Engineering biominerals for personalised nanovaccine and biomedicines

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Despite significant progress in oncological therapies, including targeted and combinational therapies, the five-year survival rate for metastatic cancer remains low, with about 20% across all cancer types. Immunotherapy has emerged as a promising modality in metastatic treatment by activating systemic immune responses against malignancy. However, its therapeutic efficacy is hindered by pervasive immunosuppression, the intrinsic complexity of metastatic cancer, and dose-limiting toxicity associated with treatment. Thus, developing more effective and personalised therapeutic strategies is critical.

To overcome these challenges, we have engineered a novel "Trojan horse" cancer cell membrane (CCM) nano-vaccine, encapsulated within layered double hydroxide (LDH) nanoparticles to overcome the immune escape challenge, efficiently boosting the immune response to cancer cells. This innovative nano-vaccine, designated as LGCMB, is constructed by assembling CCM antigen onto CpG oligodeoxynucleotide-functionalized LDH (LG), and subsequently following by mannose–BSA coating for the APC target and BSA coating to mask immune-escape protein on the CCM. The results from in vitro studies on cellular uptake and APC maturation have demonstrated that the strategic application of a BSA coating, integrated with mannose, serves as an effective "Trojan horse" mechanism, specifically directing the nano-vaccine towards APCs (including macrophages and dendritic cells) and markedly obstructing the CCM's capability to evade immune detection. This approach has significantly improved APC maturation. Furthermore, LGCMB has exhibited the capacity to navigate towards and accumulate in the draining lymph nodes, thereby initiating a robust tumour-specific CD8+ T cell response in vivo. As anticipated, the application of the LGCMB nano-vaccine leads to a substantial diminution in tumour proliferation in vivo, thereby underscoring its immense promise as a targeted therapeutic strategy in the realm of precision cancer immunotherapy