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EMERGING TECHNOLOGY SNAPSHOT

COLD CLIMATE CLOTHING MATERIALS AND PHYSIOLOGICAL MONITORING

In extreme cold environments humans lose heat through temperature, air movement, relative humidity and clothing. Proper clothing and layering provides thermal management and protection from cold weather injuries. Advances in new materials such as organohydrogels, ion gels, and phase change materials are improving cold weather textiles and wearables. These materials have increased strength, electrical conductivity, moisture absorbency, air-permeability and heating effects. Innovations in wearables that monitor physiological states are advancing their flexibility, biocompatibility, anti-freezing, washability, self-healing capabilities and sensor sensitivity.

ENABLING SCIENCE AND TECHNOLOGY

High performance textiles

High performance textiles are built on advances in fibers that are specialized for specific applications. Various fibers can be used to increase the thermal comfort of clothing, including heat-retaining hollow fibers based on polar bear hairs and kapok fibers, fibers that retain solar energy, conductive fibers such as electric (Joule) heating fibers and phase change materials.

Wearables sensors

Flexible wearable sensors have shown great potential in remote health monitoring and body movement tracking. Understanding the relationship between thermal textiles, electrical resistance, thermal performance, stretchability, energy consumption and function stability are critical to optimize the fabrication of the thermal textiles. Recent research identifies organohydrogels as a potentially superior material for wearable sensors.

Thermal management

Novel materials and structures such as phase change materials, metallic materials, shape memory materials and aerogels can be used to manage heat transfer via conduction, convection and radiation. Remaining challenges include the bulk of clothing used for thermal conduction, increasing the thermal reflection ratio of heat reflective material and balancing breathability, flexibility, washability and moisture absorption.

Power and energy

Power generation is a critical component for textile based thermal management and wearable sensors. Technologies such as Joule heating, flexible electric heating and phase change materials have been explored. Energy harvesting from body heat or the sun is advancing with the use of thermo-, tribo- and piezo-electric (nano)generators and reduces dependency on on-board batteries.

Smart textiles

Smart textiles, which incorporate smart materials into textiles, have varying levels of ability to sense, react, adapt and respond to the environment. Recent innovations include smart gloves and insoles, which can be wirelessly charged and provide smart temperature control functions, and intelligent clothing, which can automatically adjust its thermal insulation by filling hollow chambers with air.

"There are three main technologies used [in smart textiles]: conductive textiles, such as for power transmission or heating; textile sensors, used in biomonitoring and monitoring environmental conditions or physical activity; and textile actuators, such as phase change materials, shape memory polymers and energy harvesters. "

Justine Decaens, R&D director, CTT Group. Advanced Textiles Source. Nov. 9, 2020

SIGNALS

Academic

Donghua University, China, a leader in the field, is researching the development of a highly flexible, efficient and wearable infrared radiation heating carbon fabric and carbon nanotubes in smart textiles.

Collaboration

International academic collaborators, including University of Toronto and McMaster University, have developed a snow-based triboelectric nanogenerator that can be used as an energy harvester that creates electricity from falling snow.

Corporate

CTT Group Canada is a research and development facility with expertise in advanced material, natural fibers and intelligent textiles as well as broad knowledge on testing protective clothing.

Government

The Polish National Research Institute tested a biomechanical energy harvesting system in a smart clothing ensemble for mountain rescuers and found that transducer location, orientation and activity conditions strongly affects performance.

Defence

The US Army is currently testing the Cold Temperature and Arctic Protection System (CTAPS) for winter conditions which offers improvements over the Extended Cold Weather Clothing System (ECWCS).

"CTAPS is an innovative multi-layer system that aims to keep Soldiers warmer in cold weather environments, spanning from 45 degrees Fahrenheit to -65 degrees Fahrenheit... [it] is designed to be lighter weight, more durable, and more comfortable for soldiers."

Private First Class, Anastasia Rakowsky. New Year, New Gear, U.S. Army. Feb. 19, 2020

IMPACT

Social

Research on advanced textiles and clothes will help people more safely enjoy cold climate adventures by expanding the length of time and conditions in which wearers can be comfortable.

Policy

Standardization and appropriate quality control methods are critical tools for regulatory bodies to ensure that wearable smart/e-textiles do not to endanger users' health, safety and privacy.

Economic

The global smart materials market was valued at US$4.7 billion in 2020 and is expected to reach US$7.6 billion by 2026, a compound annual growth rate of 6.9% (2021-2026).

Environmental

The textile industry has a large environmental footprint due to their high use of toxic chemicals, waste production and water and energy consumption. Advances in materials should aim to reduce these impacts.

Defence

Advances in clothing and wearable technologies will increase the survivability of military personnel in extreme cold climates, particularly as nations around the world increase their military presence in the Arctic.

"[we] created the IPC E-Textiles Exchange… to provide an international forum for on-demand education, standards development and collaboration in this rapidly expanding field…[it] provides the opportunity to learn about the latest technological innovations and business insights… It is free and open to anyone."

John Mitchell, IPC president and CEO. Introducing IPC E-Textiles Exchange on IPC EDGE, Nov. 12, 2020

CONTACT

Erica Wiseman
Erica.Wiseman@nrc-cnrc.gc.ca

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