N88-23904

NON-CONTACT TEMPERATURE MEASUREMENTS FOR BIOTECHNOLOGY DISCIPLINE WORKING GROUP

Robert S. Snyder

Space Science Laboratory

Marshall Space Flight Center

Abstract

There is no present need for non-contact temperature measurements in the space experiments being proposed in the biotechnology research areas, such as cell culturing, cell and protein purification or protein crystal growth. There is interest in measuring temperature changes over very small dimensions, such as the surface of a 10 micrometer diameter biological cell immersed in cell culture fluid. Non-interference measurements of other properties, such as chemical constituents and their concentration, are also needed. Contacting probes for pH have recently been developed to penetrate a cell but questions have been raised about their accuracy and net value.

In the extensive field of biotechnology, several processes have been shown to be modified in the microgravity environment. High quality single crystals of proteins and macromolecules are needed for the determination of the three-dimensional structure of the complex molecules and gravity influences the growth of crystals from solution. The separation and fractionation of biological cells and proteins by electrophoresis, isoelectric focusing and phase partitioning in aqueous electrolytes is hindered by buoyancy-induced convection and sedimentation. The culture of suspended cells requires lower shear forces in microgrvity and the totality of cell metabolism requirements appears to be different in space.

Each of these investigations occur under conditions that preclude non-contact temperature measurements. Each process takes place in an aqueous environment that is necessary to sustain the biological material in its active unmodified state. Biological cells require specific salts and nutrients to keep them viable and their fragility sets limits on these additives to the water. These properties of the environment are measured with probes for pH, conductivity, osmolarity and others. The temperature of the environment should also be kept within a temperature range around body temperature of $38^{o}C$ for maximum cell viability and function but it is unnecessary to make any of these measurements in a non-contacting manner.

Proteins are generally more resistant to changes in the environment and they are not as fragile during experiments. System measurements are also easier to make. Although proteins can be prepared so they retain their properties when dry (proteins are commonly freeze-dried for shipment and sale), all processes with proteins of present interest to NASA require the proteins to be dispersed in an aqueous environment subject to similar conditions as far cells.

Contacting probes have been developed to examine individual cells. Biological cells generally range in size from 5 to more than 50 micrometers in diameter and there is interest in studying particular cellular functions in vitro in addition to the various microscopic evaluations of cells outside of their normal environment. In the future, micron-size-probes will see more application in the study of specific cellular investiagtions.

The proteins to be separated or incorporated in cell culture facilities must be kept soluble and they cannot therefore be probed. Proteins that come out of solution as aggregates during separation processes are generally responding to improper environmental conditions and operations normally can be changed to restore the proteins to solubility. Protein crystal growth, however, can be considered as controlled aggregation. Experiment conditions are selected so proteins come out of solution and grow as crystals rather than precipitated aggregates. Measurements to date have concerned temperature measurements of the fluid environment in which the crystals of protein have grown. In fact, most protein crystal growth experiments have been conducted at "room temperature," either 20^{o}C of the laboratory or 4^{o}C of the cold room available in most biochemical laboratories.

Since cells are apparently healthy within a range of several degrees around normal temperature, processes involving cells have not controlled temperatures closer than a degree. There are no indications from experimental results that smaller temperature tolerances will modify conditions.

In summary, it is not anticipated that non-contact temperature measurements will be critical in biotechnology in the near term. Although temperature is important for biological experiments, the environmental temperature is usually sufficient for these isothermal or slowly changing systems. Since traditional temperature measurement systems are universally accepted, non-contact temperature measurements will not see much use in the biotechnology space experiments now being planned.