DISCOVERY HYBRID RHEOMETERS
TEMPERATURE SYSTEMS AND ACCESSORIES
Electrically Heated Plate (EHP) Temperature System

The EHP provides active heating and cooling of parallel plate and cone and plate geometries. With standard and disposable systems it’s ideal for rheological characterization of polymer melts and thermosetting materials up to a maximum temperature of 400 °C. The optional Gas Cooling Accessory extends the minimum temperature to -70 °C. Standard features include 25 mm diameter parallel plate geometry, environmental cover, and heated purge gas. An optional clear cover is available for sample viewing and for use with the Camera Viewer option. The EHP offers Active Temperature Control (ATC) making it the only EHP system capable of direct temperature control of the upper and lower plates (See ATC Section for more details on this exciting technology). The Upper EHP can be used with lower Peltier Plates for temperature control to 200 °C and as temperature control to 150 °C for UV curing options.

Technology

The EHP lower assembly incorporates a cartridge-heater and cooling channel directly below the lower plate. A Platinum Resistance Thermometer (PRT) is positioned at the center and is in contact with the opposite face of the lower plate, providing intimate measurement and control of the sample temperature. In the upper assembly, a cylindrical heat transfer unit, with an integrated electric heater and a liquid/gas cooling channel, surrounds the cylindrical heat spreader geometry. These two components are in very close proximity, but do not contact, enabling efficient heat transfer and unimpeded torque measurement. Unlike competitive designs, the heat transfer unit and the geometry heat spreader remain in constant spatial relation to one another regardless of the test gap, keeping heat transfer uniform at all times. A unique calibration matches upper and lower plate temperatures at all heating rates, ensuring uniform sample heating at both sides – virtually eliminating the need for thermal equilibrium time and enabling true temperature ramp programming. Patented Active Temperature Control (ATC) eliminates the need for upper heater offset calibrations by providing actual measurement and control of the upper plate temperature. See ATC technology section for more details. A heated purge and cover create an oxygen-free environment around the sample to inhibit sample degradation.
Controlling Polymer Degradation During Testing

Viscoelastic properties of polymer melts can be affected by thermal and oxidative degradation at elevated temperatures. It is important to measure rheological properties in the absence of degradation, as well as evaluating the effectiveness of stabilizing additives such as antioxidants. This figure shows how effectively the EHP controls the environment for commercial polystyrene melt during a 10-hour time sweep experiment at 200 °C. The storage modulus, $G'$, can be seen to be very stable during the early stages of the test when the sample is purged with nitrogen. The inert gas is shut off and the effect of presence of oxygen on the viscoelastic response is seen immediately. The polystyrene degrades as evidenced by the sharp decrease in $G'$.

Features and Benefits

- Unique Smart Swap™ technology
- ATC with patented Non-Contact Upper Temperature Sensor
- Patented Smart Swap™ geometries
- Maximum temperature of 400 °C
- Optional low temperature cooling to -70 °C
- Maximum heating rate of up to 30 °C/min
- Controllable heating rates of 10 °C/min
- Environmental cover and heated purge gas
- Modeled for optimum heat transfer with minimum sample thermal equilibration time
- Heat transfer to sample independent of gap setting
- Sample trimming and plate removal tools
- Disposable Plate System
- Optional glass cover for sample viewing and for use with camera
- Ideal for QC testing or R&D
- Upper heater compatible with all Peltier Plate systems and UV Curing accessories
Thermoplastic Polymer Rheology Using Parallel Plate

Parallel Plate geometries are most popular for testing of thermoplastic polymer melts. An example of polystyrene characterized over a temperature range of 160 °C to 220 °C is shown in the figure to the right. Frequency sweeps were run at multiple temperatures over an experimental range of 0.06 to 628 rad/s. The magnitude of the viscoelastic properties, storage modulus (G’) and loss modulus (G”), for the individual sweeps can be seen to decrease with increasing temperature over this frequency range. Since polymer melts are viscoelastic, their mechanical response will be time dependent, so low frequency corresponds to long time behavior. Time Temperature Superposition (TTS) is used to widen the range of data to higher and lower frequencies and generate a Master curve at a reference temperature pertinent to the application. The polymer’s molecular structure dictates the magnitude and shape of the G’ and G” curves.

Themoset Cure Using Disposable Plate Kit

Changes in the viscoelastic properties of reactive systems provide valuable information about their processing and end-use properties. Often these materials can start in the form of a low viscosity liquid, a paste, or even a powder, and after reacting end as a high modulus solid. If the material hardens and adheres to the testing surface, low-cost disposable parallel plates are required for testing. The figure to the right shows the complex viscosity from a typical oscillatory temperature ramp and hold curing test conducted on a B-stage prepreg using 25 mm diameter disposable plates. The resin is impregnated on a woven glass matrix, which becomes part of the permanent high strength composite structure once the resin is cured. Upon heating, the resin softens until reaching a minimum viscosity, which is a very important processing parameter. If the viscosity is too high or too low, the resin will not flow or coat the matrix uniformly leaving voids, creating flaws in the composite. Eventually the viscosity starts building and the curing reaction takes off dramatically. The temperature is held constant at the processing temperature and the viscosity is monitored until the viscosity reaches a plateau indicating the completion of the reaction.
Solid Polymer Rheology Using Torsion Rectangular Clamps

The ETC oven has the ability to characterize the viscoelastic properties of rectangular solid samples up to 5 mm thick, 13 mm wide, and 50 mm long. The figure to the right shows an example of an oscillatory temperature scan on a solid ABS specimen run at 3 °C/min from -160 °C to 200 °C. The ABS is a copolymer that exhibits two glass transition temperatures: one at -81 °C associated with the Butadiene and one at 114 °C associated with Styrene. Transitions, or relaxations of molecular segments, are observed as step changes in the storage modulus (G’) and as peaks in the loss modulus (G”) and damping (tan δ). The magnitude and shape of these parameters will depend on chemical composition as well as physical characteristics (such as crystallinity, orientation, fillers, and degree of cross-linking).

Extensional Viscosity measurements with the SER2 attachment

The ETC is designed to accommodate the SER2 (Sentmanat Extension Rheometer) for extensional viscosity measurements of polymer melts. In the figure to the right, data are plotted for extensional viscosity measurements of standard LDPE 1810H at 150 °C at extensional rates from 0.02 to 3 s⁻¹ using the SER2. These results are compared to three times the corresponding low shear rate viscosity, which agrees well with the zero rate extensional viscosity prior to the onset of extensional thickening at different extension rates. In addition to extensional viscosity, the SER2 can also be used for solids tensile testing, tear testing, peel testing, friction testing, as well as high-rate fracture testing.