USANS Study of Porosity and Water Content in Sponge-Like Hydrogels

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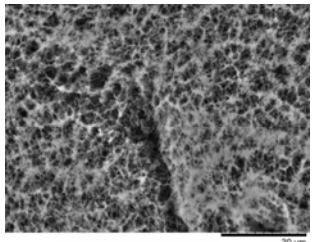
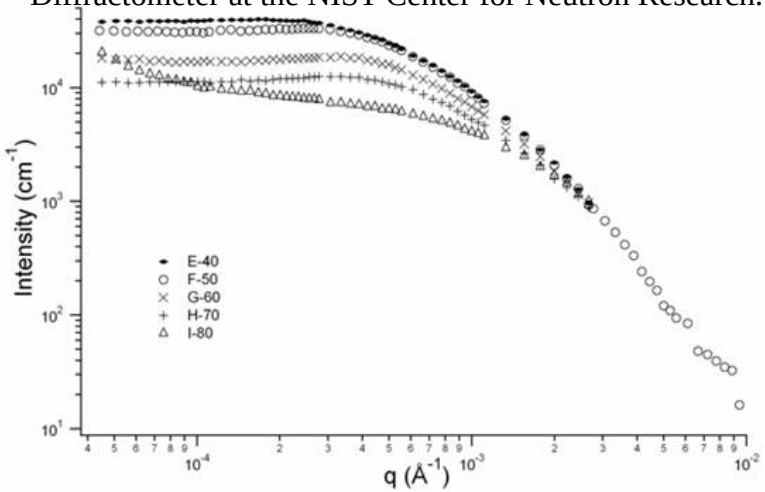
1 Our study examined swelling behavior of porous, sponge-like hydrogels of poly(hydroxyethylmethacrylate). Micrometer-scale pores were introduced by leaching out 40 to 80 mass % of a water-soluble, polymeric porogen.

Water-swollen state *Dry, extracted state*



Low-vacuum SEM image, partly hydrated state

2 Gels were swollen in D_2O and characterized by ultra-small angle neutron scattering (USANS) using the BT5 Perfect Crystal Diffractometer at the NIST Center for Neutron Research.



3 An analytical model was developed which relates the neutron scattering invariant to chemical composition and swelling behavior.

$$\phi_{1s} = \frac{M_s - M_{ex}\hat{Q}_h}{M_s + (\rho_{H2O}M_{ex}/\rho_p) - M_{ex}}$$

$$Inv = 2\pi^2\left(\frac{\rho_{D2O}/\rho_p}{(\rho_{D2O}/\rho_p)+(\hat{Q}_d - 1)}\right)^2 \left(SLD_{D2O} - SLD_p\right)^2 \phi_{1s}(1-\phi_{1s})$$

M_s= gel's swollen mass in H_2O ; M_{ex}=gel's dry mass after extraction

$\hat{Q}_h$ = gel's swollen mass in H_2O (*excluding* water in pores) divided by its dry mass, M_{ex}.

$\hat{Q}_d$ is defined similarly, except for swelling in D_2O

ρ_{D2O}, ρ_p: mass densities of D_2O and polymer

SLD_{D2O}, SLD_p: neutron scattering length densities of D_2O and polymer

ϕ_{1s} : volume fraction of pores, water-swollen state

Inv: neutron scattering invariant, $Inv = \int_0^\infty q^2 I(q)dq$

4 The neutron invariant analysis allowed us to calculate the pore volume fraction in the water-swollen state and the water content within the gel phase, important quantities which are *not readily accessible to other experimental techniques.*

5 New synthetic methods were developed to produce porous elastomers using electrospun polymer microfibers as a sacrificial porogen phase. Future USANS studies will examine effects of stretching on pore dimensions and volume fraction.