Title of Project

The Charge on Cancer: Using Induced Dipole Moment to Electrostatically Separate Healthy and Cancer Cell-Metal Nanoparticle Complex

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Summary

The current nanotechnology based strategies have introduced a number of nanoparticles of variable chemistry and architecture for cancer diagnosis and treatment. Most nanoparticles are designed to safely reach their target and specifically release their cargo at the site of the disease. But these cargos are usually coated with chemical drugs and most anticancer drugs do not kill cancer cells completely because the mechanism of cancer initiation and spread is not completely understood.

Our proposed method based on physical techniques – particularly the use of electric field to induce dipole moments - have a better chance at segregating, separating and killing cancer cells without causing damage to normal cells.

Proposal

The proposal explores the use of electric fields to segregate cancer cells using conductive nanoparticles. The technology being explored consists of two parts: (i) The technique of embedding the nanoparticle with the cancer cells, and (ii) the technique to move the cancer call-nanoparticle complex.

Electrostatic Alignment of Metallic Particles:

If a dispersion of conductive metallic particles in an insulating fluid is contained in an environment bathed in an external electric field, the field polarizes the conductive particles allowing some of them to move and chain up due to dipole-dipole attractive forces. This phenomena is described in Fig. 1 and has been used for engineering applications such as self healing circuits.

Therefore, electric fields can be used to move and cluster metallic particles.

References: http://dx.doi.org/10.1063/1.4958729; http://dx.doi.org/10.1063/1.4916513; 10.1109/TED.2012.2191557

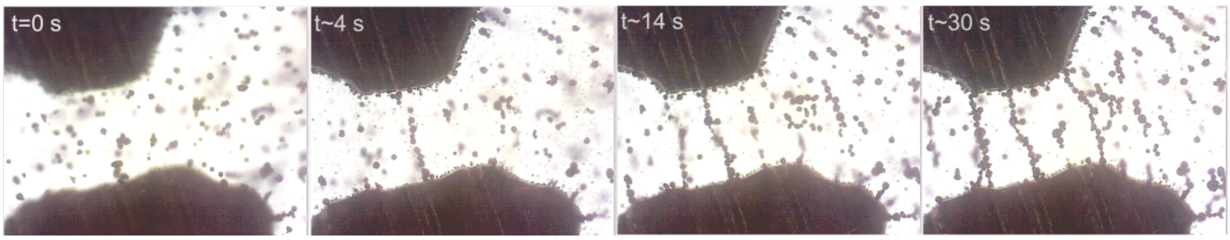

Fig. 1: Demonstration of the clustering of metallic particles in the dispersion when the dispersion is subject to an external electric field.

Forming Metallic Nanoparticle- Cancer Cell Complex:
We will use ferromagnetic nanoparticles coated with antibodies that will detect cancer cells specifically, for example antibodies that recognize newly formed blood vessel that aid in cancer development or antibodies that detect cancer stem cells. These nanoparticles will not attach themselves to the cancer cells forming a metallic nanoparticle – cancer cell complex. Therefore, the cancer cells are attached to metallic particles while healthy cells are not.

Methodology:
The work will be performed as described in Fig. 2.

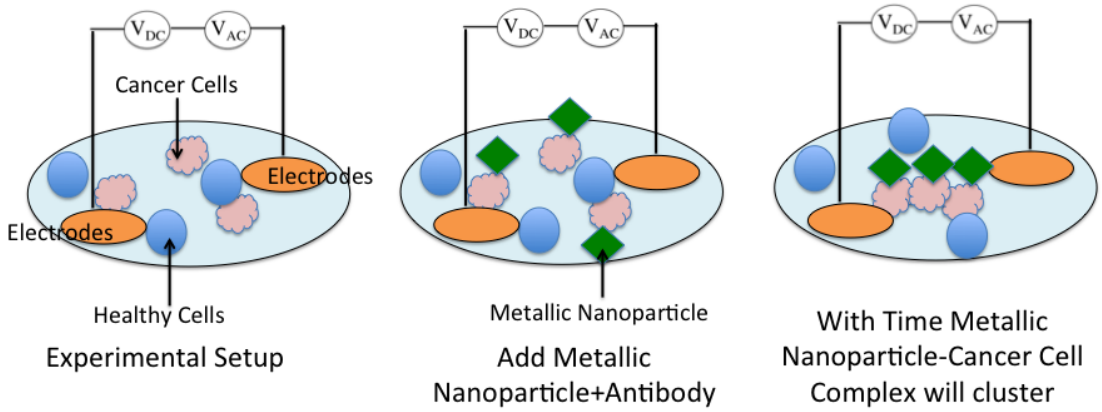

Fig 2: Experimental Method

The Methodology is as follows:
Step 1: Fabricate Electrodes (spacing about 1000 micron) on a printed circuit board. A voltage will be applied across these electrodes to establish an electric field in the gap.
Step 2: Grow normal and cancer cells in co-cultures and drop cast these cells on the substrate to create an in vitro cell culture (Fig. 2, Left).
Step 3: Coat metal nanoparticles with antibodies and drop cast them onto the substrate. The metallic nanoparticles would then target the cancer the cells specifically.
Step 4: Apply the electric field by turning on the power supply. Due to the mechanism described in Fig. 1, the metal nanoparticles should cluster and thereby pull the cancer cells with them, thereby achieving segregation and separation from healthy cells.

Benefits and outcomes
Existing methods to deliver drugs using nanoparticles to kill cancer cells do not kill cancer cells completely because the mechanism of cancer initiation and spread is not completely understood.
Our proposed method uses electric fields acting on metallic nanoparticles attached specifically to cancer cells to separate and cluster cancer cells. These cells can now be destroyed without having a significant impact on the healthy cells.

Potential Risks and Mitigation:
Without the use of fine feature fabrication, access to a fully controllable waveform – the electric field will be too low (gap between the electrodes too large) and the segregation may not be possible. Nevertheless, we will attempt to use fully insulating dispersion media to enhance electrostatic forces.

Sponsor for the research and cost centre
Both Investigators are Lecturers at the University of Cambridge. This work will be performed at the Department of Genetics and the Department of Engineering.

Budget: Consumables (Biological and Chemical Reagents, PCB fabrication, Components): £750, Biomaker Toolkit: £250.