to provide added safety for the user. Moisture and oxygen sensors monitor the environment to assure teardown safe conditions. The optical camera also enables images to be taken while inside the glovebox.

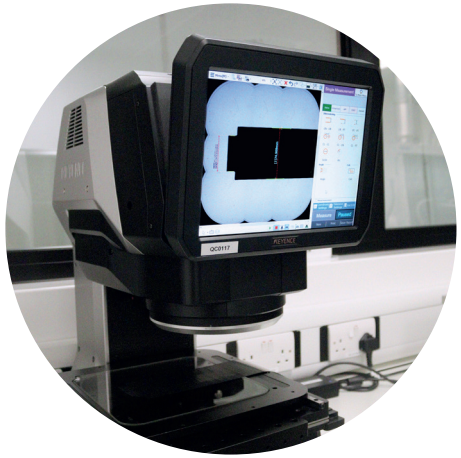
We have prior experience of teardown of different cell formats, including cylindrical 21700 and 4680, pouch cells and prismatic cells.

Components	Parameter	Specification
Glovebox	Workspace (mm)	1800W x 900H x 780D
	Filters	H13 HEPA
	Operating gas	Argon
Burst disc	Burst pressure (mbar)	+20
Thermal camera	Camera type	Uncooled IR 2D
	Measuring temperatures (°C)	20 to 120 and 50 to 500
	Max frame rate	50 Hz
	Temperature resolution	<60 mK
Optical camera	Resolution (MP)	2.3
	Frame rate (fps)	160
	Lens options	Basler 25mm focal, 200mm WD
		Basler 12mm focal, 100mm WD
		Ricoh 6mm focal, 100mm WD

FORENSICS

For cell failure investigations, safe teardown of cells, and detailed measurement and imaging of cell components

IM-7020 DIGITAL SHADOWGRAPH (KEYENCE)



The shadowgraph uses light beneath the stage and a high-density camera to measure mechanical parts. Telecentric lenses use mean high accuracy measurements with no drift. In addition to the standard shadowgraph, it has:

- The option to light from above for surface features
- A light probe to conduct touch measurements e.g. height

Multiple parts can be measured simultaneously, with the option to program automatic measurement methods and generate reports. Various basic and advanced measurement tools, including GD&T, can be used to measure with high accuracy and repeatability. It is used to check sizes of cell materials such as electrodes or other components. It is particularly useful in situations where a digital caliper is not suitable e.g. avoiding cell short circuiting.

Parameter	Specification
Max measurement area (mm)	200 x 200
Repeatability (µm)	± 0.5 to ± 2
Accuracy without binding (µm)	± 5 (wide) ± 2 (precision)
Accuracy with binding (µm)	± (7 + 0.02 L*) ± (4 + 0.02L*)
Light probe max measurement area (mm)	90(X) x 90(Y) x 30(Z)
Light probe repeatability (µm)	± 2
Light probe measurement accuracy (µm)	±(8 + 0.02 L*)

FORENSICS

For cell failure investigations, safe teardown of cells, and detailed measurement and imaging of cell components

VHX-7000 MICROSCOPE (KEYENCE)

An advanced 4K, high-accuracy microscope that allows for high-magnification imaging and measuring of samples with magnification over 2,500x. Z-stacking allows for full image focus of uneven samples and can generate 3D renders based on topographical height. Additionally, it is able to do 2D and 3D measurements of samples including surface roughness profiling. Optical shadow effect mode allows for SEM-like surface detailing without the hassle.

This microscope is typically used within the battery industry to inspect cell components from raw materials to electrodes to bought in manufactured parts (e.g. cans, caps, tabs). In particular, it can be useful for looking at defects as depth profiling gives indication whether the defect is raised or indented and to what extent.

Parameter	Specification
Frame rate	30 fps
Resolution	Up to 4000 (H) x 3000 (V) - 4K
Light source	Integrated LED
Max image size	50,000 (H) x 50,000 (V) pixels
Magnification range	20x to 6000x
Measurement accuracy	±3 pixels

SMZ25 OPTICAL MICROSCOPE (NIKON)

The optical microscope uses visible light and a series of lenses to magnify a sample to enable the viewing of surface features. The microscope is fitted with a camera to enable images of samples to be taken and analysed. In the current configuration the microscope can magnify to 150x – other objectives can be purchased to achieve higher magnifications.

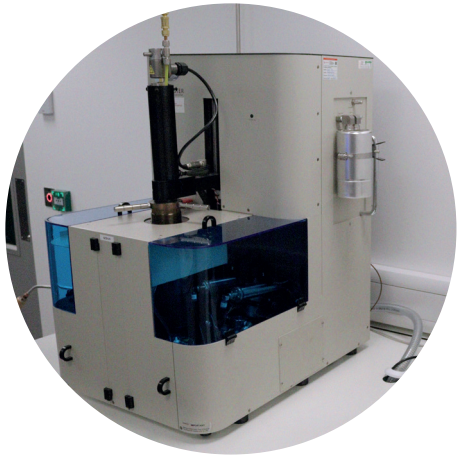
This equipment is typically used within the battery industry to inspect cell components from raw materials to electrodes to bought in manufactured parts (e.g. cans, caps, tabs). This microscope is more beneficial for looking at macro features or for quick analysis of parts.

Parameter	Specification
Resolution	5.9 megapixels
Light source	External LED source
Maximum field of view	Ø 70mm
Magnification range	6.3x to 157.5x

CHEMICAL AND PHYSICAL PROCESSING

For handling of hazardous chemicals, preparation of samples for advanced characterisation, wet or chemical analyses, small scale mixing and coating, and coin cell build.

POREMASTER 33 (ANTON PAAR)



Mercury porosimetry is used for measuring pore size distribution within a solid material.

The sample is loaded into a measurement cell and then the cell is filled with mercury. The pressure is increased inside the cell and, as it increases, the mercury fills pores within the material. This results in a reduction in volume that is proportional to the porosity of the sample. Pores of 6nm to 1100 microns can be measured using this technique.

This equipment can be used to measure porosity in powders as well as in coated or calendered electrodes. Additionally, separators can be analysed for porosity in this way as an alternative to the Gurley method.

Parameter	Specification
Low pressure stations	2
Low pressure range (psi)	0.2 to 50
Low pressure pore size range (µm)	1,100 to 4
High pressure stations	1
High pressure range (psi)	20 to 30,000
High pressure pore size range (µm)	10 to 0.0064

CONTACT ANGLE GONIOMETER (OSSILA)

The Ossila contact angle goniometer measures contact angle and surface tension of liquid droplets. The droplet can be put onto any surface to measure the interaction of the liquid with the surface of interest.

A high-resolution camera takes images of the droplets, and the software has automatic edge detection to accurately measure the angle or surface tension.

This equipment can be used to look at interactions of slurries with foil surfaces to understand if the slurry may have a high contact angle which could cause coating issues. Additionally, surface tension can be a key parameter when trying to model slurry behaviour.

Parameter	Specification
Measurement accuracy (°)	±1
Measurement range (°)	5 - 180
Stage area (mm)	50 x 50
Max sample thickness (mm)	20
Max camera resolution (mm)	1920 x 1080

CHEMICAL AND PHYSICAL PROCESSING

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MASTERSIZER 3000E (MALVERN PANALYTICAL)

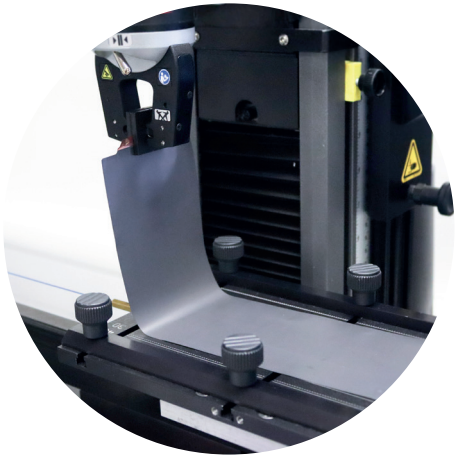
Featuring Hydro EV, Aero S, and Hydro Insight accessories.

The Mastersizer 3000 uses laser diffraction to measure particle size distribution. As the particles pass a laser, they cause scattering which is proportional to the particle size. The Hydro EV measures particles in a liquid dispersion whereas the Aero S measures dry powders. The Hydro Insight uses a dynamic imaging camera to take continuous images of particles in dispersion giving more insight into particle shape, agglomeration and quantitative shape data.

Particle size is a key characteristic for battery raw materials, affecting the electrochemical performance of the material. Analysis is used to ensure the correct particle size material goes into the process, or it can be used to understand if particle size changes upon processing.

Component	Parameter	Specification
Mastersizer 3000	Particle size range (µm)	0.1 to 1000
	Accuracy (%)	0.6
	Repeatability (%)	>0.5
	Reproducibility (%)	>1
Hydro Insight	Particle size range (µm)	1 to 300
	Detector	5MP camera, 2.2 µm pixel size
	Max frame rate (fps)	127

5942 AND 34TM-5 TENSILE TESTERS (INSTRON)



Tensile testing evaluates the mechanical strength of a material through tension or compression of the material until breaking point. It can also check the force required to separate two joined components.

We use tensile testing to check the mechanical strength of parts such as weld strength or material tensile strength, as well as coating adhesion.

UKBIC has two machines. One allows for tension/compression up to 5000N and is used for tensile strength, typically used to check material or weld strength.

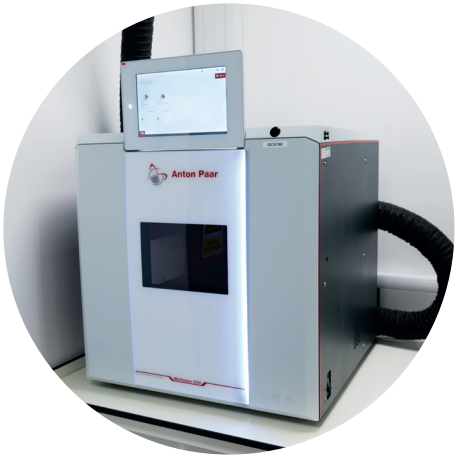
The other allows for tension up to 100N and has a rolling bed and pulley system to allow for peel testing at constant speed at a 90-degree angle, typically to test coating adhesion for electrodes.

Component	Parameter	Specification
Instron 5942	Speed range (mm/min)	0.05 to 2500
	Capacity (kN)	0.5
	Travel height (mm)	488
	Load measurement accuracy (%)	±0.5
Instron 34TM-5	Speed range (mm/min)	0.05 to 1016
	Capacity (kN)	5
	Travel height mm)	1242
	Load measurement accuracy (%)	±0.5

CHEMICAL AND PHYSICAL PROCESSING

For handling of hazardous chemicals, preparation of samples for advanced characterisation, wet or chemical analyses, small scale mixing and coating, and coin cell build.

MULTIWAVE 5000 MICROWAVE DIGESTER (ANTON PAAR)



The microwave digester is used to heat solid samples, typically in an acid medium, in a sealed vessel using microwave radiation which quickly raises the temperature and pressure. This rapid heating breaks down the sample much faster than the traditional method of using a hot plate.

This equipment is used in the battery industry to dissolve electrode or other solid samples into solutions to run on ICP-OES.

Parameter	Specification
Temperature (°C)	300
Pressure (Bar)	100
Max sample number	20
Sample volume (ml)	50

RESIN MOUNTING

Cold mounting is done using epoxy resin and hot mounting uses the Buehler Simplimet 4000. Samples are mounted to see the cross section of materials for further analysis.

Hot mounting preserves the sample in thermosetting resin under heat and pressure. This process allows for quick mounting of samples that are not sensitive to heat or pressure.

Cold mounting uses epoxy resin to encapsulate samples in a mould. A release agent is used help remove sample from mould. Cold set resins usually require longer to set and are more suitable for mounting of delicate samples which may be damaged by heat or pressure.

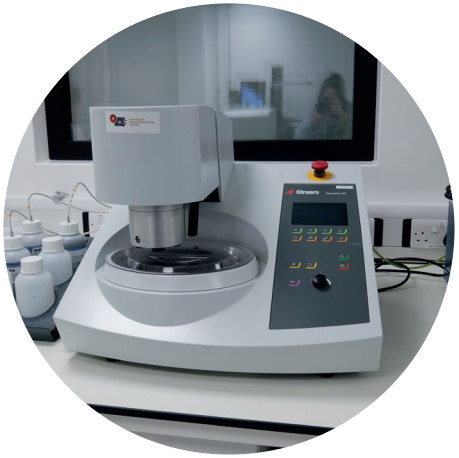
Samples such as welds are cross sectioned to look at interaction of the welded components and other features such as penetration, inclusions, cracks or fractures and porosity. Electrode coatings can also be mounted to investigate coating thickness, uniformity and foil positioning.

	Parameter	Specification
Buehler Simplimet 4000	Pressure (Bars)	70 - 300
	Heat time (mins)	1 - 20
	Heating temperature (°C)	50 - 220
Epoxy resin	Resin set time (hrs)	8 - 12

CHEMICAL AND PHYSICAL PROCESSING

For handling of hazardous chemicals, preparation of samples for advanced characterisation, wet or chemical analyses, small scale mixing and coating, and coin cell build.

TEGRAMIN 20 MECHANICAL POLISHER (STRUERS)



Mechanical polishing is used for the grinding and polishing of the cross-sectional surface of resin mounted samples, resulting in a smooth and even surface so that surface features can be clearly seen under the microscope or SEM.

The polisher uses various grinding and polishing pads and polishing solutions and can be programmed with specific profiles, all which help to achieve a polish of <1 micron.

Parameter	Specification
Number of specimens	1-4
Disc rotational speed (rpm)	40-600
Specimen head force (N)	5-50
Specimen head rotational speed (rpm)	5-150
Solution dosing	Automatic, up to 7 pumps

AUTOMATIC SPUTTER COATER (AGAR)

Samples for the scanning electron microscope (SEM) must be conductive. For samples with low or no conductivity, the sputter coater can be used to cover the samples in a thin conductive layer (~10nm). This is needed for all samples that have been mounted in non-conductive resin.

Gold is typically used as it has an extremely fine micro-structure and does not reduce the visibility of the micro-structure of the parts being inspected with the SEM. Other precious metal targets can be used upon special request.

Parameter	Specification
Sputter target	Gold
Sputter supply (mA)	10-40

CHEMICAL AND PHYSICAL PROCESSING

For handling of hazardous chemicals, preparation of samples for advanced characterisation, wet or chemical analyses, small scale mixing and coating, and coin cell build.

KARL FISCHER TITRATOR (NITTOSEIKO ANALYTECH)

The Karl Fischer titrator determines the moisture content of a sample based on the reaction:
$I_2 + 2H_2O + SO_2 \rightarrow 2HI + H_2SO_4$

The water in the sample reacts with the sulphur dioxide and iodine and, when an excess of iodine ions in the anode solution occurs, the voltage between the two electrodes will drop.

Low-viscosity liquid samples can be injected directly into the reaction vessel. With the addition of vaporiser units, solid samples can also be measured for moisture content.

NMP and electrolytes are analysed to avoid unwanted side reactions in slurry and cell production. Electrodes or separator samples can also be tested to ensure suitable dryness.

Equipment	Specification	Parameters
CA-310 Coulometric Titrator	Peak speed (µg/sec)	36
	Measurement range (mg H_2O)	0.005 to 999.9999
	Detection sensitivity (µg H_2O)	0.1
	Accuracy (% RSD)	<0.3 (at >1mg H2O)
VA-300 Vaporiser	Temperature range (°C)	50 to 300
	Sample size (g)	Up to 10g
	Carrier gas	Nitrogen
	Carrier gas flow rate (L/min)	0.1 to 0.5

MB200MOD GLOVEBOX - COIN CELL BUILD (MBraun)

An argon-filled glovebox for small-scale building of cells, particularly, half-cell coin cells.

Moisture and oxygen sensors monitor the environment to achieve safe conditions for builds, avoiding moisture in the final cell.

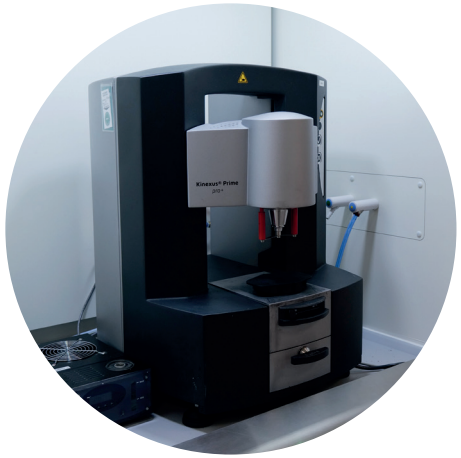
Inside the glovebox there is an argon-driven pneumatic crimper for coin cell assembly (model MTI MSK-PN-110-S crimper).

Component	Parameter	Specification
Glovebox	Workspace (mm)	2000W x 900H x 680D
	Filters	H13 HEPA
	Operating gas	Argon
Burst disc	Burst pressure (mbar)	+20
Crimper	Operational pressure	0.7 ~ 1.0MPa
	Coin cell size	CR2016, CR2025 & CR2032
	Operating gas	Argon, Nitrogen

CHEMICAL AND PHYSICAL PROCESSING

For handling of hazardous chemicals, preparation of samples for advanced characterisation, wet or chemical analyses, small scale mixing and coating, and coin cell build.

KINEXUS PRIME PRO+ RHEOMETER (NETZSCH)



The rheometer is used to measure the flow properties of a sample material to understand how it may move through a production process. Using both rotational and oscillatory testing, various material parameters can be determined, including viscosity at varying shear rates, viscoelastic behaviour, relaxation times, shear stress and strain, and more.

As rheology is heavily influenced by temperature, the rheometer is fitted with a Peltier controller to ensure temperature consistency.

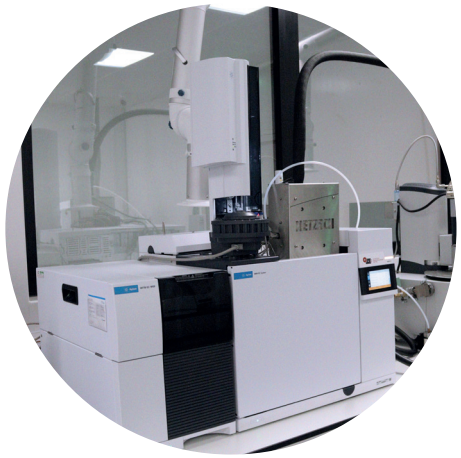
The rheological properties of a slurry are key in enabling successful coating onto foil substrates. The results obtained can also be used to support modelling of slurry behaviour throughout the electrode production process.

Specification	Parameters
Torque range - viscometry (mNm)	3 to 225
Torque resolution (nNm)	0. 1
Frequency range	6.28 $\mu rads^{-1}$ to 942 $rads^{-1}$ (1 µHz to 150 Hz)
Normal force range (N)	0.001 to 50
Vertical lift speed	0.1 μms^{-1} to 35 mms^{-1}
Gap resolution (µm)	0.1

CHARACTERISATION

For analysis of material properties such as morphology, crystal structure, and elemental composition using advanced techniques

8860 GC GAS CHROMATOGRAPHY - MASS SPECTROMETER WITH 5977B MSD (AGILENT)



Gas Chromatography - Mass Spectrometry (GCMS) separates volatile components in a mixture to enable them to be identified.

The system uses a long, coiled column with a stationary phase that interacts with the sample. The sample can be injected as a liquid and vaporised, or directly injected as a gas. The components of the sample interact with, and are slowed down by, the column. This results in different components being eluted at differing rates. The mass spectrometer then measures the components and compares them to a database to identify them.

The GCMS is typically used to determine the solvent components of electrolyte blends.

Equipment	Parameter	Specification
8860 GC	Operating temperature range (°C)	8 to 425
	Peak area repeatability (% RSD)	<2
	Retention time repeatability (%)	<0.06
	Column	Agilent J&W HP-5ms Ultra Inert (Fused Silica)*
5977B MSD	Ion source temperature (°C)	150 to 350
	Quadrupole temperature (°C)	106 to 200
	Mass range (u)	1.6 to 1050

*other columns can be used

STA449 F1 JUPITER SIMULTANEOUS THERMAL ANALYSIS (NETZSCH)

Simultaneous Thermal Analysis (STA) enables simultaneous running of thermogravimentric analysis (TGA) and differential scanning calorimetry (DSC) on samples.

This allows for concurrent measurements of changes in weight due to loss of moisture or breakdown of components, and changes in energy, to understand material changes that occur during heating.

This equipment is usually used to confirm breakdown conditions of materials and help with determining component ratios.

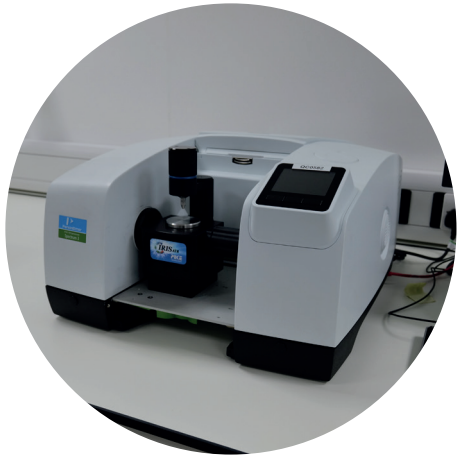
Specification	Parameters
Operating temperature (°C)	25 to 1600
Heating rate (K/min)	0.001 to 50
Temperature resolution (K)	0.001
Balance resolution (µg)	0.025
DSC enthalpy accuracy (%)	±2
Maximum sample load (µg)	5000
Gas atmospheres	Dry air, helium*

*other atmospheres may be available on request

CHARACTERISATION

For analysis of material properties such as morphology, crystal structure, and elemental composition using advanced techniques

CARY-630 (AGILENT) AND SPECTRUM 3 (PERKIN-ELMER) FTIR SPECTROMETER



The FTIR spectrometer directs infra-red light towards the sample, where the chemical bonds in the sample absorb the light at varying frequencies. Measuring the light across the spectrum enables the sample to be identified.

FTIR can be used to measure both solid and liquid samples, however it is most effective at measuring carbon-based samples.

The Agilent FTIR enables quick analysis of samples in the Mid-IR (MIR) range with limited software processing. The Perkin-Elmer FTIR expands on the Agilent model by adding increased Mid-IR range and the option to switch to Far-IR (FIR). It extends down to 30cm^{-1} analysis of metal containing components such as metal oxides, metal sulfides, and metal-ligand complexes.

Equipment	Parameter	Specification
Agilent Cary-360	Spectral range (cm^{-1})	4000 to 600 (MIR)
	Measurement modules	Transmission or ATR
	Spectral resolution (cm^{-1})	≤ 2
Perkin Elmer Spectrum 3	Spectral range (cm^{-1})	8300 to 30 (MIR to FIR)
	Measurement modules	Transmission or ATR
	Spectral resolution (cm^{-1})	0.4
	Wavenumber accuracy (cm^{-1})	0.02

AVIO 220 ICP-OES (PERKIN ELMER)

Inductively Coupled Plasma Optical Emission Spectroscopy (ICP-OES) is used to determine how much of an element is present in a sample.

The sample is introduced to a high-temperature argon plasma which excites the atoms in the elements, causing them to emit light. Different elements emit light at specific wavelengths as they transition to a lower energy level. A detector then measures the light and processes the signals to determine the elemental composition.

It is usually paired with a digestion unit to allow for solid samples to be dissolved into a liquid solution for analysis on the ICP-OES.

At UKBIC, we typically use the ICP-OES to measure the concentration of elements within battery components down to ppm level.

Specification	Parameters
Spectral range (nm)	165-900
Spectral resolution (nm)	<0.009 at 200nm
RF generator	40 MHz
Argon flow rates (L/min)	8 to 20
Detector type	CCD

CHARACTERISATION

For analysis of material properties such as morphology, crystal structure, and elemental composition using advanced techniques

INVIA QONTOR RAMAN MICROSCOPE (RENISHAW)

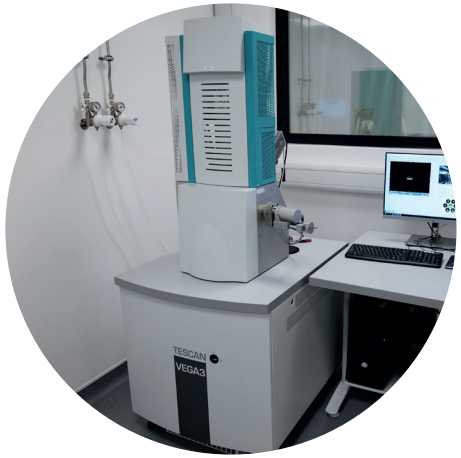
Raman spectroscopy is a chemical analysis technique that involves illuminating a sample with laser light and measuring the scattered light from the sample's surface. The scattered signal provides valuable information about the composition and structure of the material.

The InVia confocal microscope integrates multiple mapping and imaging techniques, enabling samples to be studied in both 2D and 3D. With additional automated focus tracking, it is possible to effectively analyse samples with uneven, curved, and rough surfaces.

At UKBIC, Raman spectroscopy is particularly useful for analysing carbon-based materials found in cells. It can differentiate between various carbon allotropes and can also provide insight into defects within the graphite structure.

Equipment	Parameter
Wavelength range (nm)	200-2200
Spectral resolution (cm^{-1})	0.3 (FWHM)
Laser available	Green 532 nm (50 mW) Red 633 nm (30 mW)
Spatial resolution (lateral)	Standard 1 µm (depending on objective and laser used)
Objectives (LWD)	5x, 20x and 50x
Motorised xyz stage step size	100nm in x and y; 15 nm in z

VEGA 3 SCANNING ELECTRON MICROSCOPE (TESCAN)



The scanning electron microscope (SEM) uses electrons to view a sample in opposition to light.

Secondary electron and back-scatter detectors allow both topographical and compositional information at microscopic scales.

It is also equipped with an energy dispersive x-ray detector (EDX), measuring characteristic x-ray emissions from atoms during electron bombardment. This enables identification of chemical composition.

The SEM can achieve a theoretical maximum magnification of 150,000x and is typically used at UKBIC to analyse the microstructure of electrodes and welds to a resolution of ~5 µm.

Specification	Parameters
Cathode type	Tungsten
Accelerating voltage (keV)	5 to 30
Chamber size (mm)	285 x 340

CHARACTERISATION

For analysis of material properties such as morphology, crystal structure, and elemental composition using advanced techniques

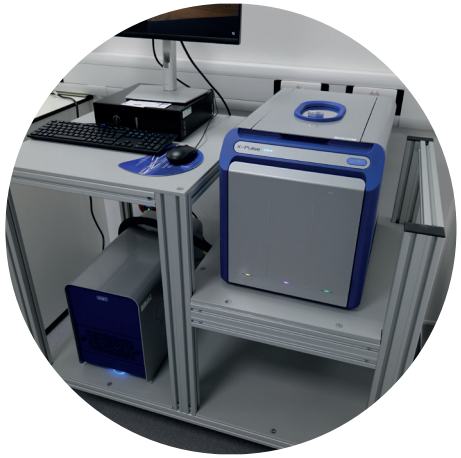
X-FLASH 6|30 ENERGY DISPERSIVE X-RAY SPECTROMETER (BRUKER)

Energy Dispersive X-Ray (EDX) spectroscopy allows the user to analyse the elemental composition of a sample by detecting characteristic x-rays emitted by the elements in the sample. When working alongside SEM, EDX can be used to create elemental maps of samples.

At UKBIC, this is useful to map the elemental distribution across an electrode, looking for an even spread of components and identifying contamination which may negatively affect performance.

Specification	Parameters
Energy resolution	123 eV at Mn Kα

X-PULSE NUCLEAR MAGNETIC RESONANCE SPECTROMETER (OXFORD INSTRUMENTS)



The Nuclear Magnetic Resonance (NMR) spectrometer is acompact, high performance system for fast analysis of liquids and gels. It does not require cryogens and features a high-homogeneity, permanent magnet for exceptional temperature stability.

The system works with standard 5mm NMR tubes or 4mm tubes for variable temperature analysis. Using a magnetic field and radiofrequency pulses, it detects a response from the sample nuclei which is then converted into a spectrum. The standard channel can be set to ^{1}H or ^{19}F, with the X-channel able to be tuned to a wide range of elements from ^{9}Si to ^{31}P.

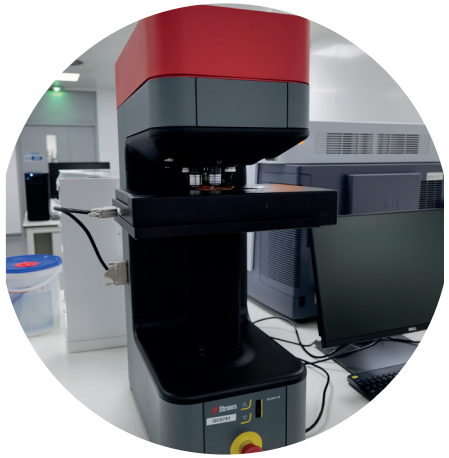
At UKBIC, NMR can be used to look at electrolyte composition, providing benefit over GCMS due to the ability to detect the salt components that are not able to be vaporised for GC analysis.

Specification	Parameters
Magnet type	60 MHz permanent magnet
Resolution (Hz)	<0.3 (50%) to <10 (0.55%)
Enhanced sensitivity	130:1
Sample types	Liquids and gels
X-channel - current tunings	^{13}C, ^{9}Si, ^{31}P, ^{11}B, ^{7}Li, ^{23}Na
Variable temperature (°C)	0 to 65

CHARACTERISATION

For analysis of material properties such as morphology, crystal structure, and elemental composition using advanced techniques

DURAMIN 40 MICRO-HARDNESS TESTER (STRUERS)



Hardness testing measures a material's resistance to permanent deformation at its surface, using an indenter that presses into the sample for a few seconds with a specific load behind it.

The indenter is deforms the surface of the material by a measurable amount and the measurement is used to assign a hardness value.

There are several different hardness test methods, each suited to a certain scale of measurement or type of material.

Our available test methods include:

- Vickers- Uses a diamond pyramid to make a square indentation
- Knoop – Uses a shallower diamond pyramid used to test thin or brittle materials

Hardness testing can be used in the battery industry to confirm the hardness of cell materials or to assess the change in hardness during welding processes.

Specification	Parameters
Load range (kgf)	1 to 62.5
Stage size (mm)	220 x 120
Objective lenses	5x, 10x, 50x, 100x

AERIS X-RAY DIFFRACTION (MALVERN PANALYTICAL)

X-Ray diffraction (XRD) is a non-destructive analytical technique used to obtain information about the chemical composition and crystal parameters of a sample, including structure, orientation, and size.

Phase identification is achieved by comparing x-ray diffraction patterns from unknown samples to reference patterns in the database. The composition (in weight percent) and detailed information about lattice parameters of the sample can also be determined through Rietveld refinement analysis.

The XRD features an autosampler with six positions that enable sequential programming and measurement of samples. Air-free sample holders, including Kapton holders, PC and PEEK domes, are available to prevent sample exposure to ambient air.

Specification	Parameters
X-ray source	Co - 1.79 (Å)
Max. 2θ range	-4° < 2θ ≤ 142°
Max. scan speed	2.17°/s
Achievable resolution	< 0.04° 2θ on LaB6

CT SCANNING

For non-destructive analysis of cells and materials.

CT SCANNER (WAYGATE TECHNOLOGIES)

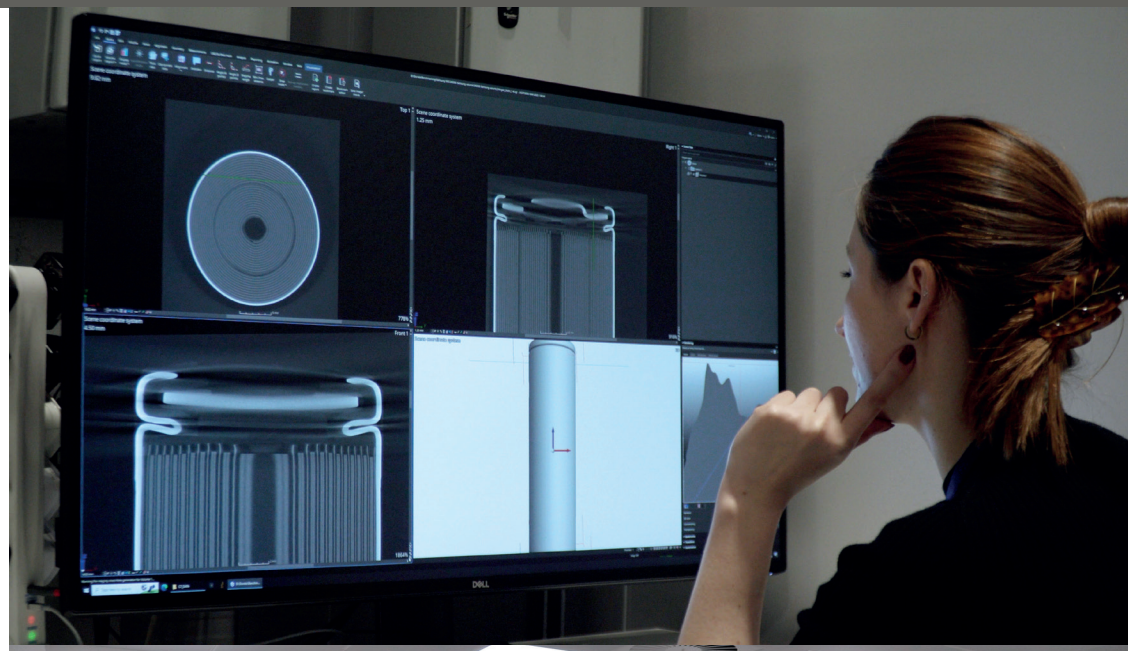
Using x-rays and a rotating stage, multiple x-ray images are taken through 360° and then reconstructed to create a 3D render of the cell or material, with the ability to slice through the sample and look at any cross section of the object.

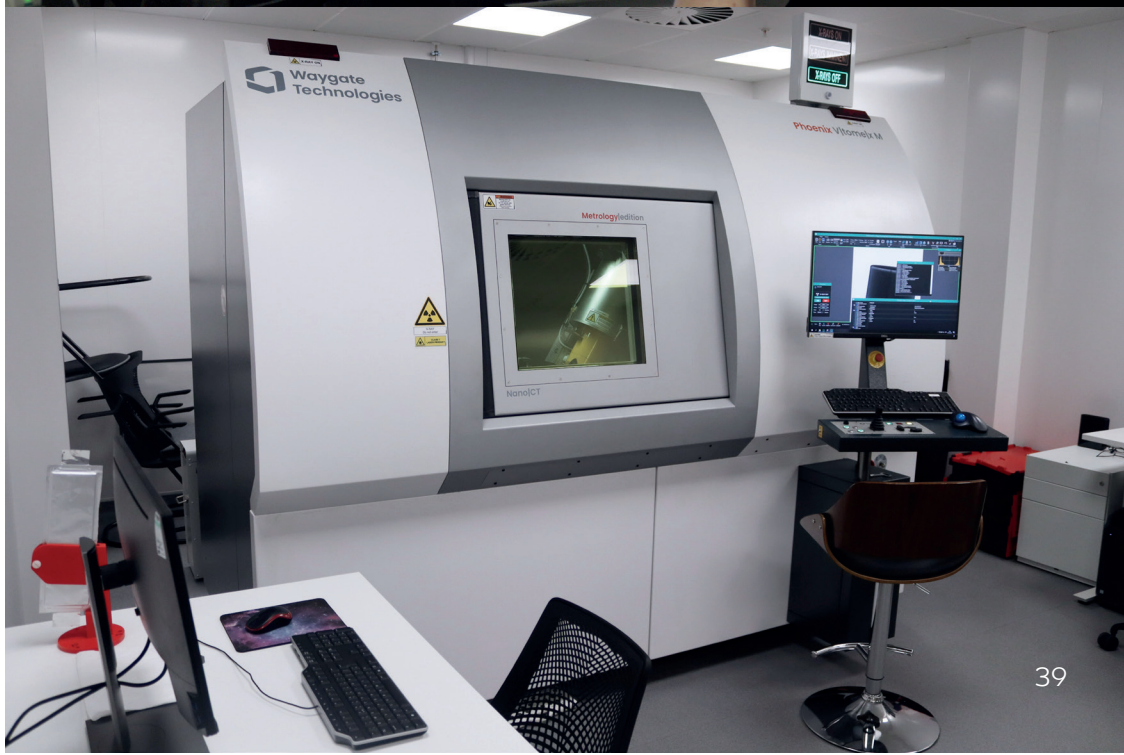
The scanner is able to easily swap between two x-ray tubes, enabling both microfocus and nanofocus.

CT scanning can help identify:

- Missing components
- Misplaced components
- Defects
- Electrode alignment
- Weld position and condition
- Leak path on seals

X-ray tube	Specification	Parameters
Microfocus	Voltage maximum (kV)	300
	Power maximum (W)	500
	Geometrical magnification (3D)	1.3x to 100x
	Detail detectability	Down to 1 µm
Nanofocus	Voltage maximum (kV)	180
	Power maximum (W)	20
	Geometrical magnification (3D)	Up to 200x
	Detail detectability	Down to 0.2 µm
General	Max. sample size (mm)	400 Ø x 400 H
	Measurement accuracy (mm)	SD < 3.8+L/100





DRY LABORATORY

Small-scale mixing, coating, calendering, and assembly to support smaller builds.

ARE-250 MIXER (THINKY)

An industrial, non-contact, planetary mixer designed to mix, disperse, and degas materials in sealed containers.

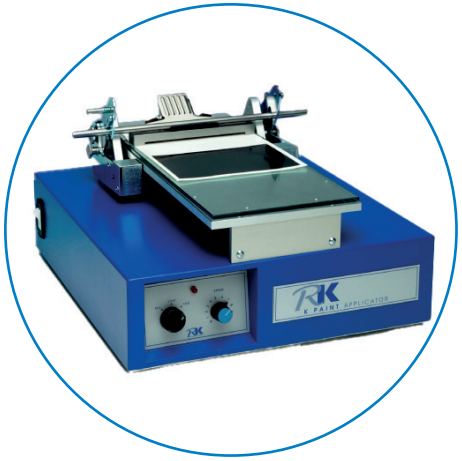
The mixer can be programmed for various mixing and degassing conditions (time and speed per mode) within a single batch cycle, with up to five sequential time and RPM steps.

The minimum material capacity is 0.5g and the maximum is 250ml, in a 300ml container.

We operate two THINKY ARE-250 mixers at UKBIC: one in the dry laboratory used for mixing NMP-based cathode slurries and the other in the chemical and physical processing laboratory for water-based slurries.

Specification	Parameters
Container capacity (ml)	150, 300
Time setting range	10 sec to 30 min
Revolution mixing mode (rpm)	200 to 2000
Rotation mixing mode	1/2.5 revolution speed
Revolution degassing mode (rpm)	400 to 2200
Rotation degassing mode	1/36.7 revolution speed

K101 PAINT APPLICATOR (COATER) (RK PRINT)



An automatic coater equipped with an adjustable gap applicator designed for precision.

The coating is applied on a heated bed capable of reaching 150°C and the vacuum rubber bed ensures the material remains flat on the bed surface by applying vacuum from the edges of the substrate only.

At UKBIC, we have two coaters: one located in the dry laboratory for processing NMP-based cathode slurries, and another in the chemical and physical processing laboratory for water-based slurries.

Specification	Parameters
Max. heated bed temperature (°C)	150
Substrate/blade gap (mm)	Adjustable 0 to 10 in 10µm increments
Coating speed (m/min)	2 to 15

DRY LABORATORY

Small-scale mixing, coating, calendering, and assembly to support smaller builds.

MSK-HRP-1A CALENDER (MTI)

A hot rolling cylinder press designed for preparing coated electrodes and enhancing the active material density after coating.

It features a pair of 100mm wide steel rollers with a heating capacity of up to 200°C.

Specification	Parameter
Roller size (mm)	96 Ø x 100 W
Rolling gap (mm)	Adjustable 0 to 1.2
Mechanical dial gauge (mm)	0 to 3, accuracy of 0.01mm
Temperature (°C)	Max. 200 for 1hr, 190 continuous

MSK-180-N DIE CUTTER (MTI)

A precision semi-automatic die cutter designed for pouch cell electrode sheets, accommodating a maximum sheet size of 200mm x 200mm.

Die cutter	Dimensions
Cathode (mm)	56 (L) x 43 (W) with a) with a 14 mm (L) x 11 mm (W) protruding current collector.
Anode (mm)	58 (L) x 45 (W) with a 13 mm (L) x 11 mm (W) protruding current collector

MSK-11A-L POUCH CELL STACKER (MTI)

A semi-automatic 'Z' fashion stacking machine designed to alternately stack anode and cathode electrode sheets with a separator film in between.

The machine ensures consistent tension of the separator film and features an automatic counting and zeroing feature to monitor the stacks.

It can accommodate electrode sheets up to 180mm (including tab length) x 150mm, with a maximum stack thickness of 9mm.

Specification	Parameter
Max. stacking electrode size (mm)	180 x 150
Max. electrode thickness (mm)	9
Aligning accuracy (mm)	±0.5
Max. separator roll size (mm)	220

MSK-800W WELDER (MTI)

An ultrasonic metal welder operating at a frequency of 40 kHz, designed for welding stacked electrode (on copper or aluminium) and tabs onto current collectors.

Specification	Parameters
Welding area (mm)	4 (L) x 4 (W)
Ultrasonic frequency (kHz)	40

DRY LABORATORY

Small-scale mixing, coating, calendering, and assembly to support smaller cell builds.

MSK-115A-MS SEALER (MTI)

A compact heat sealer with multiple functions, including side sealing, purging, vacuum standing, and vacuum sealing.

The purging function effectively removes oxygen and moisture from the chamber during the sealing process.

Specification	Parameter
Sealing temperature (°C)	50 to 260
Purging pressure	-90 KPa to 100 Pa
Vacuum range (kPa)	-95 to 0
Maximum sealing area (mm)	160 (L) x 180 (W) x 12

MSK-110 COIN CELL BUILD AND DISASSEMBLY (MTI)

A hydraulic manual crimper for assembling coin cells, including CR2032, CR2025, and CR2016.

The second hydraulic crimper is equipped with a disassembly die to extract materials from coin cells after electrochemical testing.

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