Analysis of Stochastic Polymerization Dynamics

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Polymerization of actin filaments is the underlying mechanism of various biological processes such as cell growth and motility. In order to analyze the dynamics of the polymerization process and to examine possible stochastic effects, we have constructed deterministic and stochastic models. The deterministic model is analytically solved, providing the average length of the polymer as function of time and kinetic parameters. The stochastic model was simulated using Kinetic Monte Carlo (Gillespie) algorithm, and steady state length distribution was calculated using the Master Equation.

Analysis of the results revealed three phases of dynamics. Initial phase is characterized by formation of a distribution with increasing width. In the main phase the width of the length distribution decreases as function of time, and can be approximated by a power law. The final phase is a steady state distribution that can be analytically calculated. The width of the distribution is a quantitative measure of the system's stochasticity. These simple models can be extended by additional reactions in order to make them more realistic and to analyze more complex systems.