HUMMINGBIRD

— Technical Specs



	1400 Series
Number of Inlets	1 or 2 depending on model, single outlet
Biasing Contacts	4
Tubing Type	User-replaceable microfluidic tubing
Delivery System	Variable speed liquid delivery system
Тір Туре	Removable tip
Flow Type	Continuous flow or static liquid
EDS Compatible	Yes
TEM Compatibility	TFS, JEOL, Hitachi, Zeiss





Liquid Flow

Continuous Flow

Our liquid specimen holder's unique liquid-cell assembly and safety features protect your microscope from contamination and damage. Interchangeable tips and user-replaceable tubing allow researchers to perform controlled and cross-contamination-free experiments and to easily upgrade the system to incorporate new capabilities.

Once the sample is prepared, the system seals it within a microfluidic liquid cell in the holder tip, which is separated from the vacuum of the TEM via a patented sealing mechanism. The sample is then exposed to a continuous flow of liquid running through the environmental cell. Our two-chip fluid cell guarantees that once they are placed, samples remain within the viewing area.



Dual Flow

Hummingbird Scientific's dual-flow mixing tip for the liquid TEM holder allows users to combine two liquids within a single environmental cell. The design supports liquids flowing at equal or varying rates. In addition to reagent mixing, the tip can be used for research requiring a traditional single-flow tip.



Static Cell

Hummingbird Scientific offers a sealed-cell liquid holder for static liquid applications. Once prepared, the sample is enclosed within a microfluidic liquid cell in the holder tip and separated from the vacuum of the TEM via a patented sealing mechanism. This tip can be paired with Hummingbird Scientific's wide range of liquid-cell chip configurations, each aimed at a specific set of experimental requirements. The continuous-flow and dual-flow configurations both also support static-liquid experiments for researchers interested in maximizing experimental flexibility.

Electrochemistry

Hummingbird Scientific was the first company to provide a commercially-available holder capable of supporting liquid-electrochemical experiments conducted inside the TEM. In subsequent years, we have continued to refine the holder's capabilities. In its current configuration, the holder enables electrochemical research via integrated biasing contacts that connect to our specially-patterned electrochemical chips, which are available in a variety of materials. Among other topics, the system has been used for key research into battery materials.

The analytical electrochemistry tip features the sample basic capabilities of the standard electrochemistry liquid cell, but it also keeps the electrical contacts outside the experimental space. This option includes an optional low-noise potentiostat and fully shielded cabling for maximum analytical capabilities.



Wiring Configurations

Standard configuration: In the standard configuration, the system's wires are not individually shielded. This configuration can connect to Hummingbird's heater control box as well as a variety of electronic source and measurement devices. The system can be configured for compatibility with a range of potentiostats and power supplies.

Low current/noise: For very small current or voltage values, we offer an individually-shielded, low-noise wiring system. In this system, a shielded coaxial cable runs through the holder shaft and connects through special micro-coax connectors in the holder. The system can be configured for compatibility with a range of potentiostats and power supplies. It is particularly well-suited for small-scale in-situ liquid electrochemistry measurements.



Biologic SP-200 potentiostat

We are proud to offer the Biologic SP-200 potentiostat as a research-grade measurement tool for electrochemistry experiments. Hummingbird Scientific's electrochemistry tip and Biologic's SP-200 potentiostat can be used in combination for corrosion experiments, electrochemistry, electrolysis, and battery and photo-voltaic research.



Heating

Our liquid heating system is specifically optimized for homogeneous sample heating at moderate temperature requirements. Each chip features its own thin-film heater, which heats the contents of the liquid cell up to the boiling point of your solution. The system's custom heating-control box and software user interface features closed-loop temperature control and integrated protection against boiling. Hummingbird's heating chips are specially calibrated for this system in order to ensure optimal capability. The image shows an example of the heated liquid cell membrane under a thermal camera.

Spectroscopy

Hummingbird Scientific's liquid TEM holder includes an energy-dispersive X-ray spectroscopy (EDS) feature for spectroscopic measurement inside the liquid cell. Our specialized chips ensure the thinnest possible liquid layer, allowing for electron energy loss spectroscopy (EELS) inside the liquid cell. This in turn allows researchers to perform direct elemental analysis and mapping at high magnifications. The EDS liquid-cell holder's large viewing angle ensures direct access from the sample to the EDS detector (even for multiple-detector configurations).





Cross-Correlative Imaging

Our liquid TEM holder's unique removable holder tip allows for **multi-modal correlative imaging** of transmission electron, scanning electron, X-ray, and optical microscopy of samples in liquid environments. Dedicated holders are available for each technique. All holders can interface with the same liquid-cell tip allowing multi-modal correlative imaging.

Correlative imaging allows researchers to acquire data across different length scales. It also allows for the acquisition of complementary data: high-resolution internal microstructure with TEM and X-ray, surface topography with high magnification and high depth of field in SEM, and lower magnification screening with optical microscopy. And it supports the use of different spectroscopy techniques, including fluorescence, X-ray absorption spectroscopy, energy-dispersive X-ray spectroscopy (EDS), and electron energy loss spectroscopy (EELS).

Vapor Delivery System

Hummingbird Scientific's low-pressure vapor system allows researchers to introduce water vapor into the sample chamber of our fluid TEM sample holders, thus providing greater control over *in-situ* reaction conditions and protecting delicate biological samples. The system is available as an add-on to Hummingbird's liquid and gas holders and can be used with all existing environmental cell systems.



Liquid TEM Holder System Options

TEM Safety

Careful preparation of your samples and system are essential for effective use of environmental holders. A critical component of any holder system is a high-vacuum leak check station.

Our high-vacuum pumping station is a compact, all-in-one vacuum storage and sealchecking mechanism for TEM specimen holders. The station features short pumping and venting times, a low base pressure (10-6mbar), and a glass viewing port for the holder tip. The integrated stereo-microscope allows researchers to inspect and test the seal of a liquid or gas cell assembly before loading it into the TEM, crucial for protecting vacuum quality. A convenient, easy-to-use control-panel and a compact design make the check station a worthwhile addition to your electron microscopy laboratory.





System Components

- A. Liquid-Flow Holder
- B. Liquid Holder Stand
- **C.** Liquid Holder Tip Cover
- **D.** Microfluidics Syringe Pump
- E. High-Vacuum Pump
- F. Seal Checking Station with Integrated Microscope
- **G.** Accessory Kit and Liquid Cell Starter Batch. More accessories, along with a wide array of specialty chips, are available at our Web Store.
- H. Optional Thin Film Heater Controller Power Supply
- I. Optional Biologic Potentiostat (see page 2)

Available For

ThermoFisher THERMO FISHER SCIENTIFIC TEM



Award Winning

Hummingbird Scientific's Liquid flow holder allows scientists to image samples in flowing or static liquids, at atomic resolution. This system is a complete, all-inone solution, opening up exciting new avenues for materials characterization.

This ground-breaking product was the winner of the Tibbets Award (pictured) for Small Business Innovation Research in 2010 and the Federal Lab Consortium Award in 2011. The Microanalysis Society of America awarded the 2011 Birks Award for the first in-situ liquid TEM electrochemical study performed with the patented **Hummingbird Scientific Liquid Flow TEM Holder**.

Our award-winning liquid ElectroChemistry holder was the first commercial holder to allow liquid electrochemical experiments inside the TEM.



Self-assembly guided by shape and force

Scientists from the National University of Singapore used Hummingbird's Liquid Cell TEM imaging platform to demonstrate that nanoparticles' shape influences their self-assembly and growth. These results are published in Advanced Materials. In this study, nanoparticles with different shapes such as rods, bipyramids, spheres, and cubes were capped with a monolayer of amphiphilic surfactant in the solution and flowed through the enclosed liquid cell. Direct evidence of the nanoparticle dynamics shows that the strength of their interactions depends on how they are shaped. For example, cuboidal Au nanoparticles show directional (face-to-face) attachment. This work can be a great step towards developing new materials bottomup with self-assembly.

Reference: Utkur Mirsaidov *et al.* Nanoparticle Interactions Guided by Shape-Dependent Hydrophobic Forces. *Advanced Materials* (2018).



Interaction mechanism of NPs with different shapes. Image copyright © 2018 WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim

Selected Publications

Wenhui Wang, Hongwei Yan, Utkarsh Anand, and Utkur Mirsaidov. **"Visualizing the Conversion of Metal–Organic Framework** Nanoparticles into Hollow Layered Double Hydroxide Nanocages," JACS (2021)

See Wee Chee, Thomas Lunkenbein Lunkenbein, Robert Schlög, and Beatriz Roldan Cuenya. **"In situ and operando electron microscopy in heterogeneous catalysis – Insights into multi-scale chemical dynamics,"** *Journal of Physics: Condensed Matter* (2021)

Albert Grau-Carbonell, Sina Sadighikia, Tom A. J. Welling, Relinde J. A. van Dijk-Moes, Ramakrishna Kotni, Maarten Bransen, Alfons van Blaaderen*, and Marijn A. van Huis. **"In Situ Study of the Wet Chemical Etching of SiO2 and Nanoparticle@SiO2 Core-Shell Nanospheres,"** ACS Applied Nano Materials (2021)

Aram Yoon, Antonia Herzog, Philipp Grosse, Daan Hein Alsem, See Wee Chee, and Beatriz Roldán Cuenya. **"Dynamic Imaging of Nanostructures in an Electrolyte with a Scanning Electron Microscope,"** *Microscopy and Microanalysis* (2021)

David A. Shapiro, Sergey Babin, Richard S. Celestre, Weilun Chao, Raymond P. Conley, Peter Denes, Bjoern Enders, Pablo Enfedaque, Susan James, John M. Joseph, Harinarayan Krishnan, Stefano Marchesini, Krishna Muriki, Kasra Nowrouzi, Sharon R. Oh, Howard Padmore, Tony Warwick, Lee Yang, Valeriy V. Yashchuk, Young-Sang Yu and Jiangtao Zhao. **"An ultrahigh-resolution soft x-ray microscope for quantitative analysis of chemically heterogeneous nanomaterials,"** *Science Advances* (2020)

For the most up-to-date Selected Publications please visit: https://hummingbirdscientific.com/liquid-holder-selected-publications/





2610 Willamette Dr NE Lacey WA 98516 t: 360.252.2737 - f: 360.252.6474 www.hummingbirdscientific.com ©Hummingbird Scientific 2022 -The specifications provided are subject to change without notice.

Visit our Website