Life Sciences 生命科學

Fluorescent nanomaterials ideal for biological imaging

熒光納米物料最適合用於生物成像

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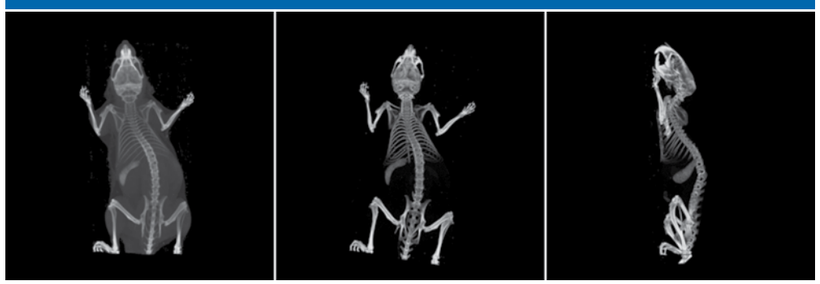
PolyU experts have developed ground-breaking, cost-effective nanoprobes with a very low degree of cytotoxicity and long circulation time (lifespan), making them very promising candidates for fluorescent/X-ray tomography/magnetic bioimaging applications.

理大專家研發出具成本效益的突破性納米探針，它具備低細胞毒性和長循環時間等特質，預期可應用於熒光／X-射線斷層掃描／磁共振成像中。



In vivo X-ray CT imaging of a mouse after intravenous injection of UCNPs. The spleen signal is clearly observed: (left) maximum-intensity projection, (middle) corresponding 3D volume-rendered (VR) in vivo CT images and (right) lateral view of 3D VR CT images
尾靜脈注射上轉換納米顆粒在小鼠的活體以X射線計算機斷層掃描成像，脾臟信號清晰可見。(左)最大密度投影圖；(中)對應的體宣染圖；(右)側面的體宣染圖像

Bioimaging techniques such as fluorescent imaging, computed X-ray tomography (CT), and magnetic resonance imaging (MRI) have widespread application to biological organisms ranging from microbes to human beings. Although CT and MRI techniques possess many advantages, both suffer from limited planar resolution, which renders them unsuitable for cellular-level imaging. The ideal solution would be the synergistic combination of fluorescence, CT and MRI contrast agents in a single system, which would combine the advantages and avoid the disadvantages of each, but development of such a system faces a number of challenges.

With support from the Innovation and Technology Support Programme of Hong Kong, Associate Professor Dr Hao Jianhua (the Principal Investigator), Chair Professor and Head Prof. Helen Chan, and Postdoctoral Fellow Dr Zeng Songjun of PolyU's Department of Applied Physics have developed a bioprobe based on multifunctional upconversion nanoparticles (UCNPs). Compared with conventional fluorescent probes, such as organic dyes and quantum dots, these near-infrared (NIR)-excited UCNPs possess a number of advantages, including low autofluorescence, deep tissue penetration, large anti-stokes shifts, high photostability and low toxicity.

These novel nanoprobes can be synthesized using a simple environmentally friendly and facile synthesis technique using water and low-toxicity organic agents as reaction media. Tri-modal fluorescence/CT/MRI bioimaging has been achieved using a surface-modified single-phase material. The as-designed nanoprobe has been shown to present NIR to visible upconversion emissions in the bioimaging of HeLa cells. In addition, these UCNPs exhibit an excellent intrinsic paramagnetic property that can also be used for magnetic imaging and bioseparation.

The research team has demonstrated in vivo CT images of a mouse spleen with enhanced signals for two hours, indicating that the UCNPs can be used successfully as a CT contrast agent to improve the detection of splenic diseases. The developed nanomaterial combining two contrast elements may also meet the diagnostic imaging requirements of other patient groups. The team's research findings have been published in several prestigious journals, including *Small, Biomaterials* and *Nanoscale*.

生物成像技術如熒光成像、X-射線計算機斷層掃描及磁共振成像，在微生物以至人類的生物體系中應用廣泛。雖然X-射線計算機斷層掃描及磁共振成像技術有很多優點，但是它們的平面解析度都較低，不適合細胞水準的成像。將熒光成像、X-射線計算機斷層掃描及磁共振三模式結合在單一系統中，結合各自的優勢，同時避免各自的缺點固然理想，但這項研究顯然面對很大的挑戰。

在香港創新及科技基金的支持下，理大應用物理學系副教授郝建華博士(首席研究員)、講座教授兼系主任陳王麗華教授，以及博士後研究員曾松軍博士，研發出一種基於多功能上轉換納米顆粒的生物納米探針。與傳統熒光探針(有機染料和量子點)相比，近紅外激發的上轉換發光納米粒子具有很多優點，包括低背底熒光、深部組織滲透、大反斯托克斯位移、高光穩定性和低毒性。

通過簡單而環保的合成方法，只利用水和一些低毒性的有機溶劑作為反應介質，就可以製備這種嶄新的納米探針。在表面改性的單相材料中實現了三模態的上轉換熒光/X-射線計算機斷層掃描/磁共振的生物成像。這納米探針展現了人類子宮頸癌細胞的近紅外可見上轉換發光生物成像。此外，這些納米探針還表現出卓越的內在順磁性質，因此也可應用於磁共振成像及生物分離。

研究團隊發現，這些上轉換納米顆粒也可作為X-射線計算機斷層掃描的對比劑，用於活體X-射線計算機斷層掃描成像，並能實現小鼠脾臟長達兩小時的增強成像。這新開發的納米材料結合了兩種具備不同X射線吸收度的元素，可滿足不同類別患者的診斷成像的要求。有關研究結果已在《微納》、《生物材料》和《納米尺度》等著名期刊中發表。