Globally Aligned Single-Wall Carbon Nanotube Films through Electrostatic Ordering

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The one-dimensional nature of single-wall carbon nanotubes (SWCNTs) creates unique, anisotropic optical, electrical, and thermal characteristics. To utilize these anisotropic properties, researchers must be able to easily and reproducibly fabricate aligned SWCNT structures. To be most useful, SWCNT alignment protocols must incorporate solution-based nanotubes, as they provide the highest quality (chiral enrichment, length sorting, tube filling, etc.) nanotubes [1] which are necessary for applications.

We expanded [3] upon the slow-filtration SWCNT alignment technique [2] through automation and parallelization. Such advances not only provided increased film reproducibility and throughput, but also enabled a rapid optimization of the complex parameter space to produce the highest aligned films to date. Furthermore, this work provides researchers with a new capability to investigate the underlying physics driving alignment. We find that by controlling flow rate, flattening the meniscus, and membrane buffing, we can repeatably and automatically produce globally aligned SWCNT films. Using polarized spectroscopy, we show that high, two-dimensional nematic ordering ($S_{2D} \approx 0.9$) of SWCNTs can be achieved [3]. Experiments altering the ionic strength and membrane surface charging suggest that this ordered SWCNT phase is driven by linear charging on the membrane and inter-nanotube electrostatic interactions.

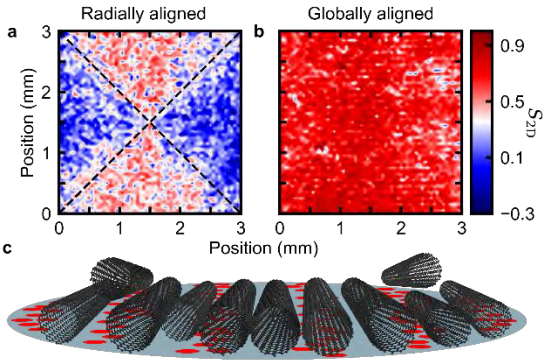

Figure 1. a) Spatial map of nematicity (S_{2D}), showing radial nanotube alignment. b) Spatial map of nematicity indicating global SWCNT alignment after meniscus flattening and membrane charging. c) Depiction of the membrane surface/SWCNT-dispersion interface showing quasi-linear charging.

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[3] Walker, J., et al., "Global alignment of solution-based single-wall carbon nanotube films via machine-vision controlled filtration". *Nano Lett*., **2019**, Article ASAP.