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Mg_xONi_{1-x} Nanocrystalline for Magnetic Hyperthermia: Preparation, Characterization, and Heating Ability

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fulfillment of the requirements for the degree of Master of Science in Physics**

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Abstract

$\text{Mg}_x\text{ONi}_{1-x}$ nanocrystalline composites were synthesized and evaluated for their potential application in magnetic hyperthermia for cancer treatment. The $\text{Mg}_x\text{ONi}_{1-x}$ ($x = 20, 30$, and 40 wt%) nanocrystalline materials were fabricated using the ball milling technique and subsequently characterized by X-ray diffraction (XRD) and vibrating sample magnetometry (VSM). XRD analysis confirmed the formation of a nanocomposite phase after 20 hours of milling, with a slight increase in lattice parameter as the Mg concentration increased. The crystallite size exhibited a significant reduction, decreasing from 34.14 nm in pure Ni to approximately 16 – 17.2 nm in the Ni-Mg nanocomposites.

Magnetic characterization at room temperature revealed a decrease in saturation magnetization (M_s) with increasing Mg content, accompanied by an increase in coercivity (H_c) and remanence (M_r), indicating a ferromagnetic nature for all samples. The Law of Approach to Saturation (LAS) was employed to accurately determine M_s .

The heating efficiency of the nanocomposites was assessed under an alternating magnetic field (AMF) with a field amplitude of 160 Oe and a frequency of 469 kHz using a Magnotherm system. All samples exhibited a significant temperature rise, demonstrating their ability to effectively dissipate heat under AMF. Notably, the $\text{Mg}_{30}\text{Ni}_{70}$ composition achieved the highest specific absorption rate (SAR) of ~ 26 W/g, indicating optimal energy conversion within this system. These results highlight the potential of $\text{Mg}_x\text{ONi}_{1-x}$ nanocomposites for efficient magnetic hyperthermia applications.

ملخص

يهدف هذا البحث إلى تحضير ودراسة الخواص البنيوية والمغناطيسية للمركبات النانوية Mg_xONi_{1-x} ، بالإضافة إلى تقييم كفاءة هذه المواد في توليد الحرارة عند تعرضها لمجال مغناطيسي متردد، مما يعزز إمكانية استخدامها في علاج الخلايا السرطانية عبر تقنية Magnetic hyperthermia.

تم تحضير العينات باستخدام تقنية الخلط الميكانيكي مع نسب مختلفة من المغنيسيوم (Mg) ، بينما تم تحليل البنية البلورية والخصائص المغناطيسية باستخدام كل من حيود الأشعة السينية (XRD) ومقياس المغناطيسية بالعينات المهتزة (VSM).

أظهرت النتائج ازدياد طفيفاً لمعامل الشبكية للنيكل مع ارتفاع نسبة المغنيسيوم، في حين لوحظ تناقص في حجم البلورات إلى حوالي 17 نانومتر. أما من الناحية المغناطيسية، فقد بينت القياسات أن زيادة تركيز المغنيسيوم تؤدي إلى انخفاض التشبع المغناطيسي (M_s) ، مصحوبةً بارتفاع في كل من $Coercivity (H_c)$ و $Remanance (M_r)$ ، مما يؤكد أن جميع العينات تحتفظ بسلوك مغناطيسي (Ferromagnetic).

كما أظهرت الدراسة أن هذه المواد تولد حرارة عند تعرضها لمجال مغناطيسي متردد، مما يعزز قابليتها للاستخدام في التطبيقات العلاجية مستقبلاً. ومع ذلك، يستلزم الأمر إجراء دراسات تفصيلية إضافية لفهم تأثير العوامل المختلفة على كفاءة الانبعاث الحراري، بما في ذلك تركيز المغنيسيوم، شدة المجال المغناطيسي المتردد، والتردد المستخدم.