Pore Size Measurement of Track Etched Membranes by Capillary Flow Porometry

Relevant for: through pores, membranes, porometry, and filtration

Capillary flow porometry is ideal for the pore size measurement of track etched membranes because these materials usually have almost a perfect cylindrical pore structure from one side to the other. The results of testing five different track etched membranes with the Porometer 3G series of instruments are described.

1 Introduction

Track etched membranes (TEMs) are ultra-thin, well-regulated membranes that have been traditionally used for high specification filtration in laboratory applications. These plastic films have discrete pores that are formed through a combination of charged particle bombardment (or irradiation) and chemical etching. The etching process involves passing the *tracked* film through a number of chemical baths, creating a clean, regulated membrane with good precision in terms of pore size. This etching process determines the size of the pores, with typical pore sizes ranging from 20 nm to 14 µm. Polymers commonly employed are polycarbonate (PC) and polyethylene terephthalate (PET), but some TEMs are also manufactured using other polymers (e.g., polyvinylidene fluoride).

Typical membrane thicknesses are between 10 and 20 µm, controlled to within +/- 1 µm with roughness not exceeding 50 nm (peak to valley). Pore size is usually between -20 to 0% of the stated pore size, with a typical intra-lot coefficient of variance for pore size between 2-3%. In addition to pore size, pore density (or porosity) can also be controlled, typically ranging from 1×10^{-5} to 6×10^{8} pores/cm^2 and can vary within certain limits in relation to pore size. The internal shape of the pores can also be closely controlled to allow the formation of a truly cylindrical structure. A scanning electron microscopy (SEM) image of a membrane is shown in Figure 1.

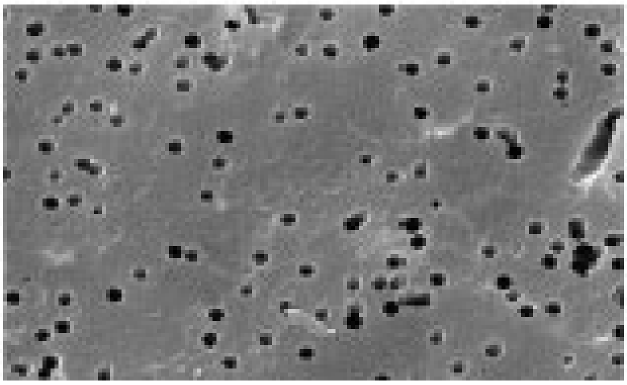

Figure 1: SEM image of a track etched membrane.

The variety of tightly controlled pore sizes that can be produced allows TEMs to be used for a multitude of applications, not just simple filtration. For example, they are increasingly important for diagnostic tests as the narrow pore size distribution allows cells of a specific size to be captured on the membrane surface yielding improved accuracy. Similarly, the distinct pore size of TEMs enables the use of latex-bound capture agents, or antigen-caused agglutinations of known sizes to be selectively retained on the membrane. Specific examples include healthy red blood cells (erythrocytes) which are highly flexible and will readily deform in order to pass through a small opening. In certain blood disorders, erythrocytes lose much of their ability to flex such that they can no longer pass through small apertures such as the pores in a TEM. Also, biosensors require controlled liquid migration rates, so a properly chosen TEM yields the correct flow of liquids or gases through the membrane to the sensor *and* prevents potential contaminants from reaching the sensor surface.

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2 Measurement

A series of five polyester membranes, produced by ion-beam technology, was measured at different pressure ranges to ensure maximum data resolution for each nominal pore size (0.1, 0.2, 0.4, 0.5, and 0.8 µm). All samples were measured using the standard 25 mm diameter sample in the standard sample holder using Porofil wetting fluid. Detailed parameters are given in Table 1.

Table 1: Parameters for TEM measurements via capillary flow porometry

	P-1	P-2	P-4	P-5	P-8
Sample Thickness (µm)	8.0	23.0	12.0	8.0	23.0
Sample Diameter (mm)	25	25	25	25	25
Measured Sample Area (cm^2)	2.1900	2.1900	2.1900	2.1900	2.1900
Fluid Name	Porofil	Porofil	Porofil	Porofil	Porofil
Fluid Density (kg/m^3)	1850	1850	1850	1850	1850
Surface Tension (dyn/cm)	16	16	16	16	16
Contact Angle (°)	0.00	0.00	0.00	0.00	0.00
Size Constant	0.64	0.64	0.64	0.64	0.64
Pore Tortuosity	1	1	1	1	1

3 Results

The wet and dry runs for each of the five membranes are overlaid in Figure 2 and the calculated characteristic pore properties are given in Table 2. Pore size distributions are shown in Figure 3 and Figure 4.

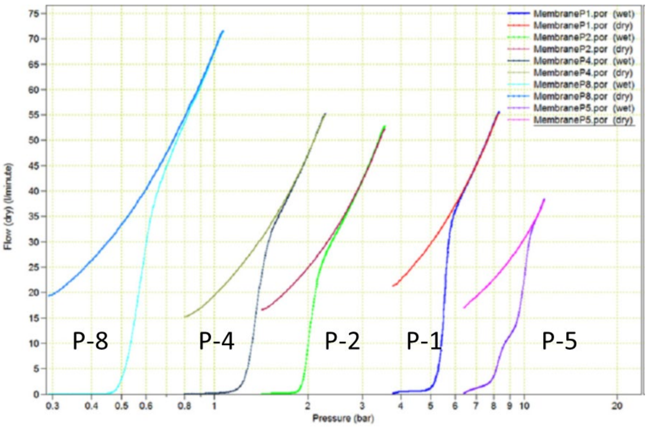

Figure 2: Wet and dry flow vs. pressure for track etched membranes.

Table 2: Measured pore properties of track etched membranes

	P-1	P-2	P-4	P-5	P-8
Maximum Pore Size (µm)	0.168	0.439	0.783	0.097	1.920
Mean Flow Pore Size (µm)	0.116	0.314	0.472	0.068	1.129
Minimum Pore Size (µm)	0.080	0.189	0.295	0.057	0.636
Bubble Point Pressure (bar)	3.800	1.455	0.817	6.420	0.333
Bubble Point Flow Rate (l/min)	0.558	0.118	0.018	0.034	0.117

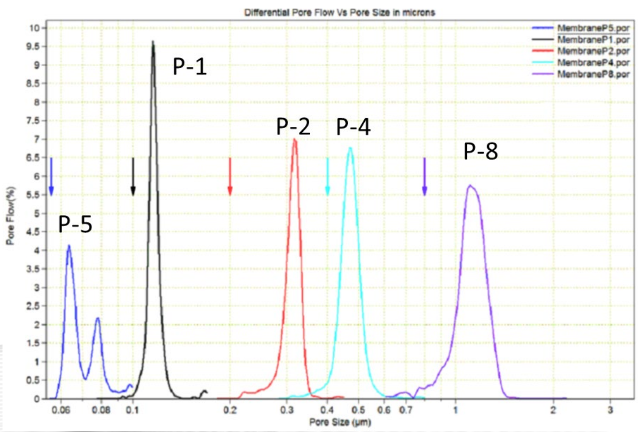

Figure 3: Differential percent flow vs. pore size. Manufacturers nominal pore sizes are indicated by the arrows.

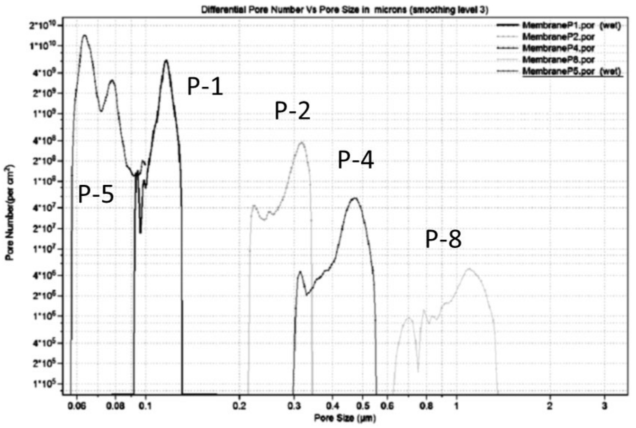

Figure 4: Differential pore number per unit area vs. pore size. The larger the pore, the fewer of them there are.

The pore size range is, as expected, very narrow for all samples (Figure 3). However, P-5 unexpectedly has a bimodal pore size distribution. The nominal pore sizes given by the membrane manufacturer, shown by the arrows in Figure 3, correspond closely to the smallest pores measured in each case. This suggests that these TEMs are classified by bubble point diameter and not the modal diameter, which is significantly larger than the nominal value in all cases, whether defined in terms of flow (Figure 3) or number of pores per unit area (Figure 4).

4 Conclusions

Capillary flow porometry using the Porometer 3G series is perfectly suited for pore size measurement of the through pores in TEMs. While classified typically by the minimum pore size, information about the entire distribution of pores may be more relevant and necessary information for manufacturers and users of TEMs.

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