



# Petroleum Thermodynamic Research Group



Labs 6-128 & 6-133  
Chemical and Materials Engineering (CME) Bldg.



*The Petroleum Thermodynamic Research Group investigates the properties of hydrocarbon resources including reservoir fluids, heavy oils and bitumen. Our overall goal is to integrate quantitative materials property knowledge and theory from the molecular scale to the nanometer scale to the macro scale so that thermophysical properties, transport properties, and phase behaviors identified across these length scales are better understood.*

**Principal Investigator**  
**Dr. John Shaw**

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# Equipment Highlights include:

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## Differential Scanning Calorimeter

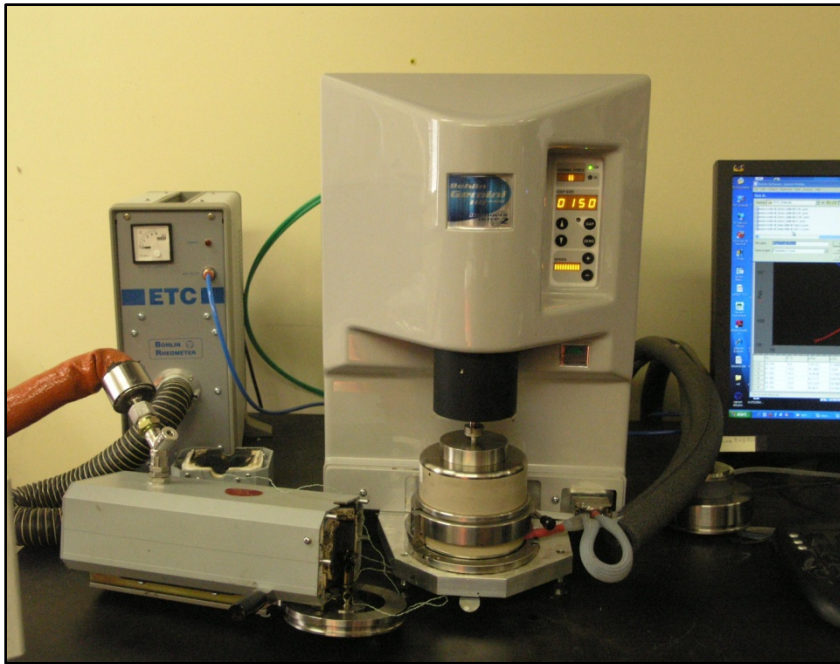


The TG-DSC 111 from Setaram can be operated from  $-100\text{ }^{\circ}\text{C}$  to  $600\text{ }^{\circ}\text{C}$ .

The unit can be used alone horizontally or vertically (DSC) for measuring heat capacity, phase transitions and enthalpy of mixing.

The DSC coupled to the microbalance (TG-DSC) is used for measuring mass change with temperature

## Gemini HR Nano Rheometer



A rheometer from Malvern with a broad range of operating conditions for temperature and shear rate.

The unit has the following configurations:

✓ Parallel Plate:

Temperature: (ETC ~liq. N<sub>2</sub>) -100 °C ~ 500 °C  
For moderate to high viscosity samples

✓ Double Gap:

Temperature: (Peltier ) -20 °C ~ 170 °C  
For low to moderate viscosity samples

✓ Parallel Plate:

Temperature: (Peltier ) -24 °C ~ 180 °C  
For moderate to high viscosity samples

## Nanofiltration Unit



✓The nanofiltration unit has been set-up to filter heavy oils (e.g., Maya oil, Athabasca Bitumen), vacuum residue and mixtures of asphaltenes in solvents.

✓The average pore diameters of the membranes used (gamma alumina or zirconia) range from 5 nm to 500 nm

✓The operation temperature range from room temperature to 200 °C.

✓Partially deasphalted oil (permeate) and asphaltene rich (retentate) are obtained.

✓Applications include sample preparation, asphaltene particle size

## X-Ray View Cell



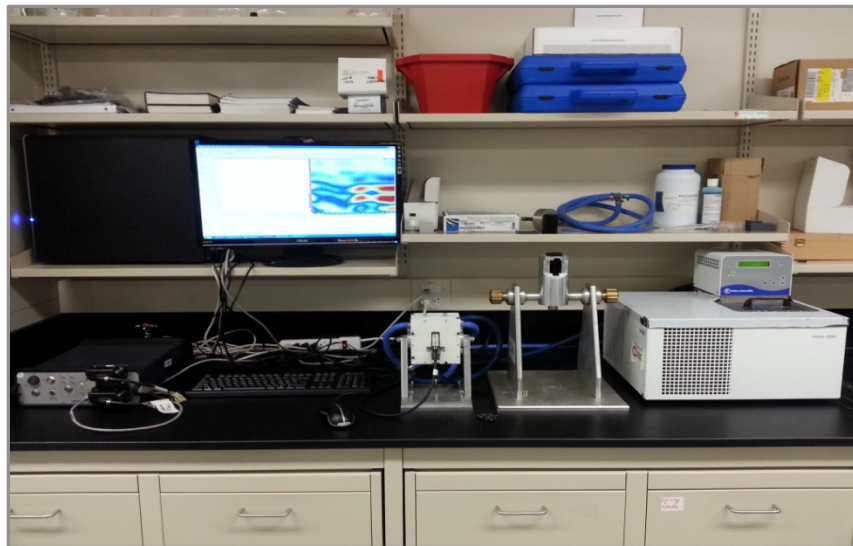
The x-ray view cell can be used for measurements with black oils:

- ✓ Phase behavior
- ✓ Phase density
- ✓ Phase volume
- ✓ Phase composition based on elemental analysis
- ✓ Mutual diffusion coefficient
- ✓ Gas solubility measurements

The operating window is up to 30 MPa and 740 K (467 °C).

The principle followed here is the same in the X-ray analyses for medical applications...

## Acoustic Cell



- ✓ Phased array acoustic measurements can be used to:
  - Investigate the phase behavior of opaque mixtures.
  - Measure phase distributions and mass transfer in porous media.
- ✓ Each acoustic probe has an array of 64 acoustic elements with a nominal frequency of 10 MHz.
- ✓ Each probe can send simultaneously 113 acoustic beams with a resolution of 0.3 mm
- ✓ Speed of sound and attenuation profiles can be measured along the height of the cell.
- ✓ Speed of sound maps of resolution 40  $\mu\text{m}$  can be generated at 8 minute intervals.
- ✓ Operational Temperature range= 0 - 45 °C

## Density Meter ~ DMA 5000



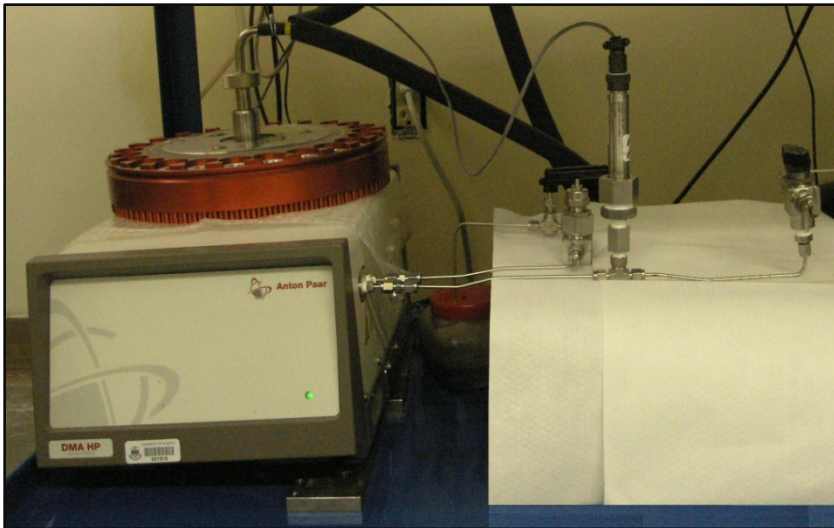
The DMA 5000 from Anton Paar

- ✓ Density range: 0 to 3,000 kg/m<sup>3</sup>
- ✓ Pressure range: 0 to 10 bar.
- ✓ Temperature: 0 to 90 °C
- ✓ Accuracy: 0.005 kg/m<sup>3</sup>

Automatic sample changer “SP-3m” that allows filling, cleaning and drying samples with a viscosity up to 1,000 mPa.s

There is an Optional heating attachment for samples with viscosities up to 30,000 mPa.s

## Density Meter~ DMA HP



For high pressure and/or high temperature conditions, we have the external density measuring cell “DMA HP” which is coupled to the DMA 5000.

- ✓ Density range: 0 to 3000 kg/m<sup>3</sup>
- ✓ Pressure range: 0 to 700 bar.
- ✓ Temperature: -10 to 200 °C
- ✓ Accuracy: 0.1 Kg/m<sup>3</sup>

This unit is recommended for:

- ✓ Studying the behavior of liquid and gases a high P & T in order to develop equations of state.
- ✓ For high viscosity samples
- ✓ For samples that present high melting points or require extreme measurement conditions.





## TAM III

TAM III is a microcalorimetric system from TA Instruments. Four independent calorimeters can be used simultaneously to perform repetitive or different types of experiments.

Currently, three calorimeters “Titration Calorimeter”, “Solution Calorimeter” and “Perfusion Calorimeter” have been acquired.

TAM III can be operated in isothermal, step-isothermal or temperature-scanning and the liquid bath temperature can be precisely controlled to within 0.0001 °C.



## PERFUSION CALORIMETER

- ✓ Liquids are injected using a peristaltic pump while gases can be perfused using a mass flow controller.
- ✓ The perfusion ampoule can be used to measure either the heat production rate from a flowing gas/liquid or the effect of the gas/liquid on a sample placed in the perfusion ampoule.
- ✓ It can be used up to 150 °C.

## PRECISION SOLUTION CALORIMETER

- ✓ The Precision Solution Calorimeter is a single-position, semi-adiabatic calorimeter for measurements of the heat generated or consumed when a solid or liquid sample is dissolved or diluted into a solvent.
- ✓ The instrument is used for determining enthalpies of mixing.
- ✓ It can be used up to 80 °C.

## TITRATION CALORIMETER

- ✓ Titration enthalpy measurements provide data on association and interaction of asphaltene in solution.

Perfusion Ampoule



Solution Calorimeter



## Standard High Pressure Cell



Standard pressure cell from Anton Paar for rheological measurements of samples with low to moderate viscosities a different pressures and temperatures.

- ✓ Pressure: up to 150 bar.
- ✓ Electrical heating: from room temperature to 300 °C
- ✓ Peltier: From -25 °C to 200 °C
- ✓ Measuring systems: Concentric cylinder, double gap and parallel plate

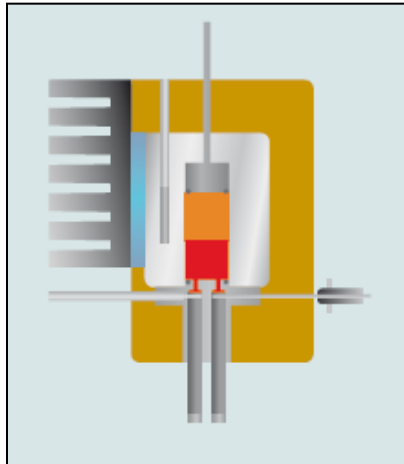
## Olympus GX71 Inverted Microscope



### Features:

- ✓ Easy to alternate between brightfield, darkfield, polarized light & fluorescence observation.
- ✓ High-resolution digital camera DP73 → 17.3 megapixel.
- ✓ Long working distance objective lenses: 5X, 10X, 20X, 50X & 100X.
- ✓ Advanced image analysis software for the digital images transferred to the PC.

## MINIVAP VPXpert-L: Pressure Vapor Unit

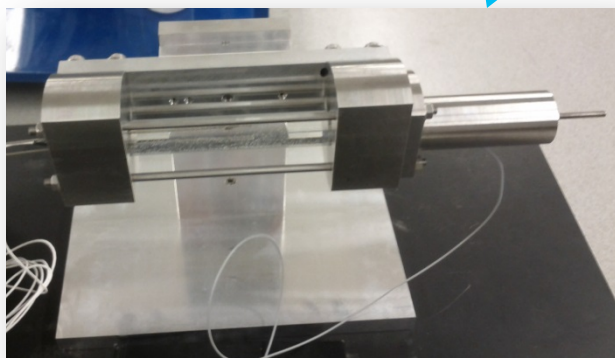


Automatic determination of the vapor pressure of low volatility compounds, gasolines and jet fuels

### Key features:

- ✓ Absolute vapor pressure determination (Static Triple Expansion Method)
- ✓ Temperature range: 20–120 °C
- ✓ Temperature stability:  $\pm 0.01$  °C
- ✓ Temperature profile: single temperature, stepped or ramped
- ✓ Pressure range: 0–100 kPa
- ✓ Pressure resolution: 0.01 kPa
- ✓ Uncertainty: Maximum 1.5 kPa
- ✓ Sample Volume: 1 mL

## Dynamic Pressure View Cell – under development



### Objectives:

- ✓ Observe the effect of pressure fluctuations (sound waves) on bulk fluids, at fluid interfaces and on particle translation/deformation.

### Features:

- ✓ Pressure transducer to measure resulting dynamic response.
- ✓ 10 bar design pressure
- ✓ Static to ultrasonic pressure fluctuations
- ✓ Fluid composition control through access tubes

# Acknowledgements

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