Not just products... Solutions!
iPore Porometers

The iPore is an advanced capillary flow porometer series, which yield accurate and reproducible data. The iPore series porometers require minimal operator involvement with considerably small test durations. The iPore porometers are designed for linear turbulence free flow of test gas, the pressure is measured closed to the sample thereby minimizing the correction in differential pressure measurement. iPore series has six different models to suit varying pore size ranges and flow rates. Each model has appropriate measuring system with pressure control, sensing, acquisition and data analysis software, sample holders, various unique upgrade options, accessory and consumable kit.

iPore Principle

iPore is based on capillary flow porometry, where a non toxic wetting liquid is allowed to spontaneously fill the pores in the sample and a non reacting gas is allowed to displace liquid from pores. First the largest pores will get emptied, as they require lower pressure than smaller pores. As the pressure is increased, more and more smaller pores are progressively emptied. The pressure and flow rate of gas through the emptied pores provides the through pore distribution. The pressure at which through pores empty is inversely proportional to the pore size. Through pores (fig.1) are the pores connected from one side of material to the other side. iPore capillary flow Porometer measures the pore throat diameter, which is the most constricted part of the entire pore path.

Fig.1 shows the through pores
Measurement Technique

The iPore series capillary flow porometry allows the user to obtain several parameters and information in single measurement. Generally, a measurement with the wet sample (impregnated with wetting liquid) is carried out first. It is normally known as the "wet run" and the representation of the gas flow vs. the applied pressure i.e. "wet curve" is obtained. After the wet run the measurement of the same sample in dry state is carried out in order to register and analogous "dry curve". The half-dry curve is calculated and represented by dividing the flow values with respect to the applied pressure by 2 and it is also represented in the same graphic. From the representation of the three curves it is possible to identify relevant information about the sample: the maximum pore size (or first bubble point) is recorded when gas flow through the sample is detected, the mean flow pore size corresponds to the pore size calculated at the pressure where the wet curve and the half dry curve meet (it corresponds at the pore size at which 50% of the total gas flow can be accounted), and the minimum pore size results from the pressure at which the wet and the dry curve meet (from this point onwards the flow will be the same because all the pores have been emptied).
Pore Characteristics

Bubble Point

The Bubble point is one of the preliminary but important attributes measured by iPore. The Bubble Point is defined by the ASTM F-316-03 standard as the pressure at which the first continuous gas bubbles are detected, this measurement corresponds to the largest (or maximum) pore size. Besides Bubble Point, iPore provides a comprehensive set of pore size and flow measurement to study the pore characteristics.

Pore Size

The pore size is calculated using Washburn equation:

\[ D = \frac{4 \gamma \cos \theta}{p} \]

Where:
- \( D \) = pore diameter
- \( \gamma \) = surface tension of liquid
- \( \theta \) = contact angle of liquid
- \( p \) = differential gas pressure

From measured pressure and flow rates, the pore throat diameters, pore size distribution, and gas permeability are calculated.

Here the pore diameter is assumed to be that of a cylindrical pore, for membranes and other materials the appropriate pore shape factor is provided in the Capwin software, which is a multiplier to the Washburn equation.

Pore Distribution

Pore distribution is calculated by

\[ f = -\frac{d[(fw/fd) \times 100]}{dD} \]

Where:
- \( fw \) = flow rate through wet sample
- \( fd \) = flow rate through dry sample

Fig.4 Pore size distribution
Pore Flow % Distribution

Pore Flow % Distribution also known as Pore size frequency is defined by ASTM Designation F 316-86 is the percentage flow through pores in a given size range.

% Flow through wet sample at pressure $p_j = (F_{wj}/F_{dj} \times 100)$

% Flow through wet sample at pressure $p_{j+1} = (F_{wj+1}/F_{dj+1} \times 100)$

% of flow through pores of diameter between $D_j$ and $D_{j+1} = [(F_{wj+1}/F_{dj+1} \times 100)] \text{ - } [(F_{wj}/F_{dj} \times 100)]$

Percentage flow through pores calculated in this manner from data in Fig.5(a) is presented as pore size frequency in Fig.5(b).

Pore Density

Pore Density can be expressed in terms of fractional pore number distribution, $f_N$

$$f_N = \frac{d[(N_j/\Sigma_{j}^{\infty}, N_j)]}{dD}$$

$$= [(f_{j+1}/\Sigma_{j}^{\infty}, f_j) \times 100 - (\Sigma_{j}^{\infty}, f_j) \times 100]/[-(D_{j+1} - D_j)]$$

The area under the fractional pore number distribution function in a pore diameter range gives the percentage of pores in that diameter range.
<table>
<thead>
<tr>
<th>SPECIFICATIONS</th>
<th>MODEL</th>
<th>iPore™ 1020</th>
<th>iPore™ 1050</th>
<th>iPore™ 1100</th>
<th>iPore™ 1200</th>
<th>iPore™ 1300</th>
<th>iPore™ 1500</th>
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<tr>
<td><strong>Model</strong></td>
<td></td>
<td>ASTM 316, others also</td>
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<tr>
<td><strong>Pore Size (min)</strong></td>
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<td>0.3 μm</td>
<td>0.1 μm</td>
<td>0.06 μm</td>
<td>0.03 μm</td>
<td>0.02 μm</td>
<td>0.013 μm</td>
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<tr>
<td><strong>Pore Size (max)</strong></td>
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<td>200 μm (upto 500μm with X option)</td>
<td>100 μm (upto 500μm with X option)</td>
<td>80 μm (upto 500μm with X option)</td>
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<td>20 psi</td>
<td>50 psi</td>
<td>100 psi</td>
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<td><strong>Flow Resolution</strong></td>
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<td>1 in 60,000</td>
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<td><strong>Sample Geometries</strong></td>
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<td>Sheets, rods, tubes, hollow fiber, cartridge, powder, etc</td>
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<td><strong>Sample Size Standard</strong></td>
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<td>5mm to 60mm dia upto 40mm thick</td>
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<td><strong>Large or Small Sample Size</strong></td>
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<td><strong>Pressure Regulator Switch</strong></td>
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<td>Auto</td>
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</table>
FEATURES

• 16 bit A/D Pressure sensor resolution
• Temperature compensated linear thermal mass flow sensor (upto 2 flow sensors)
• Flow sensor settling time of < 1 sec
• Flow sensor temperature coefficient (SPAN/ZERO) of < 0.05%/°C(15-60°C)
• Testing of small samples as well as complete parts
• Any sample geometry (Example: sheets, rods, tubes, hollow fibers, cartridges & powders) can be used with selection of appropriate sample holders (options available)
• Any nonwetting liquid
• Tests in QC, research or any number of user defined modes
• Real time graphic display
• Window based software for all control, measurements, data collection, data reduction and report preparation
• Automatic piston movement to close the chamber while starting the test
• Region of interest doesn’t change due to automatic piston movement
• Measurement of pressure close to the sample to minimize pressure drop correction
• Straight flow path avoiding turbulence
• Versatile sample chamber for a variety of samples and test modes
• Pore Structure characteristics:
  • Mean Pore Size
  • Pore Size Distribution
  • Pore Flow % Distribution
  • Pore Number Distribution
  • Bubble Point (the largest through pore throat diameter)
  • Bubble Point Mean flow pore diameter (50% of flow is through pores smaller than the mean flow pore)
  • Pore Surface Area
  • Gas Permeability in many desired units including Frazier, Gurley, Rayl & Darcy
  • Liquid Permeability
  • Diameter of the most constricted part of a through pore (Pore throat)
  • Unlimited Data Points

Fig.7 Sample Chamber
APPLICATIONS

• Filtration Industry

• Geotextiles/Textiles Industry

• Nonwovens Industry

• Paper Industry

• Pharmaceutical/Medical Industry

• Battery/Fuel Cells Industry

• Powder Metallurgy Industry

• Chemical Industry

• Biomolecular Engineering

• Ceramic Industry

• Automotive Industry
SOFTWARE

We work closely with our customers to provide the most user friendly software for porometry. PMI Capwin software is updated to meet customer needs & requirements. The comprehensive software can be used for all PMI porometers. The software is customized to offer convenient operation with default settings for beginners and full access to all relevant measuring parameters for advanced researchers.

• Capwin manages manual instrument control, automated measuring routines and report print out or graph
• Capwin Data manager for interactive evaluation of measured data as well as providing sophisticated tools for creating reports & generating templates for graphs, tables and screen views
• Capwin user manager for comprehensive user management regarding user access control
• Remote diagnostic from anywhere in the world
• Links to databases, outputs to: MS Excel, Text files, and other formats upon request
• User defined paths and sub directories for data filling

SALES & SERVICE

We at Porous Materials Inc., have dedicated sales team helping thousand's of our customers identify the right solution for their scientific problems. We are also proud to offer customized instruments for your unique needs. Our service and applications team is committed to effective support with short response times, we offer comprehensive range of solutions from new and customized systems, calibration and maintenance to testing services.
Explore more about us at www.pmiapp.com

Disclaimer: *We are continously improving our products, Design is subject to change without prior notice.
Additional function:

-X Extended Range (Extra Pressure Gauge): up to 4 set pressure gauge
-P Pneumatic clamp-on device
-E Extended Accuracy (Extra Flow Meter): up to 4 set Flow meter
-I Integrity Test
-S Surface Area/ Fiber Diameter
-CR Chemical Resistance Option (KOH)
-L Liquid Permeability (Penetrometer Type)
-ALD Automated Wetting Liquid Dispenser
-TL High Temperature for Liquid Permeability
-TG High Temperature for Gas Permeability
-F Frazier Permeability
-G Gurley Permeability
-R Rayles Permeability
-M Sheffield Smoothness Test
-N In-Plane
-CC Cyclic Compression Test
-C Compression Test
-HC Bubblers with Humidity Control
-B Burst Pressure Test
-H Hydrohead Test
-D Microflow (Low Flow)
-HF High Flow (up to 2,000 L/min)
Review Papers
Advances in Characterization Techniques: Krishna Gupta. Oral Presentation, 2004

Filtration Media and Membrane Industry
Characterization of Pore Structure of Nanopore Membranes: Dr. Akshaya Jena & Dr. Krishna Gupta. Achema, 2009
Homogeneity of Pore Structure Characteristics of Filtration Cartridges: Dr. Akshaya Jena and Dr. Krishna Gupta

Textiles, Geotextiles, and Fibers Industry
Pore Structure of Advanced Textiles: Dr. Akshaya Jena & Dr. Krishna Gupta
Customize your machine today!
The most advanced, accurate, easy to use and reproducible Porometers in the world