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Advanced Imaging and Separation Tools Based on Ultra-thin Porous Silicon Membranes

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A new class of ultra-thin membranes facilitates the development of imaging and separation tools for nanomaterials [1]. The UltraSM® membrane is comprised of porous nanocrystalline silicon (pnc-Si). It is unique in its combination of nanoscale thickness (5-30 nm) and tunable pore sizes in the range of 5 to 100 nm. Standard commercial separation membranes with pores in this size range are polymeric materials (polyether sulphone, cellulosic, etc.) microns in thickness, leading to pore morphologies that resemble long narrow tubes or tortuous-path 3-D matrices. UltraSM® material is 1/1,000x the thickness of polymeric membranes and has precisely controlled size nanopores. As a result, flow rates are 10X faster than for conventional membranes. These characteristics permit more precise separation of nanomaterials.

SiMPore has incorporated the UltraSM® membrane into the SepCon™ Spin Column for nanoparticle separation. Nanoparticles of interest are typically between 3 and 30 nm in size. Conventional PES or cellulose membrane separation devices can concentrate, but not separate, nanoparticles in this range. In addition, the thickness and tortuous paths of conventional membranes can result in sample loss. SepCon™ Spin Columns allow nanoparticle researchers to confidently clean-up nanoparticles after synthesis and prepare samples for further analysis. Results of high yield, precise separation of gold nanoparticles will be shown as an example of the SepCon™ Spin Column's performance.

Porous UltraSM® membranes also provide a platform for cell culture and imaging devices. For example, current cell co-culture devices separate cell layers by high surface-area, microns thick membranes leading to prolonged diffusion times and potential loss of low abundance signaling molecules. With porous UltraSM® membranes, co-culture of two cell populations is possible on opposing sides of the membrane enabling cellular communication and imaging of both cell types. Millions of nanopores and the lack of appreciable membrane thickness (15-30 nm) allow molecules to diffuse easily. The excellent optical characteristics of the UltraSM® membrane permit high-resolution optical and fluorescent imaging of both cell populations as well. Images from representative cultures will be shown.

Porous UltraSM® membranes are also available in a format convenient for preparation of transmission electron microscopy samples. The nanopores allow background-free imaging and analysis of nanomaterials by simple suspension across open pores. Non-porous / amorphous UltraSM® membranes offer lower chromatic blur than ultra-thin carbon membranes, with the added advantage of plasma cleanability to remove organic contaminants. A range of TEM images of samples prepared on UltraSM® membranes will be presented.

References

[1] C.C. Striemer, *Nature*. 445 (2007) 749.

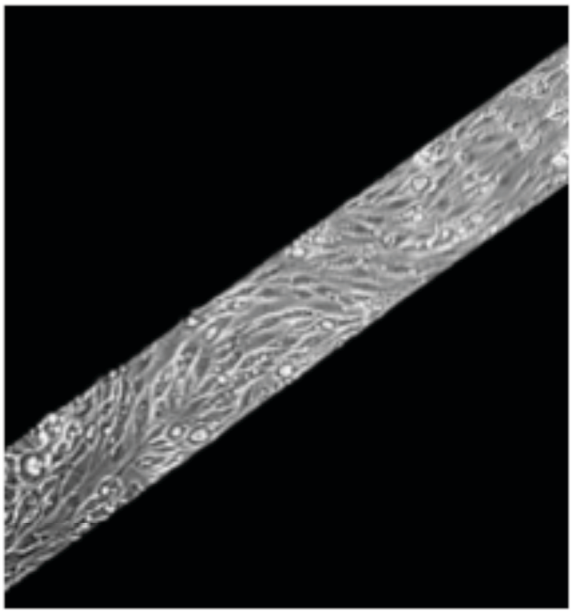

FIG. 1. bEnd3 endothelial cells on UltraSM® pnc-Si membrane, enabling visualization of cell morphology and intracellular detail. Image courtesy of Barrett Nehilla PhD., University of Rochester.

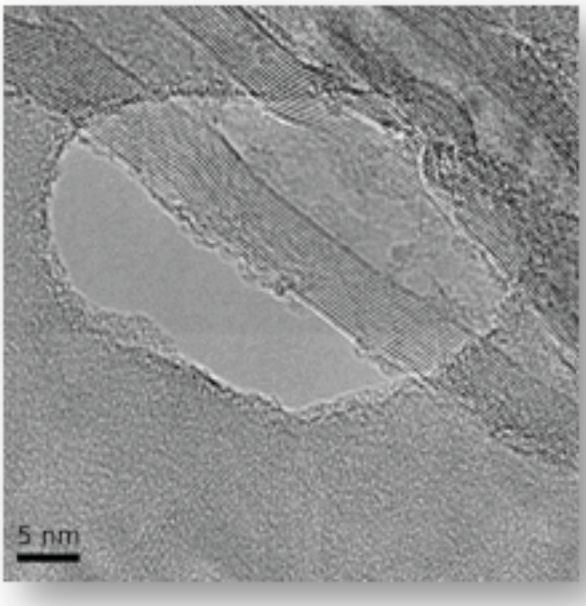

FIG. 2. Multi-walled carbon nanotubes suspended over a 15 nm thick nanoporous UltraSM® window. Image courtesy of Brian McIntyre, University of Rochester.

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