Influence of composition tuning on self-heating efficiency in FeCo nanoalloy for magnetic hyperthermia

Gongotree Phukan[a], J.P. Borah[a]

[a] *Nanomagnetism Lab, National Institute of Technology Nagaland, Chumukedima, Nagaland, India-797103*

In this work, the self-heating efficiency of Fe_xCo_{100-x} nanoalloys in magnetic hyperthermia is critically altered by their compositional tuning, which governs magnetic anisotropy, coercivity, and saturation magnetization. Induction heating experiments reveal exceptional heating performance, achieving clinically relevant temperature elevations within 500 seconds- a critical benchmark for therapeutic applications. Among tested compositions, the highest heating efficiency is shown by $Fe_{50}Co_{50}$.

Keywords: Magnetic hyperthermia; nanoalloy; self-heating; specific absorption rate

1. Introduction

Magnetic hyperthermia is a promising cancer therapy that utilizes magnetic nanoparticles (MNPs) to generate localized heat under an alternating magnetic field (AMF), leading to controlled tumor cell destruction . Among various MNPs, FeCo nanoalloys stand out due to their exceptionally high saturation magnetization and tunable magnetic properties, making them ideal candidates for efficient heat generation[1].

2. Results and discussion

Induction heating analysis of the synthesized Fe_xCo_{100-x} nanoalloys, where x= 65, 55, 50, 45, 35 are done under an AMF of strength 14.98 kA/m and frequency 337 kHz inside an 8 turn coil. As shown in Figure 1, the temperature vs. time graph indicates that the temperature rise over 900 seconds increases with Co content and reaches its maximum at the 50:50 Fe:Co ratio. Beyond this composition, the heating efficiency declines. Upon switching off the AMF after 900 seconds, the samples begin to cool immediately, demonstrating the absence of remanent heating effects. All the compositions reach the optimal hyperthermia temperature range of 42-46°C within 500 seconds, demonstrating their potential as effective candidates.

The Specific Absorption Rate (SAR), which quantifies the self-heating efficiency is calculated from the heating graphs using Box-Lucas method[2].

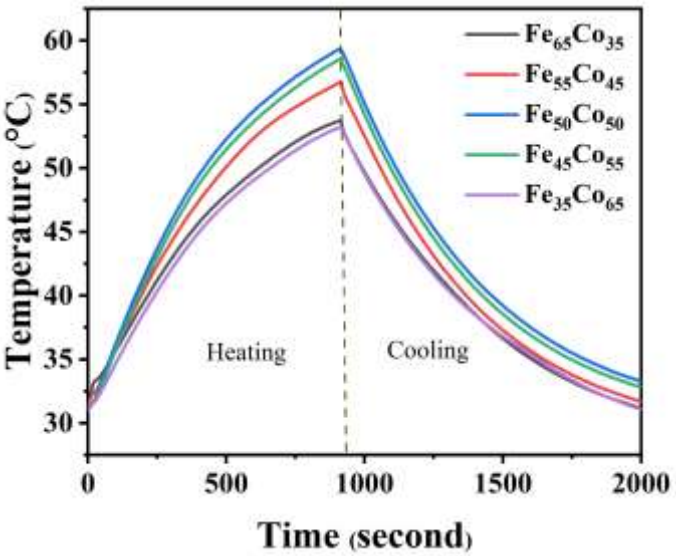

Figure 1: Temperature vs Time graph under AMF

The Specific Absorption Rate (SAR) exhibits a behavior consistent with the heating graphs. Initially, the SAR increases with the weight percentage of cobalt (Co) up to a 50:50 ratio, after which it begins to decline.

In summary, the findings underscore the potential of FeCo nanoalloys as effective candidates for magnetic hyperthermia in cancer therapy. The optimal 50:50 Fe:Co composition not only maximizes heating efficiency within the therapeutic range but also highlights the critical role of compositional tuning in enhancing self-heating performance.

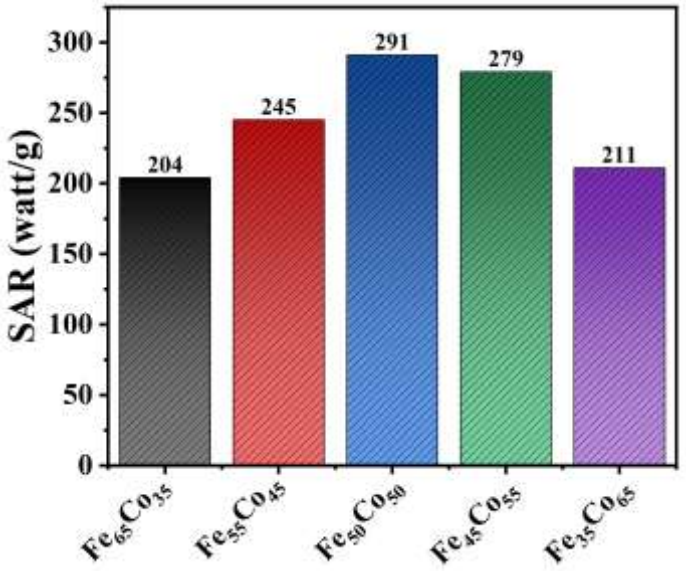

Figure 2: Specific Absorbance Rate (SAR) histogram

References

[1] Linh et al.,Mater. Sci. Eng. B. 295 (2023) 116571. https://doi.org/10.1016/j.mseb.2023.116571.

[2] Teran et al., Appl. Phys. Lett. 101 (2012) 1–6. https://doi.org/10.1063/1.4742918.

Acknowledgements: The authors sincerely thank Science and Engineering Research Board (SERB), Government of India for funding this research.