Supporting Information


Implantable Silk Composite Microneedles for Programmable Vaccine Release Kinetics and Enhanced Immunogenicity in Transcutaneous Immunization

Peter C. DeMuth, Younjin Min, Darrell J. Irvine,* and Paula T. Hammond*
Supplemental Information for:

Implantable silk composite microneedles for programmable vaccine release kinetics and enhanced immunogenicity in transcutaneous immunization

Peter C. DeMuth¹#, Younjin Min²#, Darrell J. Irvine¹,3-7, and Paula T. Hammond²-4

¹Department of Biological Engineering, Massachusetts Institute of Technology (MIT), Cambridge, Massachusetts, 02139 USA

²Department of Chemical Engineering, MIT, Cambridge, MA, USA

³Koch Institute for Integrative Cancer Research, MIT, Cambridge, MA, USA.

⁴Institute for Soldier Nanotechnologies, MIT, Cambridge, Massachusetts, 02139 USA.

⁵Department of Materials Science and Engineering, MIT, Cambridge, Massachusetts, 02139 USA.

⁶Ragon Institute of MGH, MIT, and Harvard, Charlestown, Massachusetts, 02129 USA.

⁷Howard Hughes Medical Institute, Chevy Chase, Maryland, 20815 USA.

# P.C.D. and Y.M. contributed equally to this work.

Correspondence should be addressed to D.J.I. (djirvine@mit.edu) and P.T.H (hammond@mit.edu)
Supplemental Figure 1 | Composite microneedles give effective cutaneous delivery. Reconstructed confocal x-y/x-z/y-z images depicting the microneedle application site showing deposition of cargos within the cutaneous tissue (AF647-OVA – blue, AF555-OVA – red, overlay – pink, scale bar 200 μ m).
Supplemental Figure 2 | Microneedle vaccination gives enhanced effector function. Flow cytometry analysis of inflammatory cytokine expression following ex vivo antigen stimulation of PBMCs. Shown are representative cytometry plots of IFNγ+TNFα+ CD8+ T cells measured on day 14.
Supplemental Figure 3 | Single microneedle vaccination gives comparable cellular immunity relative to prime-boost injection. Mice were vaccinated on day 0 and 35 by i.d. injection, or on day 0 by microneedle treatment (+methanol to cross-link silk implants) to deliver 9 μg OVA and 150 ng polyI:C. Microneedles were fabricated with 98% of the total vaccine dose in the PAA fraction, with the remaining 2% in the silk implant (MN PAA(98)/MeOH-Silk(2)). Flow cytometry analysis of antigen-specific CD8$^+$ T cell proliferation and cytokine secretion in peripheral blood. Shown is quantitative analysis of peak SIINFEKL-tetramer$^+$ CD8$^+$ T cell frequencies for 14 days following either prime or boost immunization (left) and frequencies of IFNγ$^+$ among CD8$^+$ T cells on day 14 post prime/boost following in vitro restimulation with SIINFEKL (right).
Supplemental Figure 4 | Silk is non-immunogenic. Mice were vaccinated on day 0 by microneedle treatment (±methanol to cross-link silk implants) to deliver 9 μg OVA and 150 ng polyI:C. Microneedles were fabricated with 98% of the total vaccine dose in the PAA fraction, with the remaining 2% in the silk implant (MN PAA(98)/Silk(2) and MN PAA(98)/MeOH-Silk(2)). Shown are anti-Silk or anti-OVA (representative positive responses) serum dilution curves for naïve serum and MN PAA(98)/MeOH-Silk(2) immunized animals.