Polymer Physics
HW 12
April 8, 2022 (Due April 12)

Zhang Z-H, Andreassen BJ, August DP, Leigh DA, Zhang L, *Molecular weaving* Nat. Mat. **21** 275-283 (2022) is a review of the manufacture of molecular fabrics for potential applications as filtration membranes, high strength materials, and 3d molecular structures. These chemical structures are based on entanglements, Box 1, which can be regulated by ionic interactions then secured by covalent bonds or can be randomly introduced.

a) Figure 3 shows four models for molecular-level entanglements one of which we discussed in class, the tube model. The other three models bear resemblance to the structures introduced by ionic interactions shown in Figure 2. Explain the difference between the tube model and the three alternative models by looking at slip-link (Ref. 45); slip-spring (Ref. 48); and the topological model (Ref. 51 and 52).
b) What problems with the tube model are addressed by each of these alternative models.
c) Reference 38, August DP, Dryfe RAW, Haigh SJ, Kent PRC, Leigh DA, Lomonnier J-F, Li Z, Muryn CA, Palmer LI, Song Y, Whithead GFS, Young RJ *Self-assembly of a layered two-dimensional molecularly woven fabric* Nat. **588** 429-436 (2020) shows a filtration device produced from "orthogonal-chemistry", Figure 5. Explain what is meant by orthogonal chemistry and how it relates to the concept of entanglement. Which model, if any, from part a would be appropriate for this structure?
d) Polymer "fabrics" in the sense of Zhang's paper would seem to exist in nature in the form of β-sheet proteins and single polymer crystals, and perhaps π-π bonded structures such as asphaltenes. Compare these existing structures with those proposed in this paper.

Unrelated question:

e) A concise review of polymer rheology was recently given by Langevin D *Motion of small bubbles and drops in viscoelastic fluids* Curr. Opin. Coll. Interf. Sci. **57** 101529 (2022). Equation (3) describes the viscosity of moderate volume fractions of a dispersion of particles using the Krieger formula. This formula differs significantly from the definition of intrinsic viscosity. Explain the origin of the Krieger formula by considering Krieger's original paper, Dörr A, Sadiki A, Mehdizadeh A *A discrete model for the apparent viscosity of polydisperse suspensions including maximum packing fraction* J. Rheo. **57** 743-765 (2013), and Hsueh CH, Wei WCJ *Analyses of effective viscosity of suspensions with deformable polydisperse spheres* J. Phys. D: Appl. Phys. **42** 075503 (2009).