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Pulsed Field Gradient NMR for the measurement of water self-diffusion in biological cells

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Pulsed Field Gradient NMR (PFG-NMR) is widely used for biological system investigations. Using this technique it is possible to study self-diffusion processes in different spatial scales. It gives us opportunity to observe restricted diffusion in biological cells. From PFG-NMR data we can obtain cell size, cell wall permeability and residence time of water molecules in cells.

PFG-NMR was applied for water self-diffusion investigation in yeast cell (Saccharomyces cerevisiae) and in chlorella cells. The measurements were made on a home-made machine at Graduate School of Biotechnology, Korea University. The NMR frequency for 1H was 63MHz, Maximum amplitude of pulsed field gradient was 50 T/m, range of diffusion coefficients was 10-8～10-14m2/s.

Water movement in yeast and chlorella characterized by two self-diffusion coefficients. The dependences of these coefficients on diffusion time show the restriction diffusion. For water molecules with the smallest coefficient, the self-diffusion was completely restricted.

The sizes of restriction were about 5.4㎛ for chlorella and 2.6㎛ for yeast. These values were comparable with electron microscopy results. The values of permeabilities were about 3 · 10-6m/s for chlorella and 10-6m/s for yeast. The residence times were about 220 ms both for chlorella and yeast.

It was shown that water permeability and residence time are very sensitive to the heating treatment. For example, water permeability increase in one order of magnitude during ohmic heating from 50℃ to 70℃. These previous results show that PFG-NMR is very powerful tool for analysis of biological systems in vivo.