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Simple Barcode System Based on Ionogels for Real Time pH-Sweat Monitoring

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8th June 2010

Outlook

- **SWEAT, WHY IS IMPORTANT?**
- **INTRODUCTION: WEARABLE CHEMICAL SENSORS**
- **IONOGEL: IONIC LIQUIDS (*I.L.)***
- **BARCODE AND MICRO-FLUIDIC FABRICATION**
- **CHARACTERISATION OF THE DEVICE**
- **RESULTS**
- **CONCLUSIONS**

Introduction

SWEAT, WHY IS IMPORTANT?

SWEAT IS NATURALLY GENERATED DURING EXERCISE, THUS THE POSSIBILITY OF MONITORING ITS CONTENTS PROVIDES VERY RICH INFORMATION ABOUT THE PHYSIOLOGICAL CONDITION OF THE INDIVIDUAL.

SWEAT ANALYSIS TO IDENTIFY PATHOLOGICAL DISORDERS:

- **CYSTIC FIBROSIS***
- **INFORMATION ON DEHYDRATION**
- **CHANGES IN THE CONCENTRATIONS OF BIOMOLECULES AND IONS HYPONATREMIA (LOW SODIUM CONCENTRATION)**

THIS INFORMATION CAN BE USED TO DETERMINE SUITABLE APPROACHES TO REHYDRATION AND RE-MINERALISATION WHICH IMPROVES PERFORMANCE AND GENERAL HEALTH.

*Common hereditary disease which affects the entire body, causing progressive disability and often early death

Introduction

WHY pH IN SWEAT?

pH

SWEAT RATE

SODIUM CONCENTRATION

DEHYDRATION

Introduction

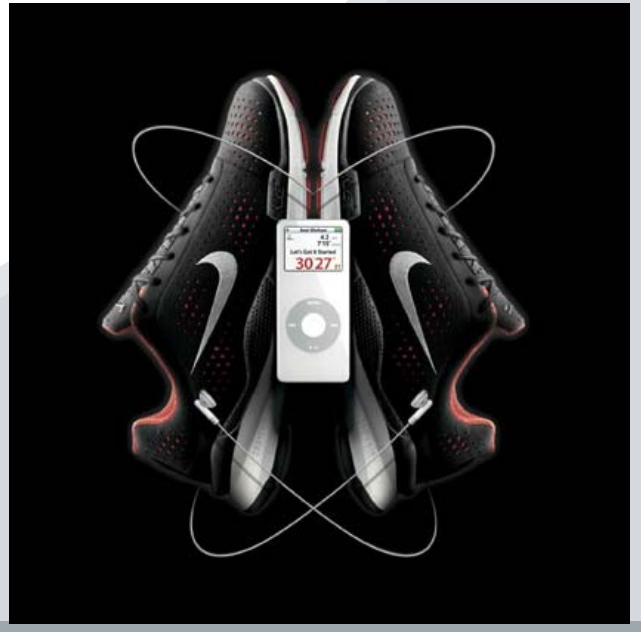
PHYSIOLOGICAL SENSORS

Breath rate, heart rate, activity, posture, skin temperature…

LIFESHIRT®

TRAINTRAK™

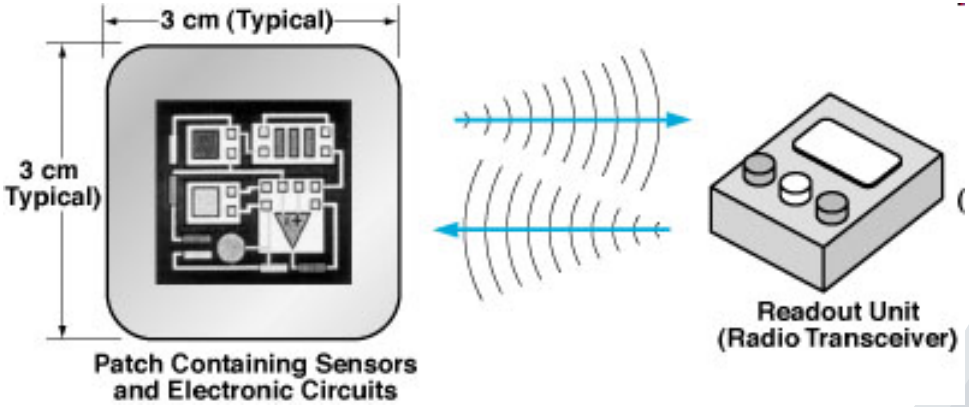
NIKE-APPLE IPOD SPORTS KIT



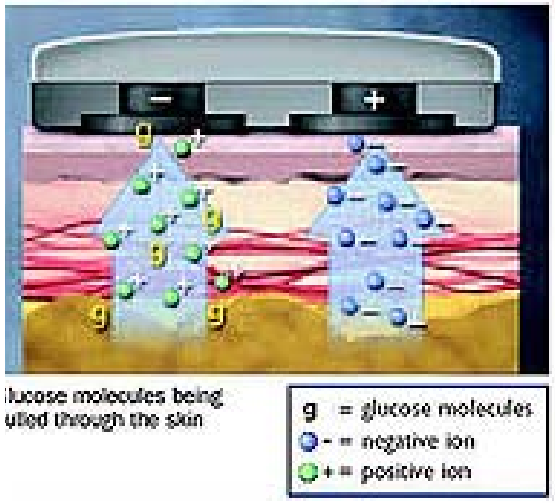
SWEAT INTENSITY

Introduction

CHEMICAL SENSORS



NASA: WEARABLE SENSOR PATCHES



GLUCOWATCH

SWEAT COLLECTION PATCHES

Introduction

PROBLEMS TO OVERCOME WITH CHEMICAL SENSORS?

SAMPLE GENERATION

COLLECTION

DELIVERY

SENSOR CALIBRATION

WEARABILITY

SAFETY ISSUES

SWEAT RATE AND FLUID LOSSES VARY FOR INDIVIDUALS AND ARE GENERALLY DEPENDENT ON BODY SIZE, GENDER, EXERCISE INTENSITY, ENVIRONMENTAL CONDITIONS AND INDIVIDUAL METABOLISM.

Introduction

WHAT DO WE NEED????

<u>DEVICE</u>:

WEARABLE

ROBUST

FLEXIBLE / ADAPTABLE

REUSABLE/ DISPOSABLE → **CHEAP**

CONTINUOUS REAL TIME ANALYSIS → **IMMEDIATE FEEDBACK**

MICRO-DEVICES!!

Introduction

DETECTION:

NOT INVASIVE

OPTICAL SENSORS!!

WIRELESS

FREEDOM FROM ELECTRICAL NOISE

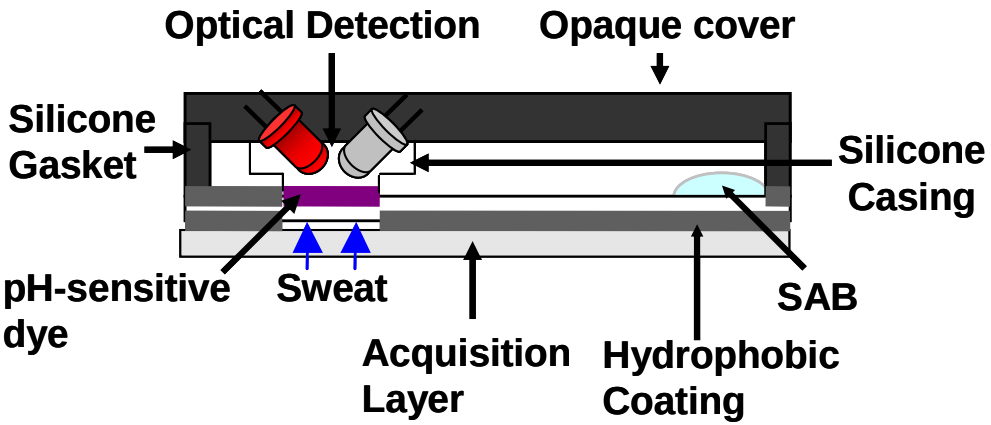
MINIATURIZATION

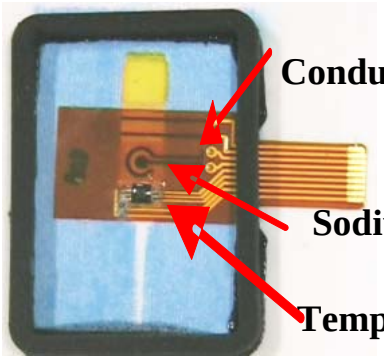
NOT PHYSICAL CONTACT

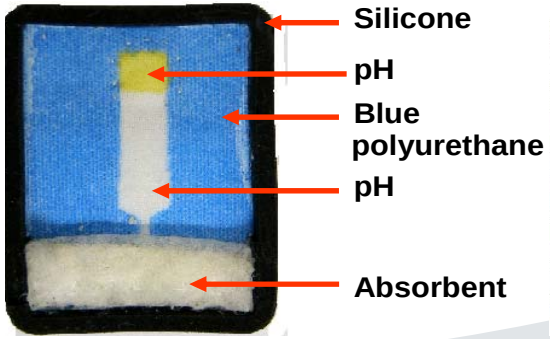
FLEXIBILITY IN INTERROGATION APPROACHES
(HUMAN EYE, LED-SENSORS, CAMERAS, SPECTROMETERS, …)

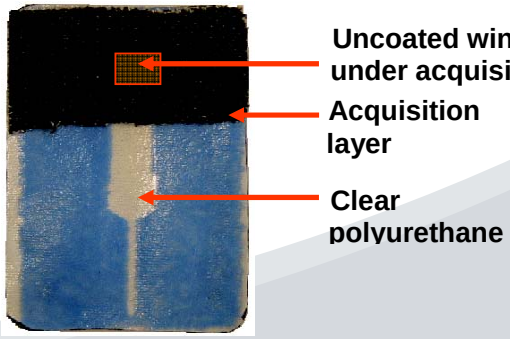
Introduction

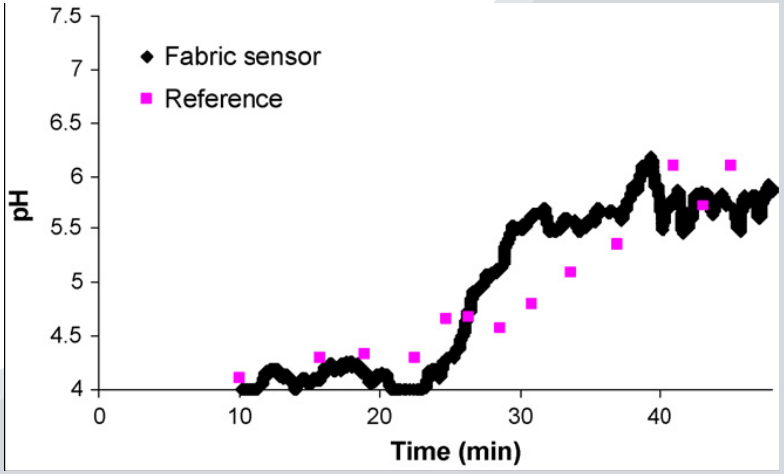
Emitter-detector LED's λ = 660 nm











S. Coyle *et al.*, IEEE Transactions on Information Technology In Biomedicine, VOL. 14, No. 2, MARCH 2010

Ionic Liquids

- **THE GREEN CHEMISTRY MOVEMENT!**

- **THEY ARE LOW MELTING POINT SALTS (< 100 °C) THAT REPRESENT A NEW CLASS OF NON-AQUEOUS BUT POLAR SOLVENTS.**

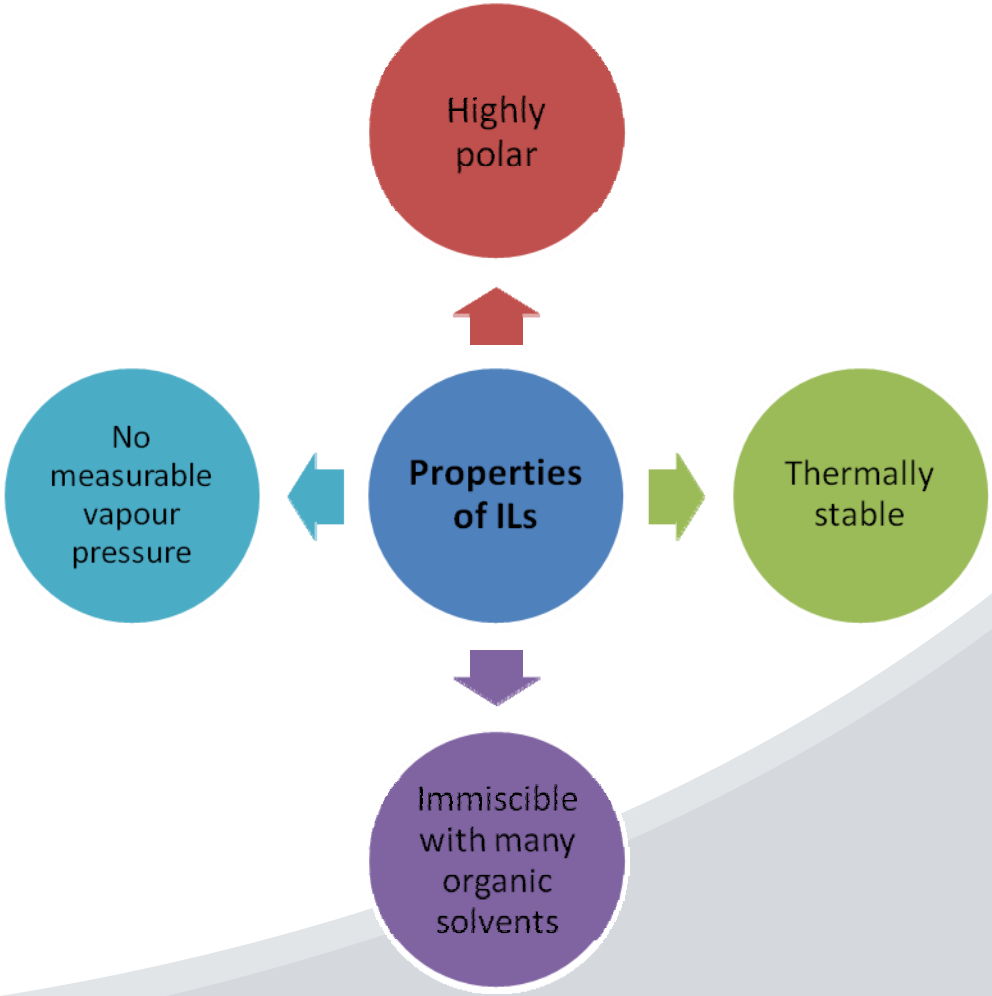
- **COMPOSED OF IONS: CATIONS AND ANIONS.**

- **'DESIGNER SOLVENTS' AS THEIR PROPERTIES CAN BE ADJUSTED TO SUIT THE REQUIREMENTS OF A PARTICULAR PROCESS.**

- **THE NUMBER OF PAPERS PUBLISHED IN 1995 WAS APPROXIMATELY 20 AND ROSE TO 2,500 IN 2006.**

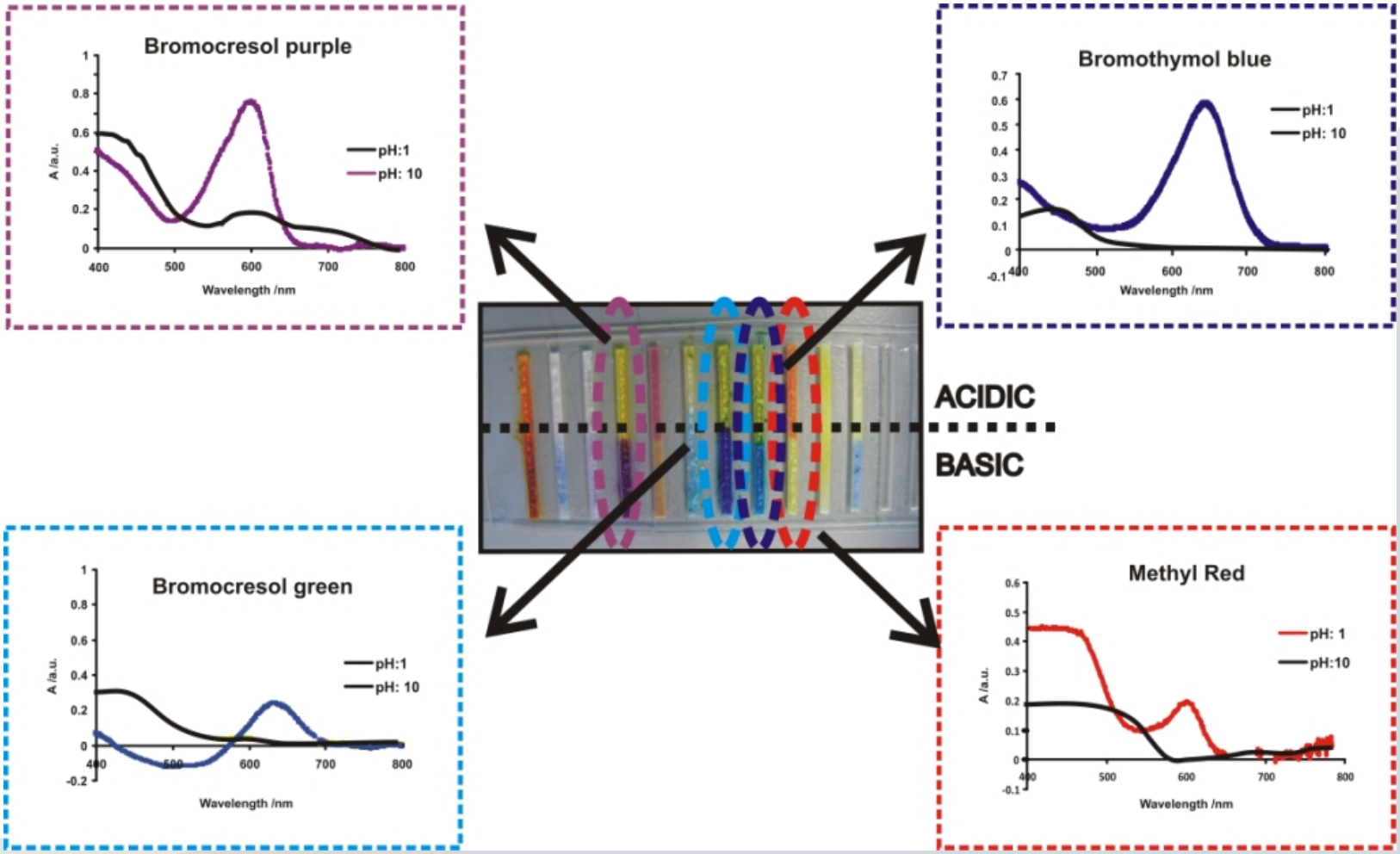
R. Byrne, F. Benito-Lopez, D. Diamond, Mater. Today, 2010, Submitted.

Ionic Liquids

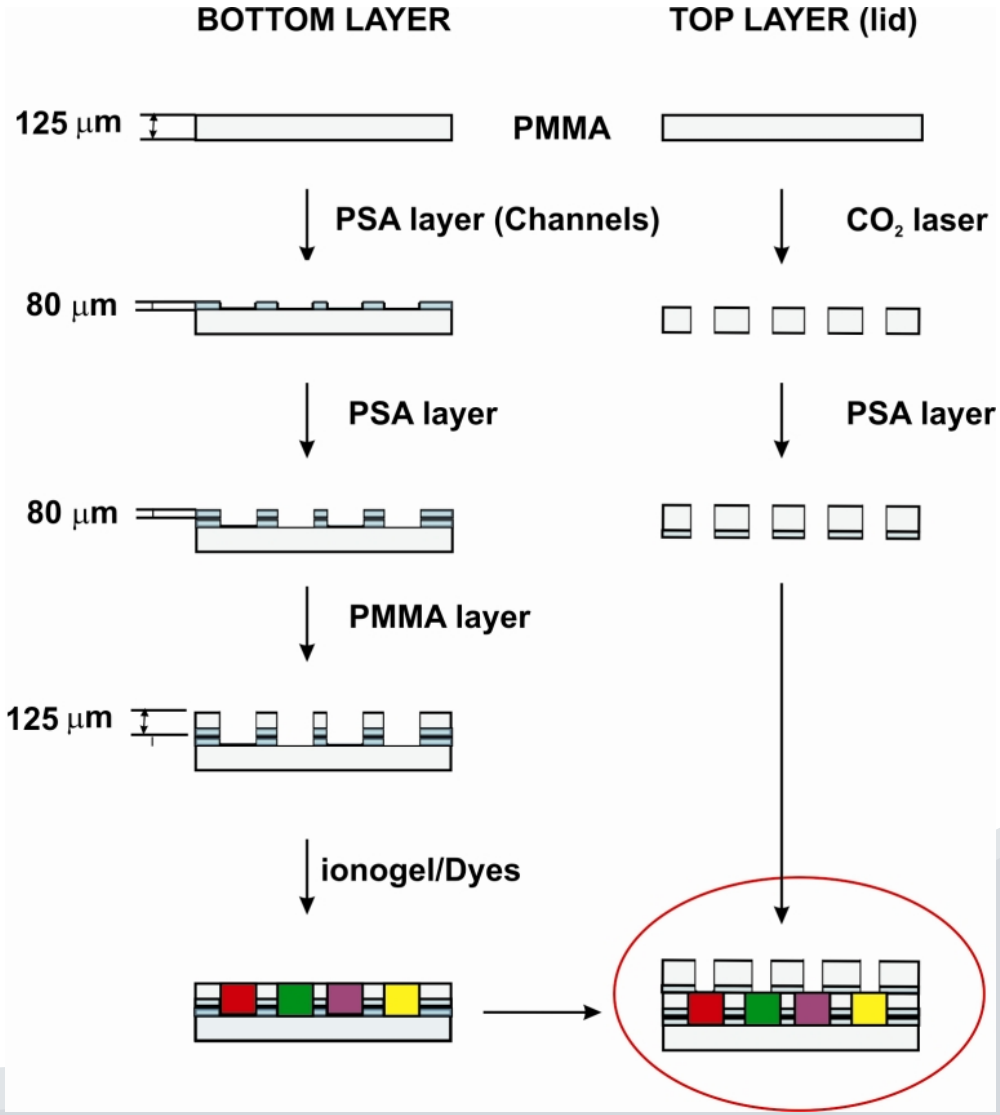


Characterisation

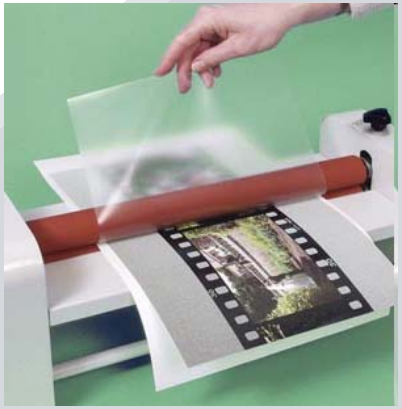
DOPING OF THE IONOGEL WITH THE pH-DYES



Fabrication



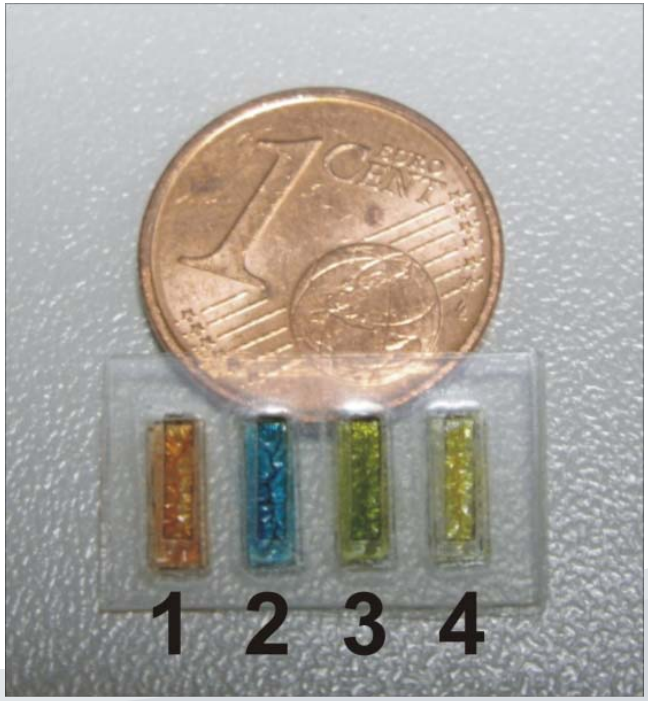
CO_2 laser

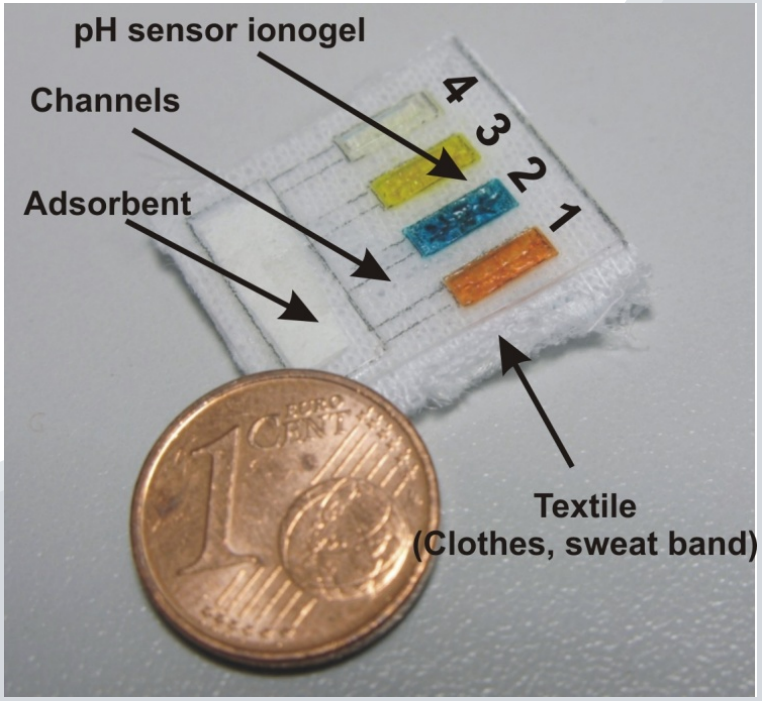


laminator

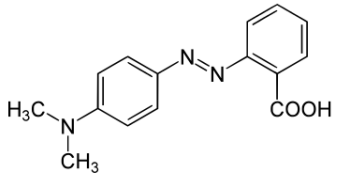
Micro-fluidic: *I.L.*

	pH
1- METHYL RED	4.4 - 6.2
2- BROMOCRESOL GREEN	3.8 - 5.4
3- BROMOCRESOL PURPLE	5.2 - 6.8
4- BROMOTHYMOL BLUE	6.0 - 7.6

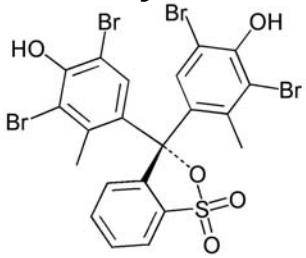




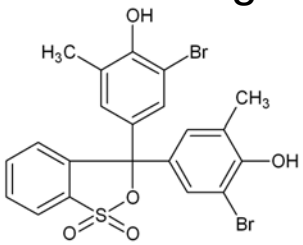
Characterisation



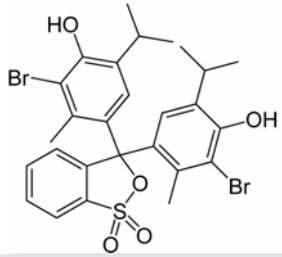
Methyl Red



Bromocresol green



Bromocresol purple



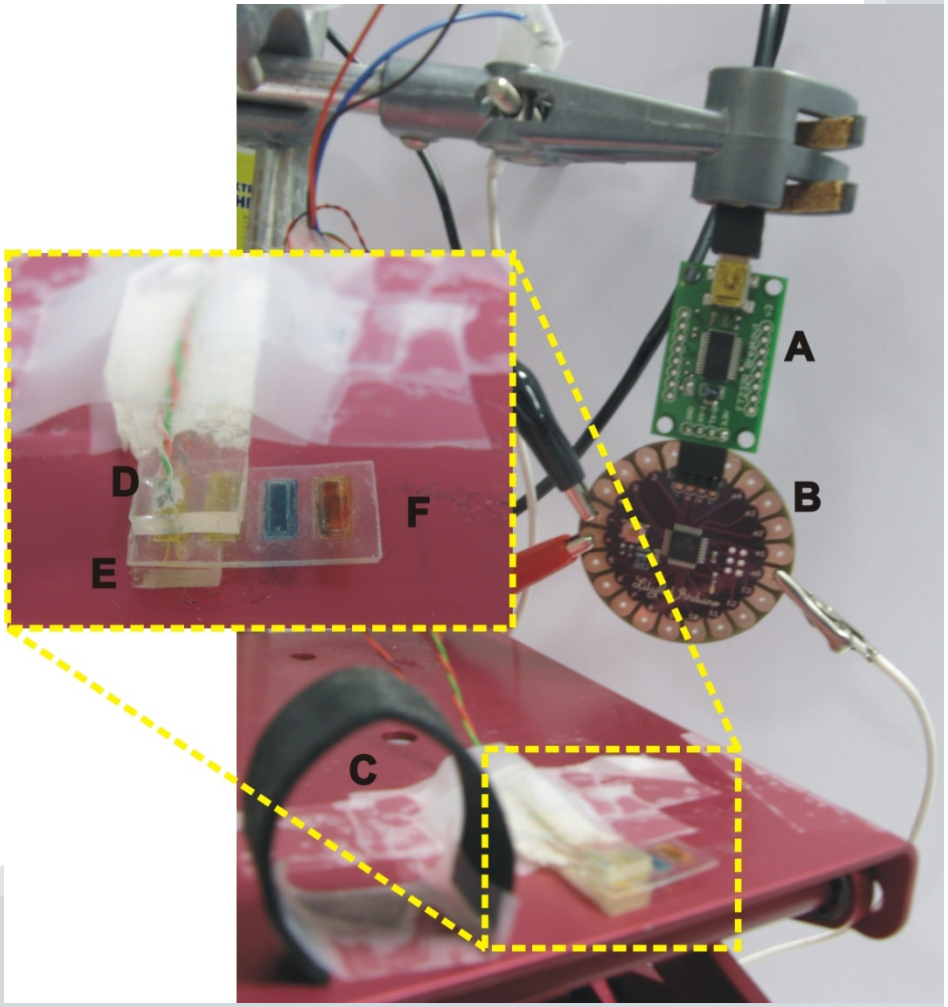
Bromothymol blue

Characterisation

OPTICAL DETECTION TECHNOLOGY

The optical detection set-up consists on:

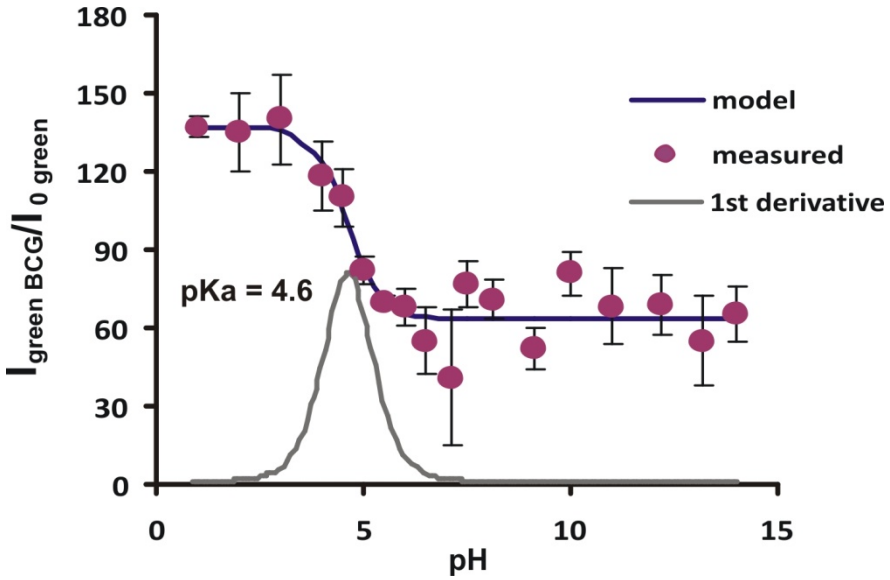
A) laptop or wireless connection link
B) microcontroller (Lilypad Arduino)
C) black masking tape
D) surface mount μ-LEDs light source
E) Surface mount photodiode: detector
F) barcode system

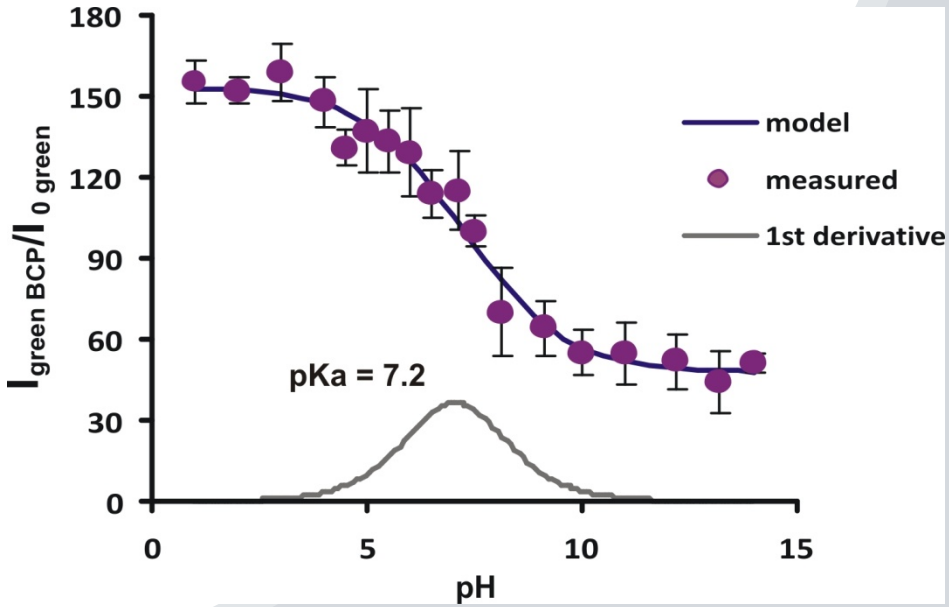


NOT INTEGRATED YET!!

Characterisation

CALIBRATION OF THE pH DYES





$pKa_{lit.} = 4.6$

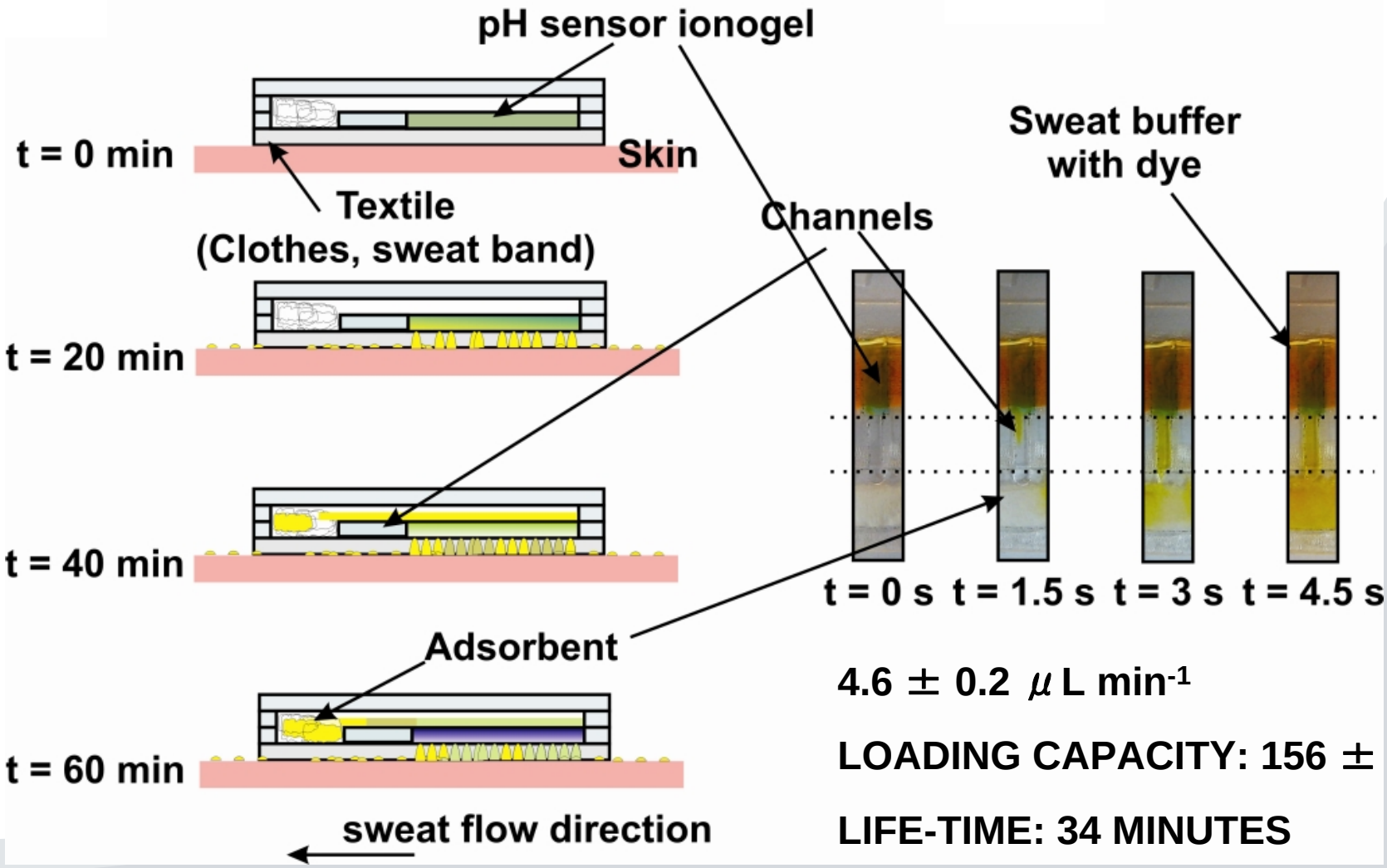
bromocresol green (n= 3)

$pKa_{lit.} = 7.1$

bromothymol blue (n= 3)

Characterisation

MICROFLUIDIC SYSTEM PERFORMANCE



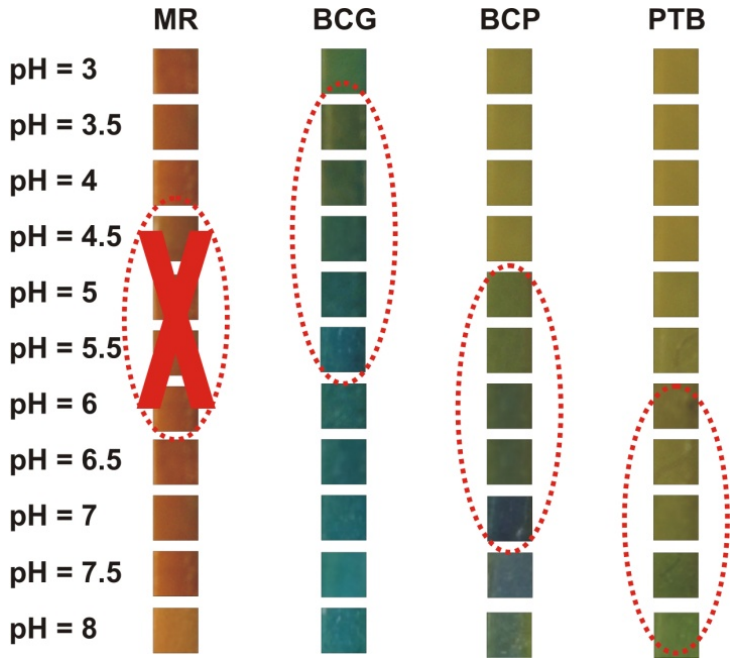
4.6 ± 0.2 μL min^{-1}

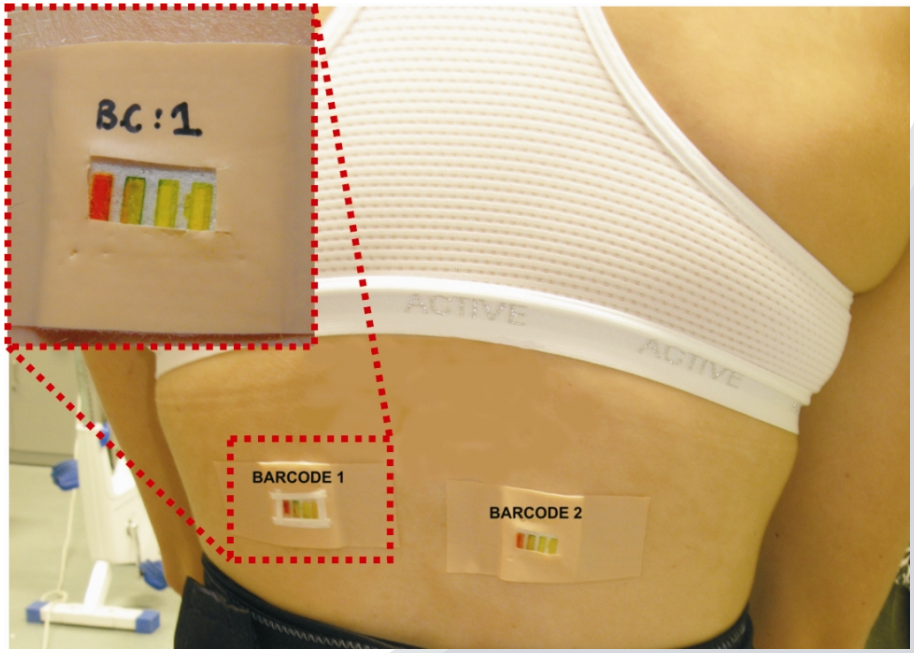
LOADING CAPACITY: 156 ± 3 μL

LIFE-TIME: 34 MINUTES

Results

ON-BODY TRIALS





Colour profile of each of the indicators at different pH's (pH range: 3-8)

Picture of the back of a trainer with a micro-device (1) and barcode (2) systems (activated at pH 2)

Conclusions

- **THE FABRICATION, CHARACTERIZATION AND THE PERFORMANCE OF WEARABLE MICRO-FLUIDIC SYSTEMS BASED ON TEXTILES AND IONIC LIQUID POLYMER GELS (IONOGELS) FOR MONITORING IN REAL TIME MODE THE pH OF THE SWEAT GENERATED DURING AN EXERCISE PERIOD HAS BEEN PRESENTED.**
- **THE IONOGEL-DYE INTERACTIONS ENSURE NO LEACHING OF THE DYES DURING EXPERIMENTS, PROVIDING LONG DURABILITY OF THE DEVICE AND ACCURACY ON THE pH OF SWEAT MEASUREMENTS OVER TIME.**
- **THIS APPROACH PROVIDES IMMEDIATE FEEDBACK REGARDING SWEAT COMPOSITION, pH, TO INDIVIDUALS DURING EXERCISE PERIOD.**
- **THIS CAN BE MEASURED BY EYE, VIDEO ANALYSIS OR BY OPTICAL SENSING COMPONENTS CONTROLLED BY A WIRELESS MICRO-CONTROLLER.**

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QUESTIONS???