The OneNMR™ Probe

PURGE Solvent Suppression[1], Deuterium Sensitivity, and Salt Tolerance

Advantage Statement: Collecting high-quality metabolomics data requires good probe performance in a wide variety of areas. Historically, no single probe design could deliver all the necessary specifications simultaneously, leading to significant compromise on some facet of the experimental results.

By combining excellent lineshape performance, superior B1 field homogeneity, and outstanding salt tolerance into a single NMR probehead, the revolutionary Varian OneNMR™ Probe is better suited to the demanding task of metabolomic analysis than any conventional probe design.

Solvent Suppression

For many years, presaturation has been the default solvent suppression technique used by most spectroscopists. While there are many published techniques that can outperform presaturation in efficiency, selectivity, etc., the simplicity and robustness of presaturation typically makes it the method of choice. With the introduction of the OneNMR Probe, however, Varian opens the way for routine use of a recently published solvent suppression technique known as "Presaturation Utilizing Relaxation Gradients," or PURGE.[1]

As shown in Figure 1, the PURGE technique involves hard rotations interspersed with short periods of gentle presaturation excitation (i.e., ~8-12 Hz decoupling fields) and gradient pulses. The result is very efficient and robust solvent suppression, excellent frequency selectivity, and no baseline perturbations outside of the suppression window. Importantly, this pulse sequence element is equally as trivial to implement as standard presaturation, with the only requirement being calibration of the 90° pulse width.

In practice, using the PURGE sequence with the OneNMR Probe delivers very high quality solvent suppression, as can be seen in Figures 2 and 3.

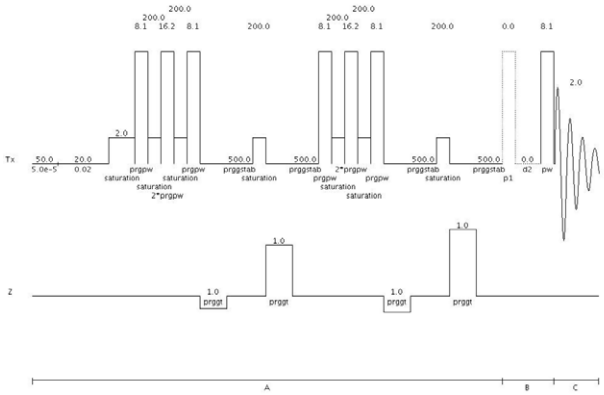

Figure 1. The PURGE solvent suppression method as implemented in a 1D proton NMR pulse sequence.

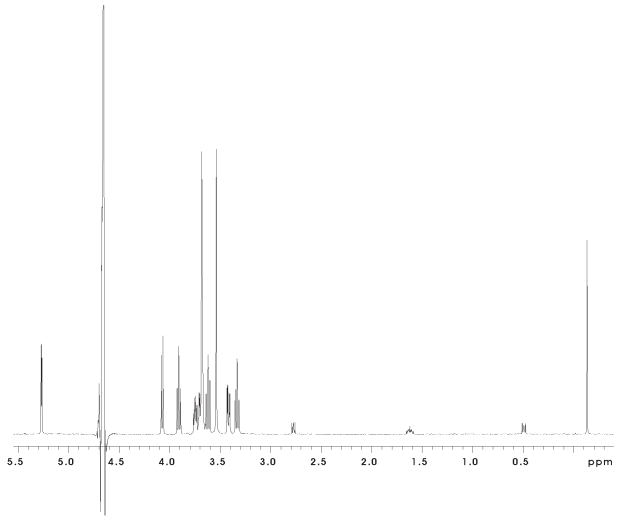

Figure 2. The PURGE solvent suppression method as applied on a 2 mM sucrose standard sample in 90% H_2O/10% D_2O.

Solvent suppression without a narrow suppression band leads to attenuation of those signals with resonance frequencies near the solvent peak. As compared to a simple presaturation experiment, PURGE delivers suppression with a high degree of frequency specificity due to the lower irradiation power required for efficient performance (See Figure 4).

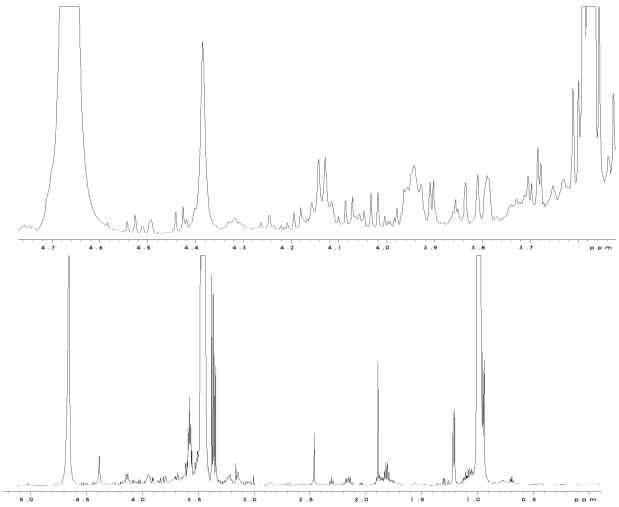

Figure 3. The PURGE solvent suppression method as applied to a sample of white wine in 90% H_2O/10% D_2O with phosphate buffer.

Figure 4. Comparison of the suppression window afforded using presaturation (52 Hz field, bottom) and PURGE (11 Hz field, top). The nominal suppression window observed for the PURGE method would allow accurate integration of resonances with no more than a 125 Hz offset from the saturation frequency.

The only drawback to the routine use of PURGE solvent suppression lies in the fact that a full 720° of spin rotation is applied to all spins in the sample prior to the beginning of the excitation pulse. Inhomogeneity in the B_1 field during rotation engenders loss in signal intensity. As shown in Figure 5, the OneNMR Probe has superior B_1 field homogeneity retaining 78% of the initial signal intensity after 810° of spin rotation. Hence, PURGE solvent suppression remains a viable solvent suppression technique in the OneNMR Probe.

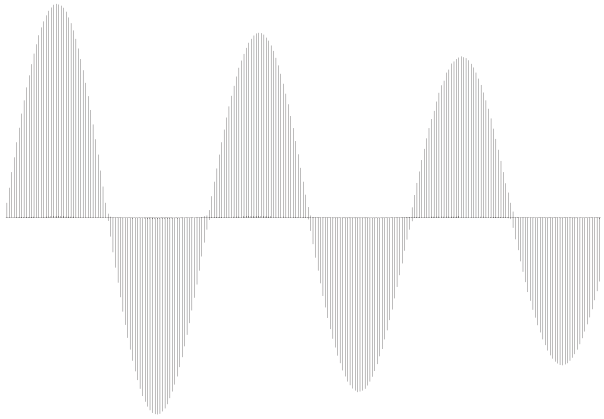

Figure 5. Proton Spin Nutation Experiment for the OneNMR Probe. This data set demonstrates the excellent B1 field homogeneity observed for the OneNMR Probe. The signal observed after 810° of spin rotation retains 78% of the intensity observed for a 90° pulse.

Deuterium Sensitivity

Spectroscopists often don't consider the sensitivity of the lock coil when choosing a probe, but this simple performance criterion can be critical in metabolomics applications. The OneNMR Probe delivers outstanding performance on the deuterium channel (see Figure 6).

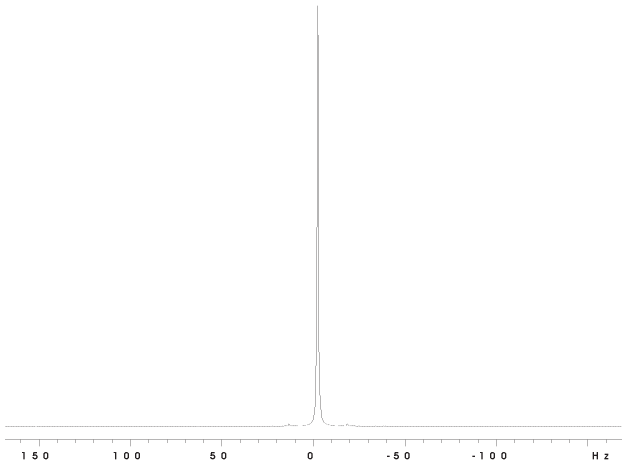

Figure 6. Deuterium signal-to-noise measurement for the OneNMR Probe as measured on $CDCl_3$. At a value of greater than 7200-to-1, this spectrum demonstrates performance that is more than double that typically seen for a standard inverse detection probe.

In those situations where minimum dilution of an analyte with D_2O is desirable, the OneNMR Probe allows automated locking and shimming with confidence on samples containing as little as 2% D_2O (see Figure 7).

The OneNMR™ Probe

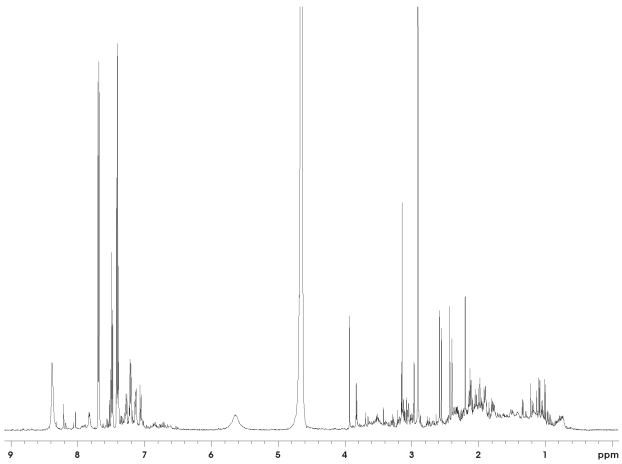

Figure 7. Proton Spectrum of urine collected using the OneNMR™ Probe. This sample contained only 2% D_2O, yet completely automated locking and shimming operations executed flawlessly.

Salt Tolerance

Biological NMR samples are commonly prepared in buffer solutions for data collection and biological fluids are often intrinsically of high ionic strength. A highly dielectric sample strongly couples to the receiver coil, thereby lowering the "Quality Factor" of the system and adversely impacting the sensitivity of the probe.

The classic indirect detection (ID) probe is currently the 'standard' probe configuration used for most metabolomics work. When compared with the OneNMR Probe, however, the performance of the ID probe suffers proportionally as the concentration of salt in the sample increases. (See Table 1.)

Comparative Salt Tolerance	
OneNMR Probe	Inverse Detection Probe
91.2%	78.5%

Table 1. Relative signal-to-noise retention for 2 mM sucrose in 250 mM NaCl solution as compared to a salt-free reference sample.

The unique design of the OneNMR Probe minimizes the effect of "lossy" samples and allows high quality spectra to be obtained with a minimum of instrument time (see Figure 8).

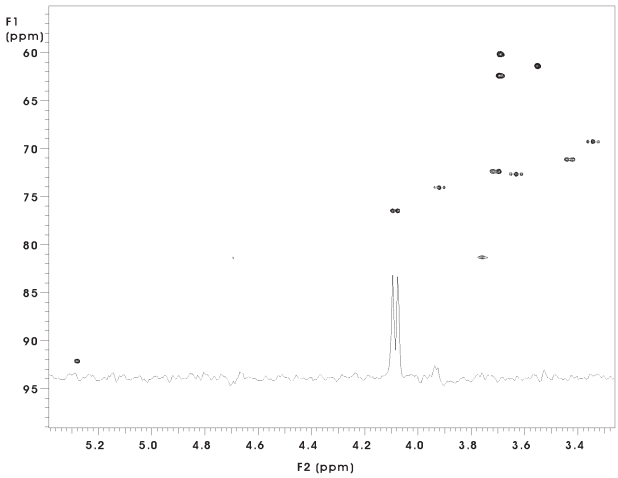

Figure 8. HSQC Spectrum of 2 mM sucrose in 90% H_2O/10% D_2O containing 300 mM sodium chloride. These data were collected in 72 minutes of acquisition time.

Conclusions

The OneNMR Probe was intended to provide the highest level of performance for metabolomic analysis. The outstanding lineshape and B_1 field homogeneity combine to afford world-class solvent suppression. The excellent sensitivity of the deuterium channel allows the preparation of biological samples with an absolute minimum of dilution with D_2O. Finally, the salt tolerant design yields the best sensitivity available in a warm probe for biological fluid analysis.

These features make the OneNMR probe a superior tool for metabolomics research.

[1] PURGE: Presaturation Utilizing Relaxation Gradients Simpson and Brown, J. Magn. Reson., 175 (2005), pp. 340-346

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