CALIFORNIA STATE SCIENCE FAIR
2002 PROJECT SUMMARY

Name(s)

Derek C. Mohr

Project Number

22377

Project Title

The Hot Zone: Achieving Virus Incubation Conditions with Phase Change Materials using Thermoelectric Heat Pumps

Abstract

Objectives/Goals

This thermophysics project explores phase change materials coupled with the use of thermoelectric heat pumps to achieve time-temperature profiles suitable for effective incubation of an array of viruses. Medical and humanitarian relief work in developing countries need methods and equipment to incubate viruses using minimal power. Portable battery-powered incubators have insufficient operating time and cannot achieve the high temperatures needed for most virus incubation.

Methods/Materials

Research began 10 months ago by studying virus incubation characteristics and exploring phase change substances that had freeze/melt temperatures suitable for incubation of various virus families. A patent search was accomplished and no similar operating concept was identified. Nine candidate phase change substances were assessed for freeze/melt temperatures, specific heats, latent heats, and time duration of phase change. Thermoelectric heat pumps were employed to achieve the range of virus incubation temperatures. Heat pump power requirements were measured at phase change (solid/liquid) conditions for each substance corresponding to virus family incubation temperatures. Over 105 individual experiments accumulated 1,120 hours of thermodynamic and power measurements.

Results

Virus incubation conditions were achieved in four of five temperature bands for virus families ranging from 34-72 degrees C. With thermoelectric heat pumps, high temperatures and incubation times far exceeded the performance of portable battery-powered incubators. Specific heats (solid/liquid) and latent heats of phase change materials were calculated from direct measurements of thermal properties. Using efficient thermoelectric heat pumps, only small quantities (20 grams or less) of phase change substances achieved specific virus incubation conditions, the total system is functionally a micro-incubator.

Conclusions/Discussion

The heat pump with phase change materials (micro-incubation) concept was successful in achieving incubation conditions for a wide variety of viruses. This design was superior in terms of thermal performance and incubation duration at a fraction of the weight, size, and cost of existing portable battery-powered incubators. This concept, using heat pumps with phase change materials for micro-incubation, has direct applications in support of worldwide medical and humanitarian relief where viruses pose a serious health risk.

Summary Statement

Virus incubation conditions were achieved by the use of thermoelectric heat pumps with phase change materials; potentially benefiting medical and relief operations in developing countries.

Help Received

None