Superparamagnetic Iron Oxide Nanoparticles in Niosomal Systems for Biomedical Applications

***Sandhya Kumar*[1*], *Viktor Maurer*[1], *Georg Garnweitner*[1]**

[1]Institute for Particle Technology, Technische Universität Braunschweig, Germany
*sandhya.kumar@tu-braunschweig.de

Superparamagnetic iron oxide nanoparticles (SPIONs) possess unique magnetic properties, characterized by the absence of remanent magnetization and coercivity, allowing rapid magnetization and demagnetization under an external magnetic field [1]. These features make SPIONs highly suitable for biomedical applications, particularly as tracers in Magnetic Particle Imaging (MPI), a radiation-free technique enabling sensitive and quantitative tracking of nanoparticle distribution [2].

In this study, SPIONs were synthesized via thermal decomposition, yielding well-defined and stable particles with either hydrophobic or hydrophilic surface characteristics. This dual surface functionality allows for versatile encapsulation within the bilayer or aqueous core of vesicular carriers. The SPIONs were encapsulated into niosomal carriers, which demonstrated that niosomes are effective for the co-delivery of SPIONs and siRNA for biomedical applications [3]. The resulting hybrid systems enabled magnetically enhanced gene delivery, leading to the downregulation of anti-apoptotic proteins in MCF-7 breast cancer cells. Moreover, the apoptotic effect was further amplified upon application of an external magnetic field, demonstrating the potential for controlled and targeted delivery. These findings confirm that SPIONs can be integrated into stable vesicular carriers while preserving their functional properties.

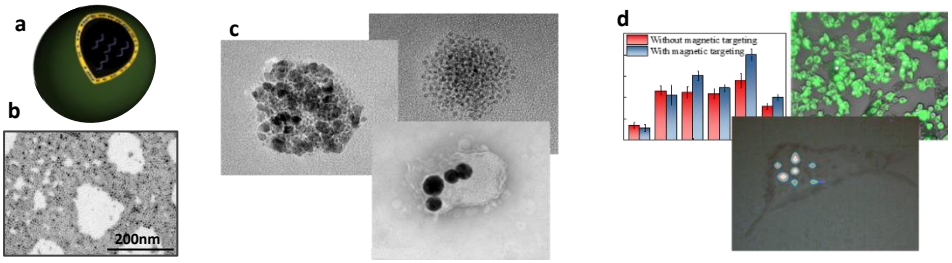

Figure 1. (a) Schematic illustration of hybrid niosomes; (b) SPIONs (<10 nm); (c) TEM images; (d) In vitro evaluation of hybrid niosomes.

The current work focuses on the systematic characterization of SPION-encapsulated niosomes, including particle size, stability, surface properties, and saturation magnetization. Building on these results, such hybrid platforms hold promise for applications in MPI, allowing for *in vivo* tracking of nanoparticle-mediated delivery of therapeutic cargos such as mRNA. Furthermore, future studies will explore lipid nanoparticles (LNPs) for the co-encapsulation of SPIONs and mRNA, enabling the development of multifunctional systems with combined therapeutic and imaging capabilities, which allow tracking of biodistribution and delivery efficiency.

REFERENCES

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