OAK RIDGE NATIONAL LABORATORY

FACT SHEET

MANAGED BY UT-BATTELLE FOR THE DEPARTMENT OF ENERGY

Microclimate Conditioning

Regenerable Chem-Bio Filtration / Oxygen Generation for Closed Environments / Personnel Cooling and Heating

Army Issues and Technology Impact

Current MOPP gear is heavy and cumbersome, can be worn only for a limited time before needing replacement, and provides no cooling capabilities. These characteristics significantly degrade the soldier's readiness and require substantial logistics support. Future dismounted warfighters, such as the Objective Force Warrior, will require extended independent operation time (up to 72 hours) even under chem-bio threat conditions.

A lightweight personal environmental protection system that integrates existing technologies to provide regenerable air filtration, oxygen generation, and personal cooling and warming will meet these needs. Such a totally enclosed, regenerable system will enable warriors to operate for long periods in extreme environments and under chem-bio threat conditions. Power requirements are modest and can be met with a lightweight fuel cell.

Technical Concept

The personal protection system incorporates three components within the warfighter's suit.

***1. Air Filtration Using CFCMS**—a rebreather-type air filtration system based on ORNL's new carbon fiber composite molecular sieve (CFCMS).*

The CFCMS adsorbs gaseous contaminants, including CO_2 and chemical agents, better than existing activated charcoals. Since the CFCMS is electrically conductive, adsorbed contaminants can also be desorbed simply by passing a low-voltage electrical current through the filter while venting a small flow of a purge gas. Thus, the CFCMS material can be developed into an electric-swing adsorption (ESA) regenerative filtration system. Tests have shown that the ESA system can function indefinitely without degradation, eliminating the need for replacement filters.

***2. Solid-State Oxygen Generator**—a solid-state oxygen generator that actively separates pure make-up oxygen from air.*

The oxygen generator works on the principle of electrically driven oxygen diffusion through hot ceramic membranes to provide pure makeup oxygen for a sealed rebreather system. ORNL's new solid-state oxygen generator designs will deliver 10 times more oxygen per unit volume than any other existing generator. It can easily be scaled to a small size and weight for dismounted operations and can operate indefinitely without replacement components.

ORNL microclimate conditioning system

3. Personal Cooling/Heating Device—*a solid-state chiller to provide personal cooling (or heating).*
The device that will provide cooling to the warfighter combines a highly advanced thermal-transport material (graphite foam) with solid-state, thermoelectric coolers (Peltier chips). Graphite foam is a new, unique material with a thermal conductivity equivalent to aluminum but at one-fifth the weight. The system would provide supplementary heating by reversing the polarity on the Peltier chips.

The ORNL approach provides enhanced cooling by providing cool air both to the respiratory system (lungs) and body surface. Respiratory cooling can significantly augment evaporative cooling. Since the lungs have both a high surface area and an effective heat transfer medium flowing between them and the rest of the body (blood), they can remove substantial amounts of heat from an individual (up to 500 W during heavy duress), providing maximum cooling when the body is generating the most heat. ORNL has already developed prototype respiratory cooling devices for NASCAR drivers, who must function at peak performance for several hours at high ambient temperatures in heavy, fire-resistant suits. While the physiological effect of the devices has not been rigorously measured, the anecdotal response from the drivers using them has been very positive.

The microclimate conditioning system based on these three technologies will maintain appropriate body temperature for a warfighter while providing continuous chem-bio protection. If all subsystems are operated in a rebreather mode, introduction of external air into the suit can be eliminated when required. However, the cooling system could also be used to cool the warfighter with the suit in the unsealed (helmet-open) condition.

All components of the microclimate conditioning system are lightweight and compact, with modest power requirements.

System	Weight	Size/volume	Power needed
Air filtration	1200 g	2.5 liters	50 W
Oxygen generation	250 g	200 cm^3	50 W
Personal cooling	500 g	1 liter	150 W

Development Approach
An integrated system prototype comprising all three technologies for personal microclimate conditioning could be produced in 24 months.

Related Programs
The CFCMS material is being extensively evaluated for gas filtration and storage systems under DOE programs and has been shown to be very effective in removing the target impurities for which it was developed, including CO_2. Preliminary tests at Edgewood Chem-Bio Center and Porton Down, England, have demonstrated that the CFCMS material effectively removes all simulants and agents for which it has been examined. The use of graphite foam for advanced heat management for transportation, electronic, and industrial applications is being investigated under programs of the DOE, NSA, DoD. The ceramic membrane technology for oxygen separation is an offshoot of ongoing DOE studies on advanced solid-oxide fuel cells.

Point of Contact:
William R. Corwin, Manager
Defense Materials Programs
Oak Ridge National Laboratory
P.O. Box 2008
Oak Ridge, TN 37831-6161
865-574-4648
corwinwr@ornl.gov

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