CALIFORNIA STATE SCIENCE FAIR
2017 PROJECT SUMMARY

Name(s)

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Project Number

S0506

Project Title

Biocompatible Microdroplets: A Paradigm Shift in the Reversal of Atherosclerosis

Abstract

Objectives/Goals

The current project introduces a completely novel concept: the use of biocompatible microdroplets to selectively target and dissolve free cholesterol, the primary component of arterial plaque which clogs arteries. The ultimate objective is to identify a safe method to bring about a reversal in the accumulation of arterial plaque.

Methods/Materials

The efficacy with which 2ml emulsions of 1,8cineole microdroplets in saline dissolve cholesterol was tested in 10ml and 40ml of swine blood. The efficacy was quantified using change in mass, and increase in sample diameter. Efficacy change vs. blood volume is an indicator of the microdroplets' selectivity to cholesterol. A theoretical aspect of the project involved the derivation of the binding force and binding pressure of microdroplets to cholesterol in blood. A binding pressure of nearly 300kPa is expected for a 500nm microdroplet, which suggests high selectivity.

Results

A 2ml emulsion of microdroplets dissolved an identical amount of cholesterol in 10ml of whole blood vs. 40 ml of whole blood, within a small measurement error. This provides experimental evidence that microdroplets preferentially bind and dissolve cholesterol while having little to no interaction with blood cells, blood proteins and other components of the cardiovascular system. After only 5 doses in 40ml of blood, the diameter of the cholesterol sample increased from 1.5mm to 2.9mm ±0.2mm, the cross section had increased by 250% ±25% and the sample had lost 45% ±2% of its cholesterol's mass. A total of 6 samples were measured, and each sample received 5 doses, for a total of 30 measurements, which shows repeatability. A second experiment was conducted to determine if microdroplets would attach and dissolve cholesterol under high shear stress conditions, typical of an atherosclerotic artery with restricted blood flow. A flow rate was induced with a pump to generate a Reynolds number ~7000 to ensure turbulent flow. Based on the Blasius equation, a shear stress of 1.9kPa is expected at the atherosclerotic cholesterol's surface. Even under such conditions, the microdroplets were able to attach and dissolve the cholesterol samples. The diameter increased from 1.5mm to 3.7 ±0.2mm after only 5 doses.

Conclusions/Discussion

The novel method of using pharmaceutically acceptable biocompatible microdroplets to safely reverse atherosclerosis systemically has been successfully verified in-vitro.

Summary Statement

A novel method of using biocompatible microdroplets to safely reverse the accumulation of arterial plaque to prevent and treat heart disease and stroke.

Help Received

Ms. Cathy Messenger gave me access to Los Gatos High School's chemistry lab. Mr. Jeff Krauss provided swine blood for in-vitro testing.