Wearable Sensing Application- Carbon Dioxide Monitoring for Emergency Personnel Using Wearable Sensors

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Proetex project- Advanced e-textiles for firefighters and civilian victims

-Developing textile and fibre based integrated smart wearables for emergency disaster intervention personnel with a goal of improving their safety, coordination and efficiency

-EU funded FP6 project
-2004-2010
-23 European project partners

Consortium partners

1 National Institute of Physics of Matter	Italy
2 Technical University of Lodz	Poland
3 University of Ghent	Belgium
4 Smartex s.r.l.	Italy
5 Milior s.p.a	Italy
6 Sofileta s.p.a.	France
7 Thuasne France	France
8 University of Pisa	Italy
9 Dublin City University	Ireland
10 Commissariat a l'Energie Atomique	France
11 Centre Suisse de Electronique et de Microtechnique SA	Switzerland
12 Sensor Technology and Devices Ltd.	United Kingdom
13 Steiger	Switzerland
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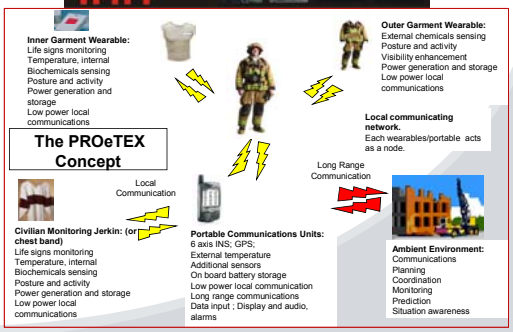
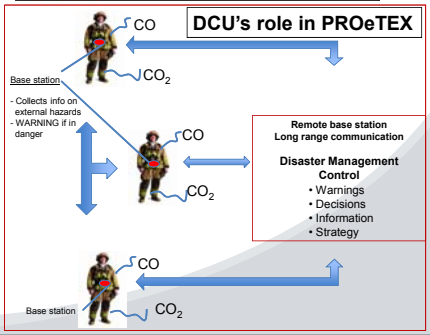
15 Ciba Specialty Chemicals	Switzerland
16 Diadora/Invicta Group	Italy
17 iXscient Ltd.	United Kingdom
18 Zarlink Semiconductor	United Kingdom
19 Brunet-Lion	France
20 Brigade de Sapeurs-Pompiers de Paris	France
21 INSA-Lyon-CNRS	France
22 EUCENTRE – Protezione Civile	Italy
23 Department de la Defense et de la Securite Civile	France

Advanced E-Textile systems can bring together sensors, connections, transmission systems, power management. The emergency disaster personnel smart garments will progressively enhance and integrate such textile systems to enable the following functions:

- Continuous monitoring of life signs (biopotentials, breathing movement, cardiac sounds);
- Continuous monitoring biosensors (sweat, dehydration, electrolytes, stress indicators);
- Pose and activity monitoring;
- Low power local wireless communications, including integrated textile antennae;
- Internal temperature monitoring using textile sensors;
- External chemical detection, including toxic gases and vapours;
- Power generation - photovoltaic and thermoelectric and energy storage;
- Longer term e-textile technologies including further sensors, light emission and logic on fibre.





Targeted gasses

Carbon monoxide- CO

- Colorless, odorless, tasteless, toxic gas
- Produced by the incomplete combustion of the fossil fuels

Concentration of CO in air	Inhalation time and toxic developed
50 ppm	Safety level as specified by the Health and Safety Executive
200 ppm	Slight headache within 2-3 hours
400 ppm	Frontal headache within 1-2 hours
800 ppm	Dizziness, nausea, convulsions within 45 minutes, insensible in 2 hours

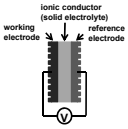
Carbon dioxide- CO_2

- Present in atmosphere as a trace gas, in conc.of 350-400 ppm
- Colourless, odourless, non-combustible gas
- Combustion of fossil fuels and deforestation
- High concentrations may occur in closed spaces

Concentration of CO in air	Inhalation time and toxic developed
10000 ppm	Drowsiness
>20000 ppm	More frequent, deeper respiration
30000 ppm	Breathing rate doubles
50000 ppm	Serious oxygen deprivation resulting in permanent brain damage, coma and even death.

CO_2 sensor characteristics

- Sensor supplier- Alphasense UK
- 3-pin sensors
- 14.5 mm diameter, 12.5 mm height (including pins)
- CO_2 sensor electrodes: reference, working



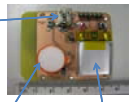
Principle of a Potentiometric Sensor for Gases The signal is measured as the potential difference (voltage) between the working electrode and the reference electrode. The working electrode's potential depends on the concentration of the CO_2 in the gas phase

Sensor integration

The less dense CO gas tends to rise and therefore CO sensor was integrated in **the jacket collar**, close to the breathing height

CO_2 gas is more dense than air it tends to accumulate in low height, the CO_2 sensor has been integrated in to a specially designed **boot pocket**

CO_2 wireless sensing module



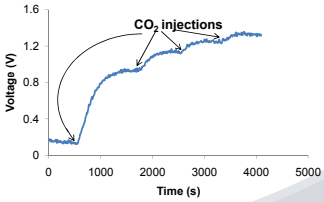
Module dimensions: 5.5x4x1.5 cm

Signal captured using a base station, connected to a PC and monitored using HyperTerminal

CO_2 module protective casing and testing chamber

Protective casing

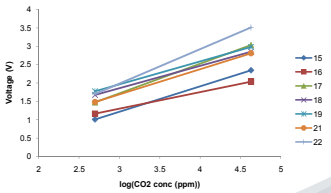
CO_2 sensor response



CO_2 concentrations
1. atmospheric (initial base line)
2. 9750 ppm,
3. 19500 ppm,
4. 29300 ppm,
5. 42800 ppm

Wirelessly transmitted signal from CO_2 sensor calibration (range atmospheric to 42800 ppm CO_2). Sensor was enclosed in an airtight chamber and CO_2 was injected.

Problem: CO_2 sensor variability

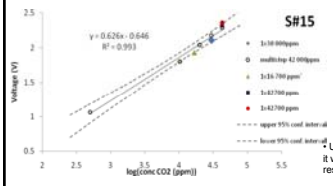


atm- 42000 ppm CO_2

It is not possible to find common slope and intercept for all sensors !!

1-1.5 V response for a single injection Resulting in 42000 ppm

CO_2 sensor- using calibration parameters



• Using slope and intercept obtained from sensors calibration it was possible to successfully predict the sensors response in volts for each known concentration of CO_2

• Prior to using any sensor/wireless module, calibration of the particular sensor will be needed and the obtained slope and intercept will have to be used as input parameters for each module.

• Once the sensor needs to be replaced, a new set of parameters characteristic for a new sensor will need to be used.

Future activities

- Re-programming the modules to account for calibration factors

-Full integration of CO/CO_2 sensors into the garment

- Wireless transmission: communication of on-body base station and the remote station

- Evaluation of prototypes in laboratory conditions

- Evaluation of prototypes in-field conditions

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-Thank you for your attention!