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Modeling, shape analysis and computation of the equilibrium pore shape near a PEM–PEM intersection

We study the equilibrium shape of an interface that represents the lateral boundary of a pore channel embedded in an elastomer. The model representing this phenomena consists of a system of PDEs, comprising a linear elasticity equation for displacements within the elastomer and a nonlinear Poisson equation for the electric potential within the channel (filled with protons and water). To determine the equilibrium interface, a variational approach is employed. We analyze: (i) the existence and uniqueness of the electrical potential, (ii) the shape derivatives of state variables and (iii) the shape differentiability of the corresponding energy and the corresponding Euler–Lagrange equation. The latter leads to a modified Young–Laplace equation on the interface. This modified equation is compared with the classical Young–Laplace equation by computing several equilibrium shapes, using a fixed point algorithm.