DMR-1420541

2018

SUPER-SEED:
Engineering of Structured Soft Materials

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New SEED addressing the engineering of self-assembled soft materials

1. Phase-separated liquids composed of many components are a material science question that is now recognized as important in cell biology.

Theory provides a framework for how a large number of interacting components can produce multiple phase-separated domains.

Figure description:

a) Hierarchically packed liquid-like nucleolar sub-compartments observed in X. laevis nuclei.

b) Phase diagram for one realization of a three component system, where interaction energies between components were randomly drawn from a Gaussian distribution.

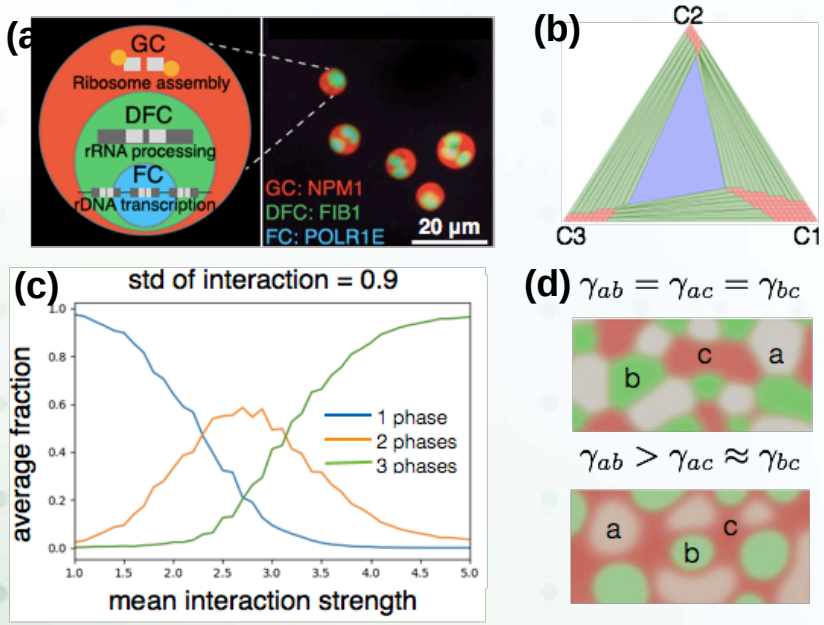
c) Average fraction of phase space that corresponds to 1, 2, 3 phase coexistence regions as function of the interaction energy parameters.

d) Different types of packing structures of three coexisting phases (white, green, red) in 2D, which depend on the surface tensions.

Phase behavior of multi-component systems

Red, green and violet: 1, 2, and 3 phase coexistence regions, respectively.

Feric et al. 2016



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2. Existing ideas: Self-assembly is generally studied at nanometer and colloidal length scales.

The team uses microfluidic fabrication, experiments and theory to study assembly of oppositely charged soft components at the scales of 10s – 100s microns.

Demonstrated wrapping dynamics/assembly.

Figure description:

(a) Overlaid time sequence of wrapping behavior with adjacent graph showing fiber length varying linearly with time.

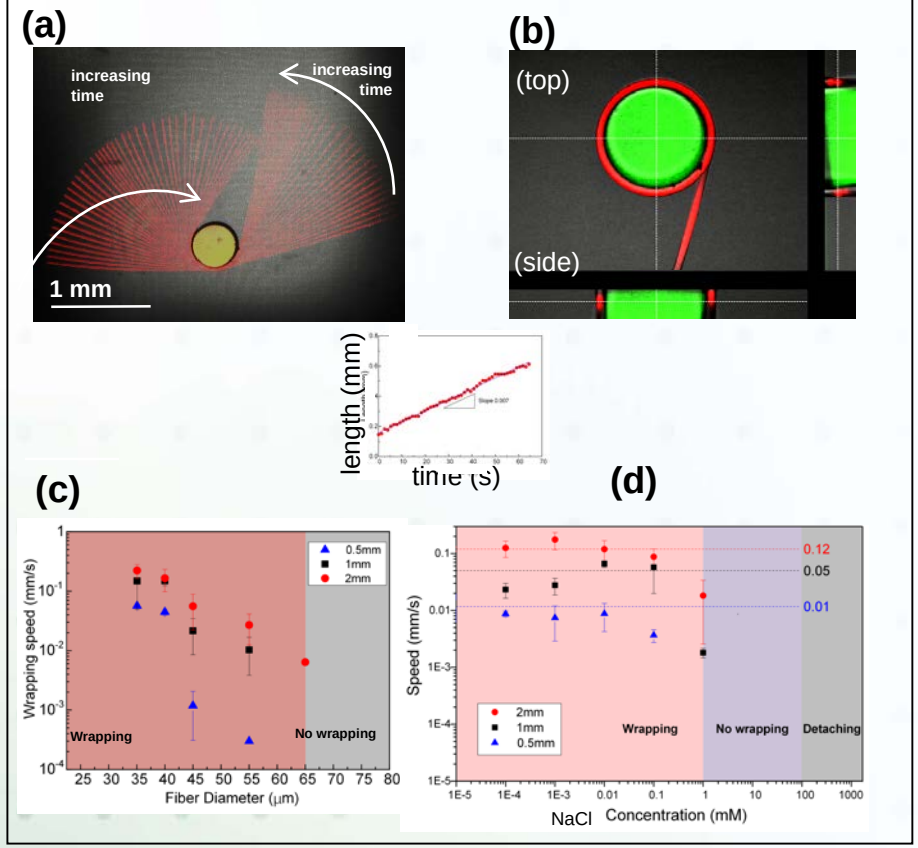
(b) Final wrapped aggregate.

(c) Rate of wrapping increases with increasing disk diameter and decreasing fiber diameter.

(d) Wrapping rate decreases with increasing concentration of NaCl in solution. Distinct regimes identified: (1) spontaneous wrapping, (2) adhesion with no wrapping and (3) easy detachment of fiber from disk.

Theory in development for transition from “no wrapping” to “wrapping”: occurs when bending energy is balanced by the attractive electrostatic energy, and wrapping proceeds when the electrostatic energy significantly exceeds bending energy.

Spontaneous fiber wrapping: charged hydrogel microfiber onto an oppositely charged hydrogel disk particle.



*collaboration with J. Li, Univ. Sci. Tech. Beijing

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The Seed team engaged in many of the PCCM MRSEC activities, including poster sessions, the REU program, integrating undergraduates into research activities, and outreach events at the Princeton Public Library and in Trenton (photos at right).

May 2017: Northeast Complex Fluids and Soft Matter Workshop at Princeton (120 participants)

Sept. 2017: Led internal Princeton workshop on future IRG themes related to new directions in soft matter.

Dec. 2017 (photos on right): Led annual Holiday lecture, including demonstrations and activities; Theme = chocolate (a popular soft material!)

Soft matter themes involving pattern formation and gels makes the NY Times Science section.

Holiday lecture 2017

Soft matter from Princeton in the press (NY Times Dec. 2017)

Outreach at the Princeton Public Library and the PUMA Academy

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