Analysis of the relationship between the dynamics and the structural polymorphism of F-actin

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Actin is one of the most abundant proteins in eukaryotic cells and plays crucial roles in various aspects of cell motility. The actin monomers (G-actin) polymerize to form a helical polymer (F-actin). Flexibility of F-actin has been suggested to be important for such a variety of functions. Understanding the flexibility of F-actin requires characterization of a hierarchy of dynamical properties, from internal dynamics of the actin monomers through domain motions within the monomers and relative motions between the monomers within F-actin to large-scale motions of F-actin as a whole. As one of the ongoing projects towards this ultimate goal, we have been studying the dynamics of actin at pico- to nano-second time range by neutron spin-echo (NSE) spectroscopy.

We carried out the NSE experiments on solutions of F-actin and G-actin in the Q-range between 0.03 Aˆ-1 and 0.2 Aˆ-1 at the Fourier time up to 30 nsec during the machine time in 2007, and found that there are differences in the intermediate functions obtained, from which it was suggested that behavior of the effective diffusion coefficients of G-actin as a function of Qˆ2 corresponds to free diffusion in solution whereas that of F-actin reflects the collective motions within F-actin.

Here, as a continuation to the experiments on G-actin and F-actin, we investigated effects of solution conditions on the dynamics of F-actin. It was shown that the flexibility of F-actin changes corresponding to a variety of the solution conditions (Isambert et al., 1995). In particular, F-actin polymerized in the presence of Mg2+ (Mg2+-F-actin) was shown to have a distinct structural conformation and be more flexible than F-actin polymerized in the presence of Ca2+ (Ca2+-F-actin), and it was suggested that such modulation of the flexibility by Ca2+ and Mg2+ may have important physiological consequences within the cell (Orlova and Egelman, 1993). We thus carried out the NSE measurements of Mg2+-F-actin and Ca2+-F-actin.

Actin was purified from rabbit skeletal muscles. Actin in the presence of Ca2+ or Mg2+ was polymerized by adding KCl. Solutions of Mg2+-F-actin and Ca2+-F-actin were prepared in D2O. The NSE measurements on these solutions were carried out on the NSE spectrometer, iNSE, run by the University of Tokyo, installed at the guide hall of the research reactor, JRR-3M, Ibaraki, Japan. The measurements were done over the Q-range between 0.03 Aˆ-1 and 0.2 Aˆ-1 at the Fourier time up to 30 nsec. During the measurements, the samples were kept at 10 °C. The normalized intermediate scattering functions obtained showed that each intermediate function can be fit with a single exponential, from which effective diffusion coefficients can be estimated, and that there are differences in the decay times of Mg2+-F-actin and Ca2+-F-actin. It appears that the decay times of Mg2+-F-actin are somewhat faster than those of Ca2+-F-actin, suggesting that Mg2+-F-actin is more flexible than Ca2+-F-actin. This result is consistent with the previous reports. Detailed analysis of the intermediate functions is currently underway.