EFFICIENT COAXIAL TRAPS FOR NMR PROBES

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Introduction

High-frequency $^{15}$N/$^1$H NMR probes for static, solid state samples have been developed at the NHMFL for applications in protein structure determination [1]. The double-frequency matching networks are based on a well-known approach [2] for nuclei with widely separated gyromagnetic ratios. Our implementation is shown in Figure 1. A natural figure of merit for a matching network is the ratio of the applied power dissipated in the sample coil to the total applied power, or simply the “power efficiency.” For both resonances, the power efficiency of the matching network is largely a function of loss in the coaxial $^{15}$N trap: a $\lambda/4$ stub that "looks like" a short at the $^{15}$N resonance but an open circuit for $^1$H. To get the best efficiency from the matching network, it is necessary to maximize the trap resistance $R_t$ at the $^1$H resonance and minimize it at the $^{15}$N resonance. At the $^1$H resonance, it can be shown that $R_t = 2\alpha lZ_0$, where $\alpha$ is the attenuation coefficient, $l$ is the length, and $Z_0$ is the characteristic impedance of the stub. However, at low frequency, $R_t = \alpha l/Z_0$. It’s clear that these two quantities can not be minimized simultaneously. It should be possible to trade off efficiency in one channel to improve efficiency in the other as needed by varying the construction of the stub.

Experimental

We tested four different $^{15}$N transmission line traps of outer diameter of 8.4 mm. The first was commercial UT-390, which has a PTFE dielectric and a center conductor of diameter 2.6 mm. Three variations with same outer diameter but with an center conductor of diameter 4.8 mm were constructed and tested for comparison. Using the same sample coil for all probes, the efficiency was characterized by measuring the 90° pulse times for standard samples.

Results and Discussion

Figure 2 indicates that, as $Z_0$ decreases from 49 $\Omega$, the $^{15}$N efficiency increases but the $^1$H efficiency drops. This indicates that changing the trap design allows one to trade $B_1$ field in the $^1$H channel against sensitivity in the $^{15}$N channel depending upon the requirements of the experiment and sample.

References