

Mechanical Properties of a Prokaryotic Actin-like Filament

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Recent work has identified homologs of actin and tubulin in bacteria. As in eukaryotes, these proteins form polymers required to maintain cell shape; transport cargo through the cytoplasm; and organize intracellular compartments. Understanding the mechanical properties of the eukaryotic polymers has helped explain the molecular mechanisms underlying their cellular functions. At present, almost nothing is known about the mechanical properties of prokaryotic cytoskeletal polymers. Using fluorescence microscopy of labeled proteins, we measured the flexural rigidity of actin-like filaments formed by the plasmid-encoded protein ParM. Assembly of ParM filaments pushes plasmids to opposite poles of rod-shaped cells in a process analogous to the chromosome segregation function of microtubules. We determined a persistence length of approximately 10 μm for freely fluctuating filaments formed from a non-hydrolyzing ParM mutant. In addition, we determined a persistence length of 20 μm for ParM filament bundles formed in the presence of parC and ParR. The persistence length of an individual ParM filament is similar to that of a eukaryotic actin filament – approximately 4–5-fold larger than the length of a bacterium. This result suggests that individual filaments may be stiff enough to segregate pairs of plasmids in vivo and that spontaneous bundling observed in the presence of parC and ParR does not contribute significantly to stiffening the structure. In contrast to ParM, the persistence length of a microtubule is more than 1000-times longer than the diameter of a yeast cell. This suggests that, in addition to its stripped-down regulatory system, the mechanics of the ParM spindle also represent a minimalist solution to the problem of DNA segregation.