Proton relaxation times $T_1$ and $T_2$ were measured on the ZrCr$_2H_x$ hydrides as a function of the hydrogen concentration $x$ in the temperature range between 180K and 380K. The spin-lattice ($T_1$) and spin-spin ($T_2$) relaxation times were obtained for the series ZrCr$_2H_x$ ($x=2,3,4$) at a resonance frequency of 33 MHz using the $180^\circ-\tau-90^\circ$ pulse sequence and the Carr-Purcell-Gill-Melboom pulse train, respectively. $T_1$ was found to decrease as the temperature was increased from 180K until about 240K, where a minimum in $T_1$ occurs. Thereafter $T_1$ increases until 480K, the higher temperature reached in our experiment. However, an asymmetrical and nonlinear behaviour of $ln T_1$ versus $1/T$ about $T_1$ minimum was observed for all hydrides studied. $T_2$ increases at the temperature is increased until about 240K when the $T_1$ contribution to $T_2$ becomes important. Thereafter $T_2$ becomes almost temperature independent for higher temperatures. We associated these features to the superposition of two contributions to the nuclear relaxation. The first contribution ($T_{1d}$) arises from the nuclear relaxation due to the protons diffusion. The second is the contribution from the interaction of the protons $^1H$ with the conduction electrons given by the Korringa relation $(1/T_{1d}) = C_kT$. These two contributions to the relaxation times were obtained by fitting the experimental $T_1$ and $T_2$ data to the BPP theory (1) assuming the relations $(1/T_1) = (1/T_{1d}) + (1/T_{1e})$ and $(1/T_2) = (1/T_{2d}) + (1/T_{2e})$ where $1/T_{1d}$ and $1/T_{2d}$ are the BPP spin-lattice and spin-spin relaxation times, respectively.

From the fitting procedure we have obtained the diffusional activation energy $E_a$ and Korringa constant $C_k$ for the several hydrides investigated: $E_a = 1500K$, $C_k = 180(10^3 s.k)^{-1}$ for ZrCr$_2H_2$; $E_a/C_k = 1700K$, $C_k = 110 (10^3 s.k)^{-1}$ for ZrCr$_2H_3$ and $E_a/C_k = 1800 K$, $C_k = 77(10^3 s.k)^{-1}$ for ZrCr$_2H_4$. Single value of $E_a$ was found for each hydrogen concentration indicating that the diffusion mechanism in these hydrides can be characterized by the Arrhenius relation $\tau = \exp(Ea/K_BT)$. This result indicates that the $^1H$ atoms are located at only one kind of sites (probably the 2Zr, 2Cr sites) in the ZrCr$_2H_x$. This agrees with recent neutron diffraction results of Fruchart et al. (2). In addition the Korringa constant $C_k$ which is proportional to $N^2(E_F)$, was found to decrease as $x$ increased, indicating a reduction of the electronic density of state at the Fermi level $N(E_F)$ in the ZrCr$_2H_x$ as the concentration of hydrogen atoms increases.

In summary, our NMR results have shown that the proton relaxation times in the ZrCr$_2H_x$ hydrides can be described by a superposition of two contributions: the diffusion relaxation mechanism of the hydrogen atoms and the Korringa mechanism that account for the conduction electrons contribution to the relaxation process. Using the simple BPP theory we were able to obtain the diffusional activation energy for the hydrides ZrCr$_2H_x$ ($x=2,3$ and 4). We have found $E_a$ values which are consistent with the known experimental data for metallic hydrides in general. A detailed analysis of our NMR results for ZrCr$_2H_x$ will be made in a further paper.

1. N. Bloembergen, E.M. Purcell and R. V. Pound, Phys.Rev. 73, 679 (1948)

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