Melanin-based Perfluorocarbon Droplets for Photoacoustic Imaging and Cavitation Therapy

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Background, Motivation and Objective

Melanin is one kind of natural biological pigments, which can emit photoacoustic (PA) signals for diagnosis due to its strong near-infrared absorption and good photothermal conversion efficiency. In the past decade, melanin has also showed promise in photothermal therapy and temperature-mediated drug delivery. In this study, we are motivated to explore the question whether melanin can be employed for the photothermal vaporization of perfluorocarbon droplets, the activation of which can be further used for acoustic cavitation therapy of tumor.

Statement of Contribution/Methods

As shown in Fig.1A, we used melanin particles of an averaged diameter of 220 nm. Using the ouzo method for O/W emulsion, melanin-based Perfluorocarbon droplets shelled by Polyvinyl alcohol (PVA) membrane were fabricated (Fig.1B). The averaged diameter of the droplets was 495 nm as measured by the Malvern Zetasizer. A375 cells were seeded in 5-week-old nude mice to induce tumors for the in-vivo imaging of melanin-based droplets and the examination of cavitation therapy. This cell line was also used for the in-vitro examination of cavitation-induced cell wounding which can be indicated by the red fluorescent tracer of propidium iodide.

Results/Discussion

As shown in Fig.1C, the melanin-based perfluoropentane droplets accumulated in the tumor region and can be imaged using photoacoustic method. In preliminary studies, we found that the exposure to a continuous 808-nm laser of 1 W/cm^2 induced the gradual vaporization of the droplet (Fig. 1D). When live cells were present, this photothermal cavitation of the droplet introduced cellular damage (Fig. 1E). To reduce the thermal damage of the laser on murine skins, we exposed the tumor region to the laser for 50 seconds to generate microbubbles of 1~3 μm, and then used ultrasound pulses (1 MHz frequency, 0.85 MPa pressure, 20 cycles per pulse, 1 kHz pulse repetition frequency and 1 minute duration) to induce acoustic cavitation to further damage the tumor cells. Our study confirmed diagnostic potential of Melanin-based Perfluorocarbon Droplets.

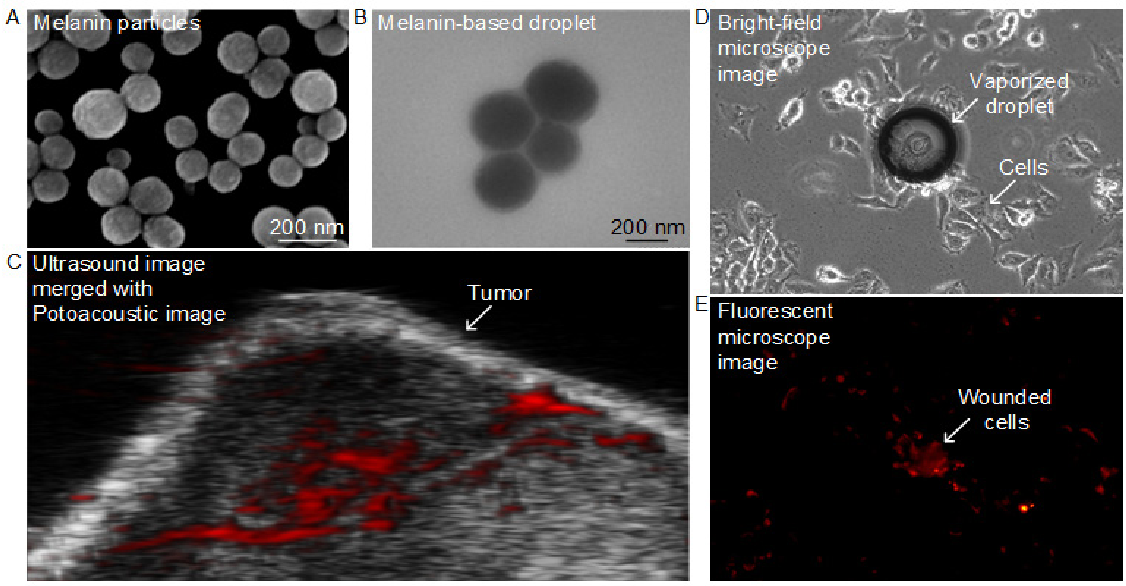

Fig.1A. Scanning microscope image of the melanin particles. Fig.1B. Transmission electron microscope image of the melanin-based perfluorocarbon droplet. Fig.1C. Combined ultrasound and photoacoustic image of the droplet in tumor. Fig.1D and Fig.1E are the vaporization of the droplet and its wounding effect on live cells.