Functionalization of SWCNTs with Collagen and the Application in Stem Cell Labeling

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Abstract

A critical aspect of stem cell-based therapies is to distinguish the implanted cells from the host cells and to monitor them in terms of their viability, migration, distribution and the relative contributions. With this respect, a long-term and cytocompatible *ex vivo* labeling method for stem cells is critically needed. On the other hand, carbon nanotubes (CNTs), especially single-walled carbon nanotubes (SWCNTs) have been extensively explored for biological and medical applications as a consequence of their unique physical and chemical properties. One of the most attractive advantages of SWCNTs is that they can penetrate the biological barriers and be internalized by the cells effectively. Meanwhile, SWCNTs exhibit various unique optical properties which are helpful in biomedical labeling and imaging.
In this study, SWCNTs were functionalized with collagen (Col-SWCNTs) and used for labeling of haman mesenchymal stem cells (hMSCs). MSCs were cultured with Col-SWCNTs-containing medium for 48 hours. The internalization of Col-SWCNTs by hMSCs was quantified by using UV-vis-NIR spectroscopy and visualized by confocal Raman imaging. The viability of the labeled hMSCs was investigated via WST-1 assay and live/dead staining. The unlabeled cells were used as control. Meanwhile, the labeled hMSCs cells were cultured with osteogenic and adipogenic induction media, respectively. Alkaline phosphatase (ALP) staining, Alizarin Red S staining and Oil Red O staining were performed to investigate the osteogenic and adipogenic differentiation capacity of the labeled hMSCs. The long-term labeling capability of hMSCs by Col-SWCNTs was investigated via co-culturing the labeled and unlabeled hMSCs in an inverse co-culture system.
The results showed that the Col-SWCNTs exhibited efficient cellular internalization by hMSCs without affecting their proliferation and differentiation capacity, which should be attributed to the good dispersibility of the functionalized SWCNTs and the bioactive collagen on the surface of nanotubes. The labeled hMSCs could be detected easily by confocal Raman imaging. The signal of SWCNTs from the labeled hMSCs through Raman imaging decreased over time, which was well consistent with the quantitative data and supposed to be caused by cell division. But no obvious Raman signal was detected in the unlabeled hMSCs co-cultured with the labeled hMSCs, suggesting that almost all of the internalized Col-SWCNTs could dwell in hMSCs for a long time period. The good cytocompatibility and long dwelling time of Col-SWCNTs in cells reveals the potential of SWCNTs-based long-term stem cell labeling and imaging.

References

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Figures

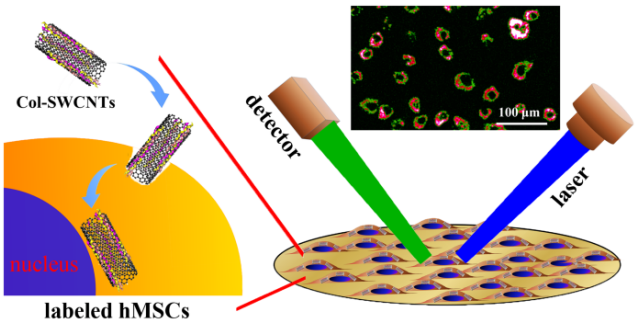

Fig. 1 Schematic illustration of this study. Single-walled carbon nanotubes were functionalized with collagen (Col-SWCNTs) and used for long-term human mesenchymal stem cells (hMSCs) labeling and imaging.