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Developing Advanced Nanomedicines

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Nanoparticles (NPs) are being actively developed for applications in disease treatment and diagnosis—for example, as carriers for mRNA, agents for photothermal therapy in prostate cancer, or as contrast agents for magnetic resonance imaging (MRI) (1). However, their clinical use remains limited. A major challenge lies in achieving targeted delivery of NPs, as well as in controlling when and where they become active, and how they are cleared from the body. These challenges are closely related to the control of their biodistribution and pharmacokinetics.

While requirements vary depending on the specific application, improved biodistribution can help reduce off-target side effects, and optimized pharmacokinetics can lower the required dosage and minimize long-term toxicity—such as by enhancing clearance mechanisms. Although many qualitative mechanisms of NP interaction with cells and tissues have been identified, detailed quantitative understanding is still lacking.

Our team focuses on developing new nanomedicines and drug delivery systems functionalized with target-specific ligands to enable tailored, precision therapies (2–3). We are also advancing nanoparticle-based probes for both in vivo and ex vivo imaging applications (4).

[1] N. Feliu, et al. Science 384, 385–386 (2024)

[2] D. Zhu, et al. Adv. Healthc. Mater. 10, 2100125 (2021)

[3] A. M. Alkilany, et al. Adv. Drug Deliv. Rev. 143, 22–36 (2019)

[4] M. Skiba, et al. Adv. Funct. Mater. 35, 2408539 (2025)

Authors: FELIU TORRES, Neus (UniversitÃ¤t Hamburg); NAKIELSKI, Pascal

Presenters: FELIU TORRES, Neus (UniversitÃ¤t Hamburg); NAKIELSKI, Pascal

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