Influence of Nanoparticle Loading and Thermal Environment on the Magnetic Hyperthermia Response in U87 Spheroids

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Área temática: F. Nanotecnología y salud

Magnetic hyperthermia is a promising therapeutic strategy for glioblastoma; however, its experimental implementation in vitro requires careful control of both biological and physical parameters. In this work, we developed a three-dimensional spheroid model based on the U87 glioblastoma cell line to investigate the factors governing nanoparticle heating performance under an alternating magnetic field.

U87 spheroids were generated and exposed to magnetic nanoparticles under different experimental configurations. By increasing the number of spheroids per sample, a threshold condition was identified, enabling the system to reach the hyperthermia temperature window. Using samples containing different numbers of nanoparticle-loaded spheroids, two distinct thermal regimes were obtained: a hyperthermia condition (~43 °C) associated with a significant decrease in viability, and a non-hyperthermia condition with no detectable loss of viability. These differences suggest that the effective nanoparticle load and heat dissipation conditions play a critical role in determining the thermal response. Additional experiments varying the thermal setup confirmed that system insulation significantly influences temperature increase under magnetic field exposure.

Together, these results demonstrate that magnetic hyperthermia efficiency in 3D tumor models is governed by the interplay between nanoparticle loading, sample configuration, and thermal environment. This work establishes a reproducible framework for defining hyperthermia conditions in glioblastoma spheroids and highlights key experimental variables for the design of in vitro magnetic hyperthermia assays.