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Microagent Swarm Control for Targeted Therapy Based on Rotating Gradient Magnetic Field

Health & Wellness

Biomedical and Genetic Engineering

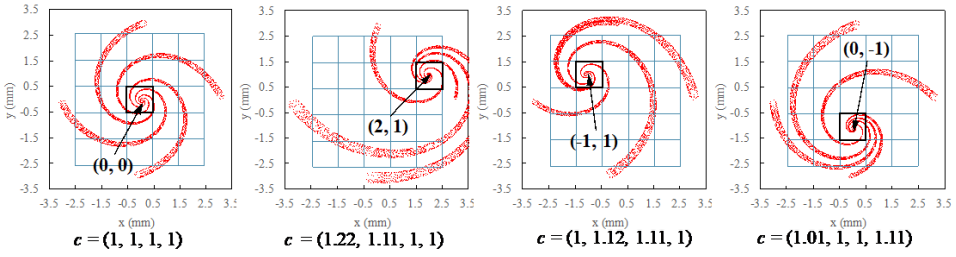

Figure 1. The trajectory of the microagent moving toward different aggregation centers by changing the current passing through the coils.

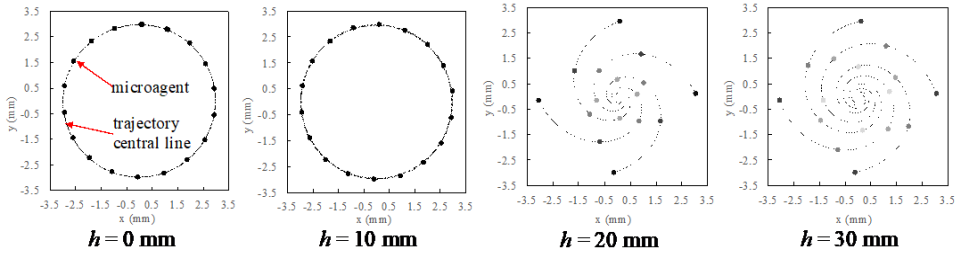

Figure 2. The moving trajectory (centerline) of the microagent in the planes with different h, and the gray scale of the microagent represents a different value of velocity.

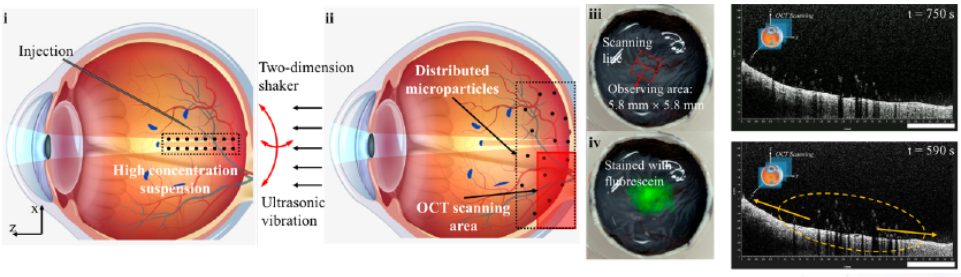

Figure 3. (i) Microparticles were injected into the fundus of the bovine eyeball. (ii) High-concentration suspension was uniformly distributed. The red dashed square and red solid line in (iii) show the observation area and scanning line of the OCT, respectively. The green sketch in (iv) shows the fluorescein released from the aggregated microparticles.

Opportunity

Precision targeted therapy is a modern medical treatment that can precisely locate a lesion in the body and deliver drugs or therapeutic cells for curing. Microagents (e.g. microparticles and microrobots) has been reported to achieve targeted delivery for various disease treatments. The success of targeted therapy relies heavily on the accuracy of delivering a group of

IP Status
Patent granted

Technology Readiness Level (TRL) 5

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microagents to the targeted location. Among the microagents delivery methods, electromagnetic actuation has attracted the most attention for in-vivo applications in a living organism for its advantages of noninvasive and good control ability, minimal damage to tissues, and insensitivity to biological substances. At present, the generally used magnetic drive methods shall be performed alongside with imaging techniques for process visualization and monitoring regardless of low resolution and/or shallow body tissue penetration depth, which hinders the application of microagent delivery in the in-vivo environment, especially in small and complex regions, such as tiny cavities of eyeball or blood vessels. This present invention can overcome a significant challenge to converge microagents to the desired position without sufficient support of real-time imaging technique.

Technology

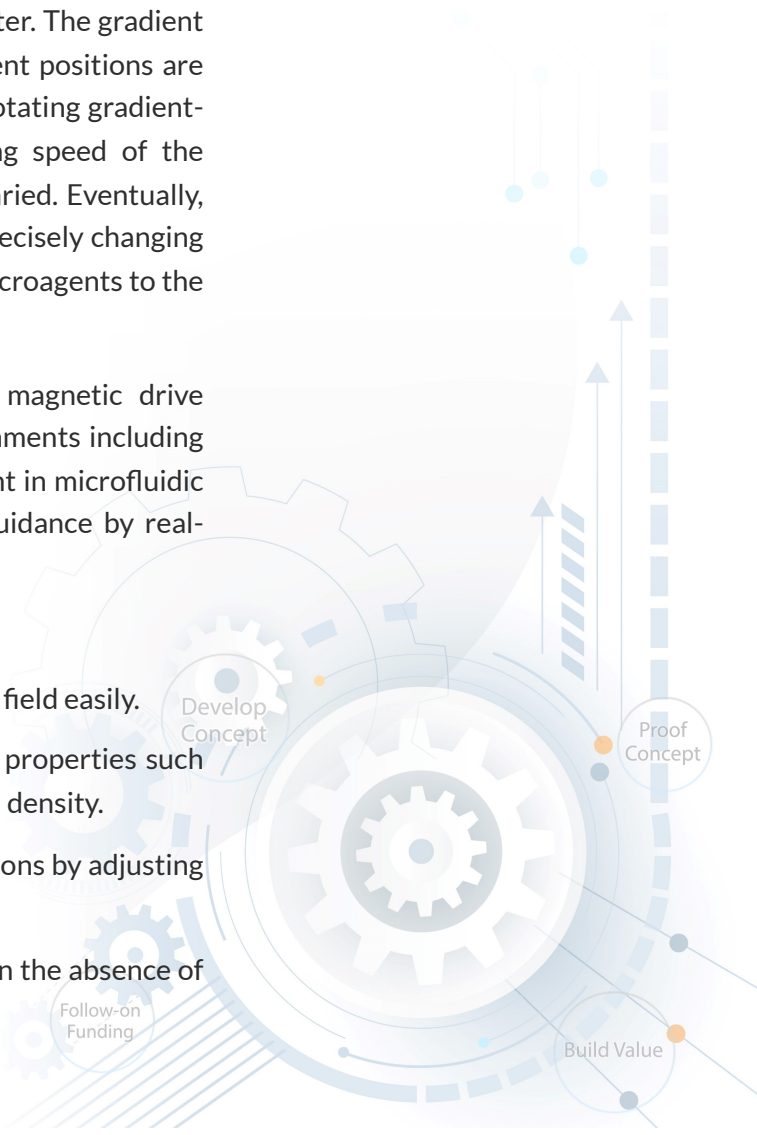
This invention provides a magnetic drive system employing multiple metal coils to generate a rotating gradient-based magnetic field to drive a large group of magnetic microagents.

When an electric current flow through a metal coil, electromagnetic field is generated to drive the movement of another magnetic material in a contactless manner. By sequentially inputting direct current (DC) to each of the metal coils to generate a rotating electromagnetic field, the magnetic microagents are caused to move toward an aggregation center. The gradient magnetic field distributions of the magnetic force at different positions are different within the magnetic drive system. In view of the rotating gradient-based magnetic field, the movement pathway and moving speed of the magnetic microagents in the planes with different height varied. Eventually, the position of the aggregation center can be adjusted by precisely changing the current input to each of the coils, in order to drive the microagents to the target site.

This invention experimentally demonstrated use of the magnetic drive system to deliver different microagents in different environments including open area environment in chamber, constrained environment in microfluidic chip and ex-vivo environment in bovine eyeball without guidance by real-time imaging.

Advantages

- Generate and adjust the rotating gradient-based magnetic field easily.
- Drive different magnetic microagents regardless of their properties such as size, shape, and material and not rely on the distribution density.
- Drive the microagents accurately to different target positions by adjusting the input current of the coils.
- Aggregate the microagents in a designed target site area in the absence of imaging guide.



Applications

- Precision targeted therapy using magnetic microagents as carriers to precisely deliver drugs or cells.
- Delivery of magnetic microagents in custom-designed chamber, microfluidic chip, bio-tissue and organ.