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Magnetically Actuated Artificial Cilia with Controlled Length and Areal Density JASON BENKOSKI, JENNIFER BREIDENICH, MICHAEL WEI, GUY CLATTERBAUGH, Johns Hopkins University APL, PEI-YUIN KENG, JEFFREY PYUN, University of Arizona — Artificial cilia have been explored for use in microrobotics, MEMS, and lab-on-a-chip devices for applications ranging from micromixers, microfluidic pumps, locomotion, acoustic detection, and heat transfer. We have previously demonstrated the ability to assemble dense brushes of magnetically actuated artificial cilia from the dipolar assembly of 24 nm ferromagnetic cobalt nanoparticles. Despite areal densities exceeding 1 cilim/μm^2, diameters below 25 nm, aspect ratios exceeding 400, and flexural rigidities below 3 x 10^{-28} Nm^2, these seemingly delicate structures resist collapse upon each other or the underlying substrate. The current study demonstrates the ability to rationally control their average length and areal density by changing the nanoparticle concentration and the dimensions of the rectangular capillary tube. We find that the length and areal density obey a simple conservation of mass relationship with concentration and capillary height such that the product of the former equals the product of the latter. Detailed statistical analysis supports a mechanism in which the role of the external field is to align pre-existing chains with the external field, assist stacking of chains along the axis of the field, and then draw them towards the ends of the permanent magnets, where the magnetic field gradient is steepest.

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