Hybrid nanoparticles for theranostics in complex media

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Novel materials properties can be achieved by engineering the size, shape and composition of an object at the nanoscale. Control over these parameters at will, however, remains as a critical challenge because minimisation of the surface energy and crystallisation forces generally result in symmetric and homogeneous nanostructures.

In this presentation, I will highlight how designer nanoparticles (NPs) can be made in a programmable manner using a physical vapour deposition technique, known as nano-GLAD.[1] Through engineering the geometry and materials combination of plasmonic NPs, we can achieve record refractive index sensitivity of 1,091 nm RIU^{-1} at λ = 921 nm (Fig. 1),[2] which is significantly higher than that of classical gold NPs (~50 nm RIU^{-1} at λ = 520 nm). The designed chirality of these NPs allows background-free detection of optical signal with a high figure of merit (FOMs > 2,800 RIU^{-1}).

We then extend the system to functioning as active nanorheology probes by combining a plasmonic material and a magnetic material within the same nanostructure. The resultant magnetoplasmonic NPs can extract rheological parameters in full blood samples (up to 50% haematocrit). These nanoscale probes can directly reveal viscosity of blood plasma without interference of red blood cells, which contribute majorly to the shear-thinning properties of blood (Fig. 2).[3]

Last but not least, I will discuss the ongoing effort of developing functional and biocompatible coatings for inorganic NPs. In particular, we have recently shown that compartmentalised coating of block copolymers can gate the release of hydrophobic drug (e.g. DOX) upon a pH trigger.[4] Meanwhile the polymer-coated NPs exhibit high biocompatibility plus excellent colloidal stability and antifouling capability in bio-media (50% PBS/FBS), showing promising potential applications in theranostics.

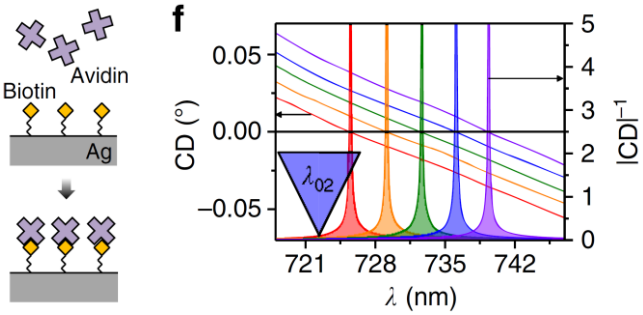

Fig. 1. Record refractive index sensitivity (1,091 nm RIU^{-1} at λ = 921 nm) can be achieved by engineering the shapes and compositions of plasmonic nanoparticles. When coupled to a chiroptical detection scheme, background-free signal can be extracted with a high figure of merit (FOMs > 2,800 RIU^{-1}).[2]

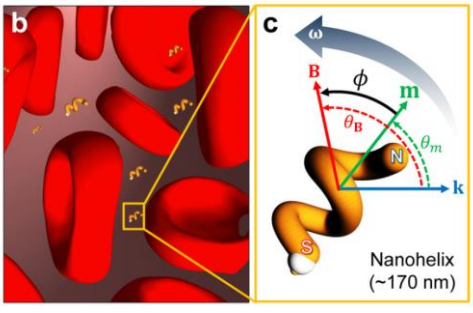

Fig. 2. Active nanorheology in full blood samples (up to 50% hematocrit) using chiral magnetoplasmonic nanoparticles. Nanoscale probes directly reveal blood plasma viscosity without interference of red blood cells. Background-free chiroptical signals can be detected in situ.[3]

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2 H.-H. Jeong, A. G. Mark, M. Alarcón-Correa, I. Kim, P. Oswald, T.-C. Lee, P. Fischer, "Dispersion and shape engineered plasmonic nanosensors", *Nat. Commun.*, **2016**, 7:11331.

3 H.-H. Jeong, A. G. Mark, T.-C. Lee, M. Alarcón-Correa, S. Eslami, T. Qiu, J. G. Gibbs, P. Fischer, "Active nanorheology with plasmonics", *Nano Lett.*, **2016**, *16*, 4887–4894.

4 E. Ellis, K. Zhang, Q. Lin, E. Ye, A. Poma, G. Battaglia, X. J. Loh, T.-C. Lee, "Biocompatible pH-responsive nanoparticles with a core-anchored multilayer shell of triblock copolymers for enhanced cancer therapy", *J. Mater. Chem. B*, **2017**, *5*, 4421–4425. (Emerging Investigators 2017 Issue)