# Mössbauer Spectrometry as a Tool for Probing Universality Classes in Magnetocaloric Compound $(Pr,Sm)_2Fe_{17}$

H. Jaballah,[1] J. Horcheni,[1,2] N. Mliki,[3] and L. Bessais[1]

[1] *Univ Paris Est Creteil, CNRS, ICMPE, UMR 7182, 2 rue Henri Dunant, F-94320 Thiais, France*

[2] *Faculty of Sciences, University of Sfax, LSME, BP1171, Sfax 3018, Tunisia*

[3] *Université de Tunis El Manar, Faculté des Sciences de Tunis, Laboratoire Matériaux Organisation et Propriétés, Tunis 2092, Tunisia.*

Gadolinium is known for its strong magnetocaloric effect near room temperature, but its limitations such as rapid corrosion, high cost, and limited global resources hinder its competitiveness with conventional refrigeration systems. In this study, our goal is to synthesize new materials that exhibit interesting magnetocaloric effects at room temperature, while being chemically stable and cost-effective compared to Gd. We focus on iron-rich $Pr_2Fe_{17}$ compounds, which show a relatively large magnetic entropy change maximum around room temperature with a broad full width at half-maximum, indicating a reversible magnetocaloric effect. This makes $Pr_2Fe_{17}$ a promising candidate for Gd-based magnetic materials. However, its Curie temperature, which is the working temperature for cooling applications, is below room temperature. To achieve a Curie temperature equivalent to room temperature, we explore the substitution of Pr atoms with Sm atoms.

For a deeper understanding of the magnetic phase transition. Traditional techniques that rely on pure magnetic measurements, such as the Kouvel-Fisher plot, Modified Arrott plot, and Critical Isotherm technique, are typically used to estimate critical exponents. However, in this research, a local approach utilizing Mössbauer spectrometry is incorporated in addition to the conventional macroscopic approach based on direct magnetic measurements.

The findings of this study indicate that for $Pr_{1.64}Sm_{0.36}Fe_{17}$ $RCP$ is found to be around $167.4\,J.kg^{-1}$ under a magnetic field change of T which is around 80% of that observed in pure Gd and makes our compound a potential candidate for magnetic refrigeration around the room temperature. the critical exponents of $Pr_2Fe_{17}$ and $(Pr,Sm)_2Fe_{17}$ closely approximate those of the 3D-Ising model, as confirmed by the scaling analysis of our critical exponents. Moreover, we observed that isotherms collapse into two distinct and independent universal branches above and below the Curie temperature when utilizing the critical exponents we obtained. This phenomenon can be described by the single scaling equation $m = f_{\pm}(h)$, where $m$ and $h$ denote the renormalized magnetization and magnetic field, respectively. Our results indicate that the exponents determined using both conventional methods and Mössbauer spectrometry closely match those of the 3D-Ising model for spins coupled in three dimensions ($d = 3$, $n = 1$) with attractive interactions between spins at the boundary of short-range and long-range decay as $J(r) = r^{-(3+\sigma)}$ with $\sigma = 1.95$.