Development of a Nuclear Spin Dewar: Hyperfine Interactions of the Short-Lived β Emitter ^{12}B in TiO_2

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The β-NMR detection of ^{12}B ($I^{\pi} = 1^{+}$, $T_{1/2}$ = 20.2 msec) implanted in a TiO_2 (rutile) single crystal following a nuclear reaction showed that its spin polarization produced in the reaction is totally maintained during its lifetime. Two implantation sites with relative populations 9:1 were identified. The electric field gradients (EFGs) were determined to be $q = +(37.1 \pm 0.5)\ 10^{15}$ V/cm^2 with $\eta < 0.03$ and $q = +(185 \pm 5)\ 10^{15}$ V/cm^2 with $\eta = 0.62 \pm 0.02$ for the major (90%) and minor (10%) sites, respectively. The EFGs were compared with the theoretical values given by the band-structure calculation in the framework of the KKR method. TiO_2 crystals with proper treatment can be a good "Spin Dewar" in which any short-lived nuclei can be implanted, and their spin polarizations as produced in nuclear reactions can be maintained during their lifetime.

Key words: Nuclear Polarization; β-NMR; Electric Field Gradient; TiO_2.