Applications of Low-E Coils to High Field SS NMR of Proteins Aligned in Bicelles

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Introduction
Magnetically aligned bicelles are a powerful tool for membrane protein structure determination [1-2]. It not only mimics the biological membranes, but it also can align the proteins so that useful structural information, such as the vector orientation of the chemical bond, can be obtained. However, most experiments in solid state NMR use prolonged decoupling pulses which often generate intolerable heating in the biological samples [3-4]. Bicelle samples can be particularly challenging for radio-frequency hardware due to the presence of lossy lipids and buffers containing high salt concentrations. By re-designing the r.f. coil, we can minimize the sample heating effect [3, 5-8] by reducing the conservative electric field generated in the sample. The 900 and 600 MHz bicelle probes (Fig. 1) developed in our group are based on the cross-coil low-E resonator which was successfully demonstrated in application to mechanically aligned bilayers [6] and later in MAS probes [9]. For the NMR spectroscopist working with bicelle samples, there are some practical aspects that must be addressed, such as, what are the tolerable salt concentrations and r.f. field strengths for a given experiment, what are the limitations of sample geometry for both heating and r.f. homogeneity, what is the temperature rise in the sample under a particular set of experimental conditions, etc.

Results and Discussion
We applied systematic procedures to determine RF sample heating in different samples and probes. Electric field prevalence in sample coils was measured by comparing the r.f. power absorbed by the sample [6] as a function of salt levels. In addition, the TmDOTP compound [3, 9] was used to record temperature inside the samples under relevant experimental conditions (Fig. 2). We consistently found the rise of sample temperature in a low-E coil to be 10 times smaller than in comparable solenoids (Fig. 2). A well designed VT gas flow around the sample helped further decrease elevation in sample temperature by 40%. Overall, low-E coils let us better exploit our high field NMR facilities by using the magnetically aligned bicelles in studies of protein structure at fields as high as 900 MHz (Fig. 3).

References

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