2. Effects Of Molecular Motion

2.1. Effects Of Relaxation & Dynamics

For the case of different nuclei, I and S (e.g. ^{1}H and ^{15}N) NOE and relaxation times are defined as follows (under the assumption: observation of spin I). [13,14,15]

$$\frac{1}{T_{1I}} = F(S(S+1))[J_0(\omega_I-\omega_S)+3J_1(\omega_I)+6J_2(\omega_I+\omega_S)]+A[J_1(\omega_I)]$$

$$\frac{1}{T_{2I}} = \frac{F}{2}(S(S+1))[J_0(\omega_I-\omega_s)+3J_1(\omega_S)+6J_2(\omega_I+\omega_S)+6J_1(\omega_S)+4J_0(0))]+\frac{A}{6}[4J_0(0)+3J_1(\omega_1)]$$

$$NOE = 1+\frac{F}{(\gamma_I\gamma_S)}(S(S+1))[6J_2(\omega_I+\omega_S)-J_0(\omega_I-\omega_S)]\cdot T_{1I}$$

I and S are the spin-quantum numbers, F and C are defined as: [16,17]

$$F = \frac{2\gamma_I^2\gamma_S^2h^2}{(15r_{IS}^6)\cdot 4\pi^2}$$

$$A = \frac{1}{3}[\sigma_{par}-\sigma_{per}]^2\gamma_I^2B_0^2$$

Introduction of statistics allows to express the dynamics of an internuclear vector IS in an ensemble of 10^{20} molecules (= 10 mM) by a correlation function. This function C(t) describes the relationship between two events observed at times t_0 and ($t_0+\Delta t$). Two extrema are easily recognized:

- if $\Delta t \to 0$, no change of the coordinates will be observed and therefore C(t) = 1;
- if $\Delta t \to \infty$, for a non restricted motion no relation to the starting orientation exists, C(t) = 0.

Correlation function and spectral density function (as defined in [4]) are related by a complex Fourier transformation.

The so-called “model-free approach” by Lipari & Szabo (J.Am.Chem.Soc. (1982) 104, 4546) introduces an order parameter (S^2) describing the restriction of the motion. It utilizes the assumptions

- isotropic, but sterically restricted motion;
- fast internal motion (> 3 ns^{-1}).

Therefore, the correlation time cannot be formulated as single exponential function and has (at least) to be seperated into a term for isotropic overall rotation and a term for isotropic internal motion $C(t) = C_O(t)\ C_I(t)$ [18] with

[19,20]

$$C_O(t) = \frac{1}{5} \cdot \exp\left(\frac{-t}{\tau_m}\right)$$

$$C_I(t) = S^2 + (1 - S^2) \cdot \exp\left(\frac{-t}{\tau_e}\right)$$

The order parameter S is equal to 1 in the absence of internal motion and drops to 0 for isotropic unrestricted motion.

TO BE CONTINUED