PORE SIZE
POROSITY
PORE ZETA POTENTIAL
INTRODUCTION

Many applications require rapid evaluation of pore size and porosity. A number of existing techniques are available for pore size measurement but might require many hours, cryogenic coolants and vacuum systems (gas sorption) or mercury and high pressures (mercury intrusion porosimetry), or are restricted to through-pores (porometry).

But now, the technique of electroacoustics is available for the rapid determination of mean pore size\(^1\) in a variety of sample types - without mercury, without vacuum pumps, without pressurized gases, and without the wait.

The fundamental method behind the mean pore size measurement is called the seismoelectric effect. An applied ultrasonic pressure wave causes the so-called electrical “double-layer” at the interface between the surface and a suitable liquid (i.e. low conductivity, for example water, polar or non polar organic) to shear, resulting in an oscillating current. When double layers overlap in pores, the seismoelectric effect depends on pore width.

The same seismoelectric effect is also employed to reveal the zeta potential of the surface inside the pore structure\(^1\). Propagation of ultrasound through a porous body creates motion of the given liquid, in this case one of high conductivity (to create isolated double-layers) inside of the pores relative to the solid matrix. This, in turn, causes relative motion of charges that are located in the diffuse layer and on the pore’s surfaces. This is expressed as an oscillating electric current called the Streaming Vibration Current.

The measurement of percent porosity uses very high frequency conductivity measurements\(^2\). And unlike direct current conductivity measurements, the high frequency oscillating current reveals the porosity of all pores - including dead-ended (blind) pores - not just those that form a connected pathway on a macroscopic scale.

\(^1\) Protected by U.S. Patents: U.S. Patent No: 8,281,662 B2 "Method for determining porosity, pore size and zeta potential of porous bodies"

\(^2\) Patent Pending: A1 20110012627 "Method for determining porosity with high frequency conductivity measurement"
MEASUREMENTS
All measurement modes are performed in a similar fashion, that is, the sample is fully wetted with a suitable fluid (water, organic solvent or electrolyte depending on the exact measurement to be done and pore size range of the sample) and then contacted by the appropriate probe (the probes can be used in any orientation to facilitate ease of use). The electronics and measuring circuits do the rest. Results are displayed on screen in a minute or two and saved to the database.

APPLICATIONS
There is no fundamental limitation as to the type of material that can be analyzed using the WAVE analyzers so long as the sample is stable with respect to the fluid used to wet the pores, and for pore size that they are within the range of the technique.

Typical applications include green and fired ceramics, core samples, chromatography silicas and resins, tablets, battery components, friction products, frits, cement and other construction materials, to name but a few.

SOFTWARE
The WAVE analyzers are supplied with Windows®-based software for control, data acquisition and report generation, and which runs on the control module so a separate PC is not required. The WAVE software features an easy-to-use interface, prompted calibration procedures, a defined materials database and real-time data capture. Data are stored in database format and can be output in popular .csv format.

SPECIFICATIONS

<table>
<thead>
<tr>
<th></th>
<th>WAVE 3805</th>
<th>WAVE 2305</th>
<th>WAVE 1905</th>
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<tbody>
<tr>
<td>MEAN PORE SIZE</td>
<td>3805</td>
<td>2305</td>
<td>1905</td>
</tr>
<tr>
<td>Measuring principle</td>
<td>Electroacoustics (seismolectric effect)</td>
<td>Conductivity (very high frequency)</td>
<td>Conductivity (very high frequency)</td>
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<tr>
<td>Mean pore size (min)</td>
<td>~10 nm</td>
<td>0.1 nm</td>
<td>0.1 nm</td>
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<tr>
<td>Mean pore size (max)</td>
<td>&gt;5 µm (5000 nm)</td>
<td>no restriction, + or -</td>
<td>no restriction, + or -</td>
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<tr>
<td>Repeatability</td>
<td>&lt;1%</td>
<td>&lt;1% absolute</td>
<td>&lt;1% absolute</td>
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<tr>
<td>POROSITY</td>
<td>3805</td>
<td>2305</td>
<td>1905</td>
</tr>
<tr>
<td>Measuring principle</td>
<td>Conductivity</td>
<td>Conductivity</td>
<td>Conductivity</td>
</tr>
<tr>
<td>Porosity (resolution)</td>
<td>0.5%</td>
<td>no restriction, + or -</td>
<td>no restriction, + or -</td>
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<tr>
<td>Porosity (accuracy)</td>
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<td>Repeatability</td>
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<td>±(0.1 + 0.5%)</td>
<td>±(0.1 + 0.5%)</td>
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<td>Conductivity</td>
<td>0.001-10 S/m, ± 1%</td>
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<td>PORE ZETA POTENTIAL</td>
<td>3805</td>
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<td>Measuring principle (zeta potential)</td>
<td>Non-isochoric streaming current (seismolectric effect)</td>
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<td>Zeta potential (max)</td>
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<td>Zeta potential (resolution)</td>
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<tr>
<td>Height</td>
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<td>12.5 cm (4.5 in)</td>
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<tr>
<td>Width</td>
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<td>Depth</td>
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<tr>
<td>Weight</td>
<td>20 kg (44 lbs)</td>
<td>4 kg (9 lbs)</td>
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<td>ELECTRICAL</td>
<td>Universal input</td>
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<tr>
<td>Voltage</td>
<td>100-240 VAC</td>
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<tr>
<td>Frequency</td>
<td>50/60 Hz</td>
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