Open source hardware in chemical analysis: Tools or toys?

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COST Action CA16215 - European Network for the Promotion of PORTable, Affordable and Simple Analytical Platforms

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1. COST Action - European Cooperation in Science and Technology

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COST ACTIONS

"European ***Cooperation*** in Science and Technology (COST) is the longest-running European framework for research and innovation. For over 45 years, we have offered ***European researchers and innovators***, a simple and flexible pathway to take part in the best science and technology network in Europe and ***across the world***.". COST is financed by H2020.
https://www.cost.eu/who-we-are/

- **23 of November 1971**: Official entry into force of COST
- **1973**: 19 Member countries, 5 COST Actions running
- **1980**: 28 COST Actions running
- **1995**: 27 Member countries, 117 COST Actions running
- **2005**: 170 COST Actions running
- **2018**: 38 Member countries with more than 300 Actions running

WHAT ARE COST ACTIONS?

A COST Action is a ***network*** dedicated to scientific collaboration, ***complementing*** national research funds. COST Actions are:

- open to researchers and innovators;
- collaborating in a field of science and technology;
- based on a joint work programme lasting four years.

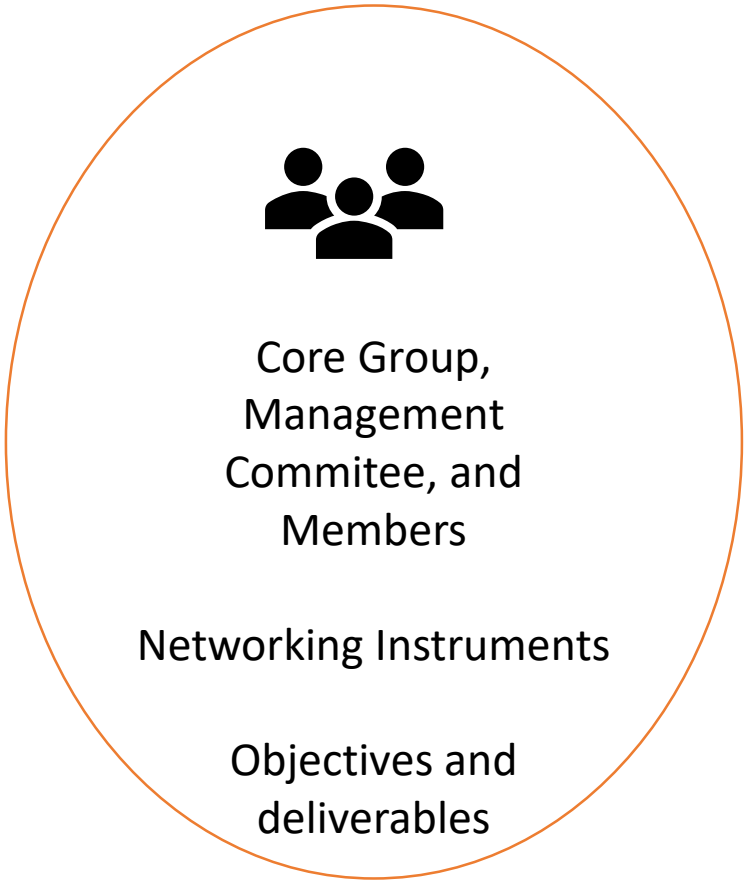
A COST Action is open to all:

- science and technology fields;
- institutions (academia, public institutions, SME/industry, NGO, European/internationals organisations, etc.);
- career stages;
- COST Member countries

A COST Action is organised by a range of ***networking tools***, with funding covering the cost of COST Action networking tools. The average COST Action support is EUR 130.000 per annum. COST Actions can pave the way to or establish synergies with EU-funded research projects. Collaboration within research projects often leads to new Actions.
You can browse through all the running COST Actions (/cost-actions/browse-actions/)

https://www.cost.eu/cost-actions/

COST Mission



Promoting and spreading excellence

Fostering interdisciplinary research for breakthrough science

Empowering and retaining young researchers and innovators

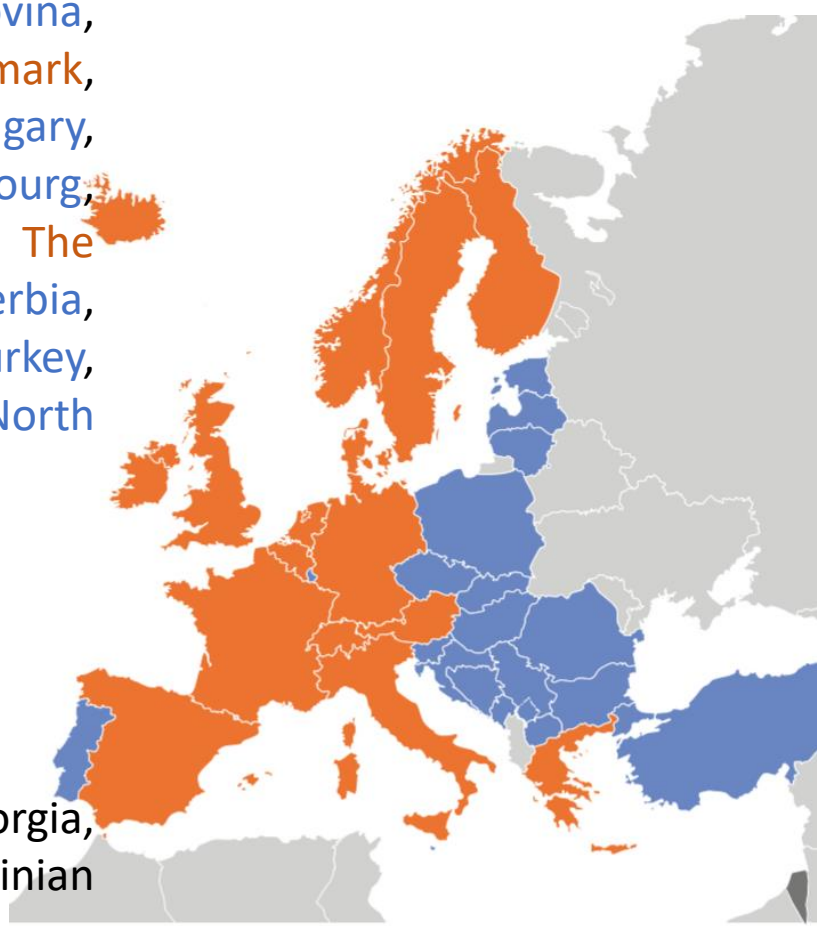
A ***COST Action*** funded by the *COST Association*

The ***COST Association*** funded by EU research framework programmes (FP6, FP7, H2020)

COST NETWORK

38 COST countries

Albania, Austria, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, The Republic of Moldova, Montenegro, The Netherlands, Norway, Poland, Portugal, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, The United Kingdom and The Republic of North Macedonia.



1 Cooperating State

Israel.

COST Near Neighbour Countries

Algeria, Armenia, Azerbaijan, Belarus, Egypt, Georgia, Jordan, Lebanon, Libya, Morocco, The Palestinian Authority, Russia, Syria, Tunisia and Ukraine.

+ INTERNATIONAL PARTNER COUNTRIES (IPC)

2. PortASAP – CA 16215

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The Need For Portable, Affordable and Simple Analytical Platforms

Major Success thanks to better instruments

Biomarkers discovery and untargeted analysis with thousands of samples

Trace analysis in environmental and forensic sciences thanks to LC/GC/CE-MS

Detection of life in exoplanets by CE

Anal. Chem. **2017**, 89, 1329 – 1337.

In vivo monitoring of biological events by micro dialysis.

J. Chrom A **2015**, 1382. 48-64

AND YET

Recurrent food scandals in EU (Fipronil - <30 Million eggs contaminated in EU, Guardian 2017)

The World Health Organization estimates that 3.575 million people die from water-related diseases a year (WHO, 2010)

10% of Drugs in Developing Nations are Counterfeit, , leading to tens of thousands of deaths (WHO, 2017)

Urgent need for affordable alternatives

THE GOALS AND THE NETWORK OF THE PORTASAP CA

Challenge: Develop and **promote** low-cost instruments and open-source hardware (OSHW) capable of **sensitive chemical analysis in specific areas and applications** where the use of complex laboratory-based instrumentation is **not the desired option**.

Network:

- 30 COST Countries, 1 Near Neighbour Country (Belarus)
- 11 Core members, 48 Management committee members
- 200 members in total with highly multidisciplinary expertise

Activities:

- 1st PortASAP meeting, Porto, March 2018
- Workshop – Build you own capillary instrument, Brno, October 2018
- 2nd PortASAP meeting and Workshop – Hands-on on Arduino for air and water analysis, Varazdin, February 2019
- Training School (Hackathon) – DIY spectrometers for wine analysis, Aveiro, March 2019
- Training School – Current and future Air Pollution management – Perspectives on new sensor technologies, Thessaloniki, September 2019
- 3rd PortASAP meeting and Workshop – Sample preparation and microfluidic, Chania, March 2020

- 16 Short Term Scientific Missions

Five + One Working Groups (WG)

WG1. Validation and dissemination of Open Source Hardware

WG4. Sample Treatment and Microfluidic

- ✓ Labware
- ✓ Open Source CE
- ✓ Smartphone based spectrometer
- ✓ Electrochemistry

WG5. New Instrumentation

- ✓ Origami-inspired paper sensor
- ✓ Sensors
- ✓ Low-cost Raman and NMR

WG2. Information and Communication Technology and Software Development

- ✓ Software, apps and databases
- ✓ Machine learning
- ✓ Chemometrics and mathematical separation

WG3. Field Tests and Applications

- ✓ Archaeometry, Conservation and Restoration
- ✓ Water treatment
- ✓ Life science
- ✓ Developing countries
- ✓ Education and lifelong learning

WG6. Exploitation of Results

3. Open Source Hardware (OSHW) – Definition and Applications

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Open Source Hardware (OSHW) Statement of Principles

Open source hardware is hardware whose design is made **publicly available** so that anyone can **study, modify, distribute, make, and sell the design or hardware** based on that design.

Open source hardware **gives people the freedom to control their technology while sharing knowledge** and encouraging commerce through the open exchange of designs.

Definition from the Open Source Hardware Association

https://www.oshwa.org/definition/

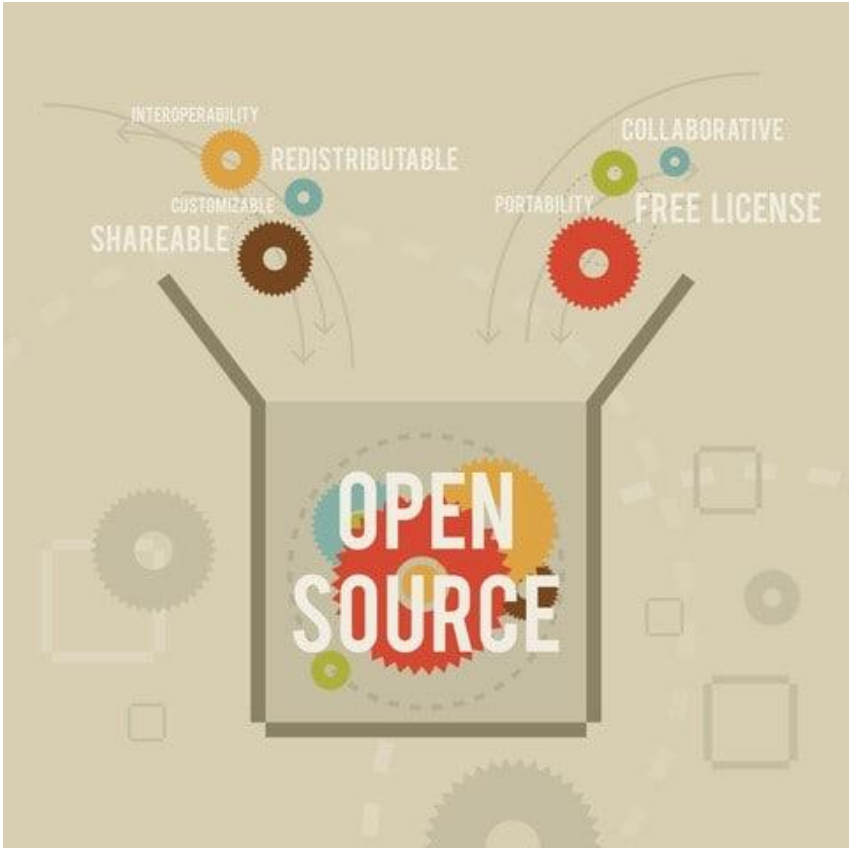

Figure: OSHW can benefit society and the world at large with creative contributions that can address every manner of concern. Source Mouser Electronics

Ideal Conjunction of Tools and Concepts

Development based on sharing and collaborative improvement has a long anthropological history. Technologically, too, the practice is **anything but new**!

Tools

- ✓ Internet and Social Media
- ✓ 3D printers
- ✓ Cheap electronics (e.g. Arduino) and computer boards (e.g. Raspberry Pi)
- ✓ Smartphones = light-sensors, data transfer and computer
- ✓ Easy and/or free programming languages (OOP) (e.g. Python, R, Matlab)
- ✓ Cloud computing
- ✓ Public repositories

Concepts

- ✓ Open Source Initiative
- ✓ FabLab and Maker Spaces
- ✓ Citizen Science Initiative
- ✓ Lifelong learning
- ✓ Do-It-Yourself and Do-It-Together
- ✓ Computer-aided design
- ✓ Internet of Things

Some Key Players in Science and Technology

CERN

CERN Open Hardware Licence

HardwareX (Elsevier)

UNIVERSITÉ DE GENÈVE

citizen cyberlab

unitar

United Nations Institute for Training and Research

4. Open Source Hardware (OSHW) in Research – Disruptive or Distractive?

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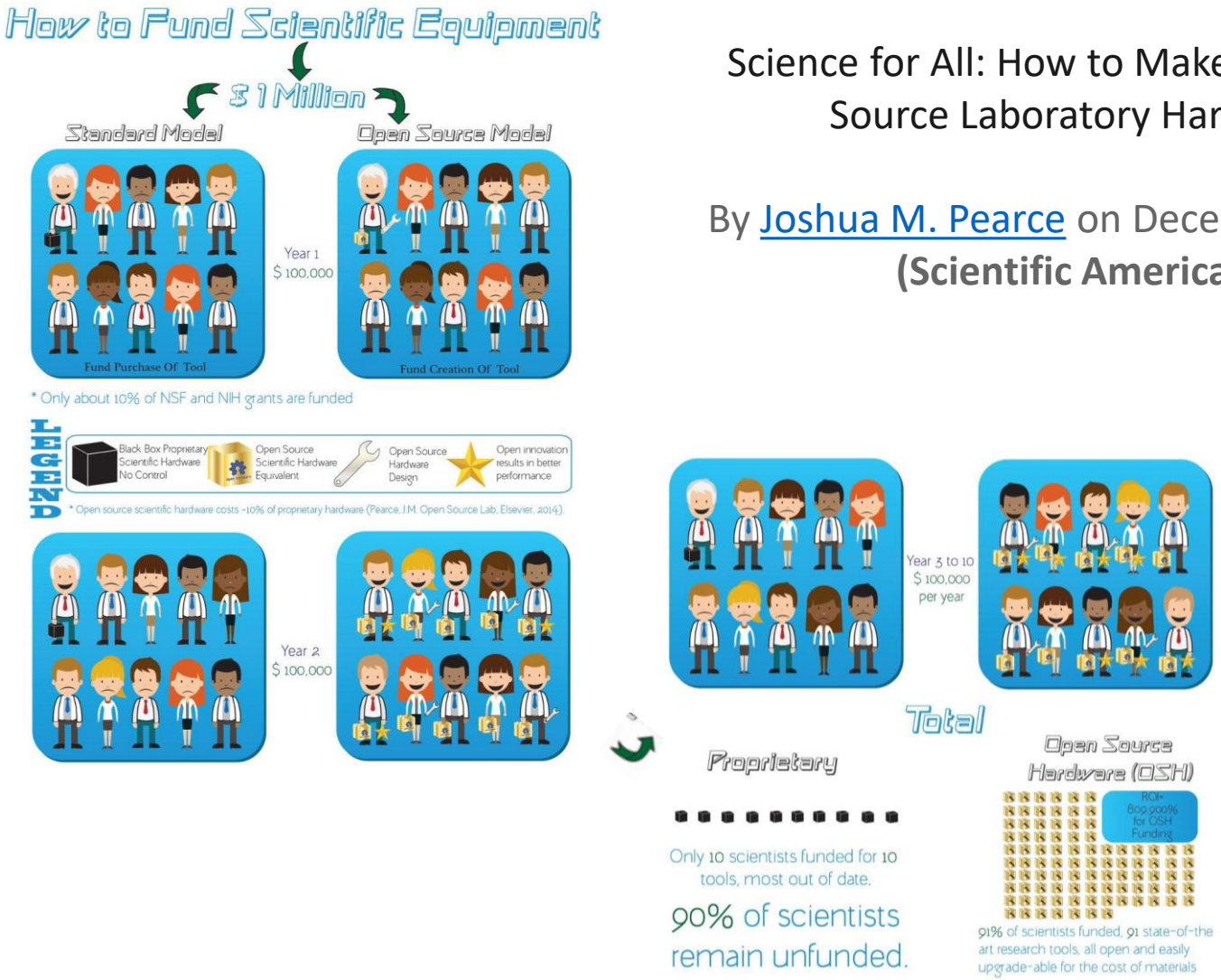
The Pitch



Science for All: How to Make Free, Open Source Laboratory Hardware

By Joshua M. Pearce on December 4, 2015
(Scientific American)

LABWARE (PIPETTES HOLDER)

=

+

Catalogue price = 420€

Catalogue price = 1020€

https://www.thingiverse.com/thing:2487363

Download and print: 10€

Low-Tech (The GaudiLab & hackteria.org)

1. WebCam Microscope
2. Hard Drive Centrifuge
3. Incubator Controller
4. Gel Box and High Voltage Supply
5. Turbidity Meeter Kit
6. DIY Microvolume Spectrometer
7. My Open PCR
8. Tube Racks
9. BLUE Transiluminator
10. DIY Electrospinner

Commercially Available Open Source Hardware

OPENQCM WI2- MOUNTED AND TESTED

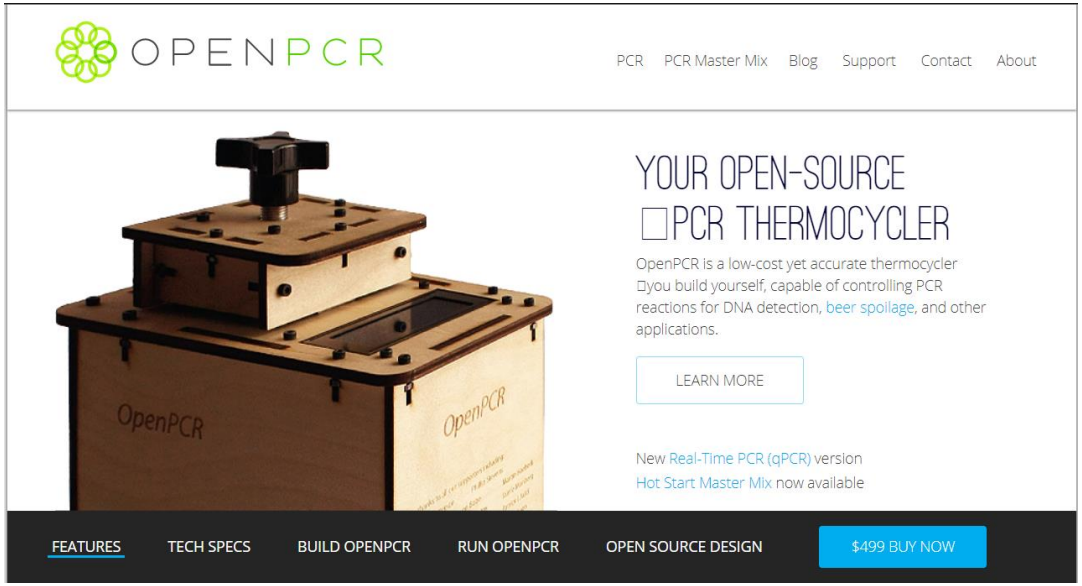
€699.00

The Quartz Crystal Microbalance openQCM is a mass sensor device designed for use in liquid or in air. A highly sensitive and fully open-source scientific device for applications in chemical and biological sensing. The mounted and tested version is ready to use and it comes with product quality test certification.

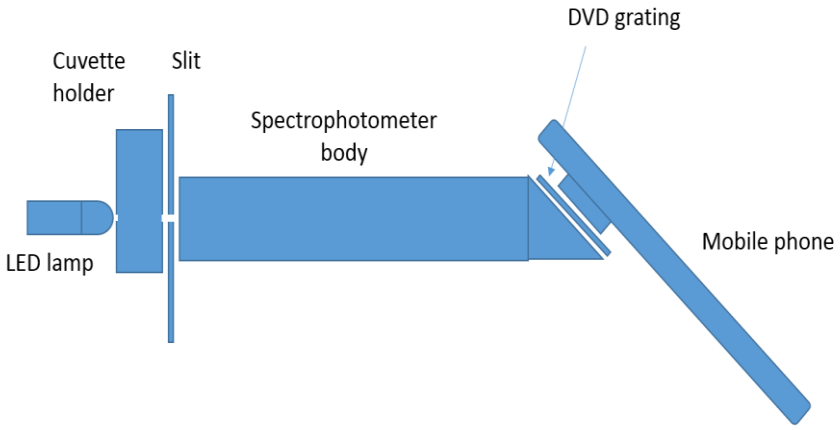
Warranty * -- Please Select --

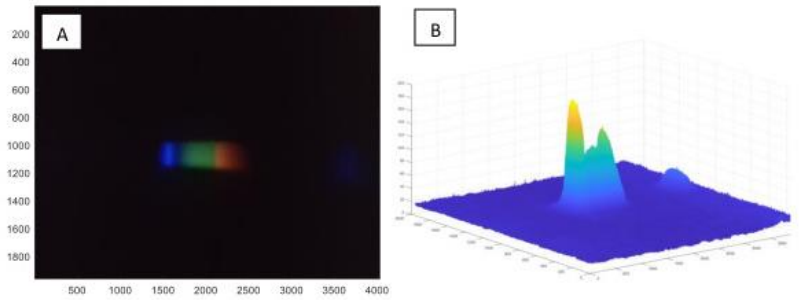
Qty 1

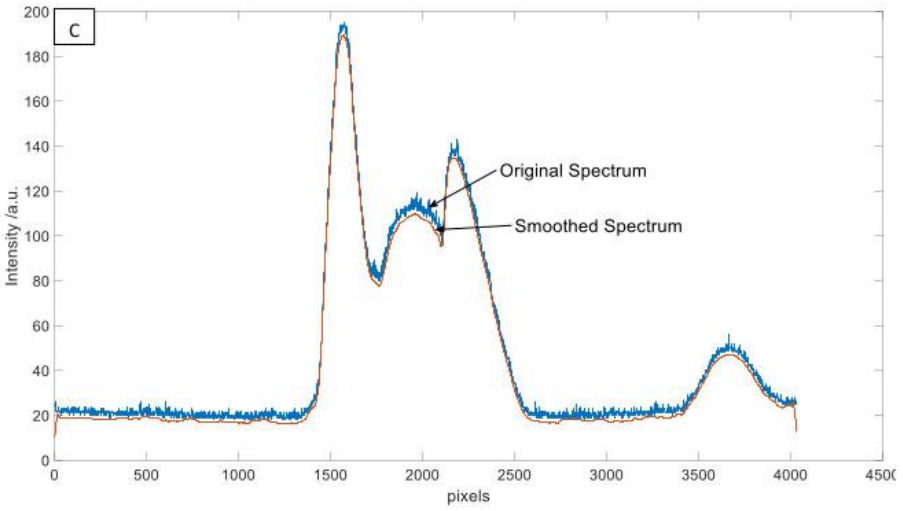
ADD TO CART



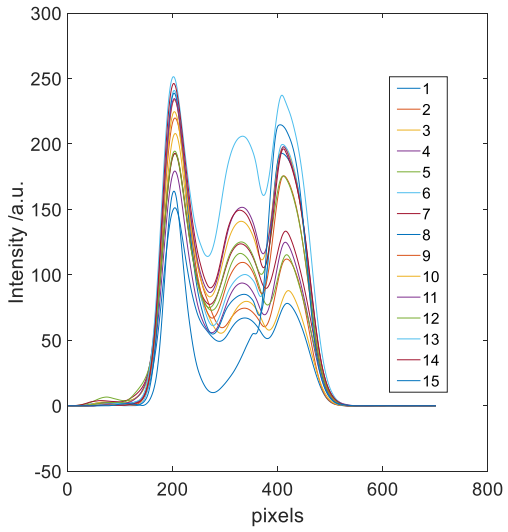
DIY OSHW for Wine Analysis - 1

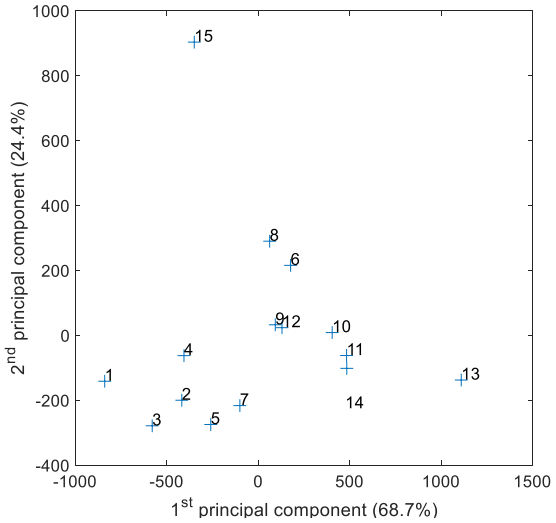


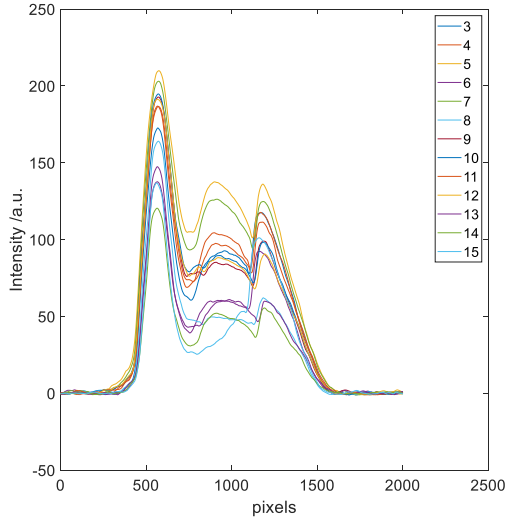


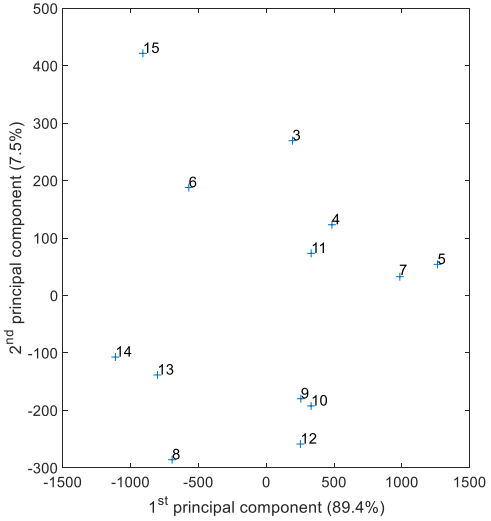


DIY OSHW for Wine Analysis - 2

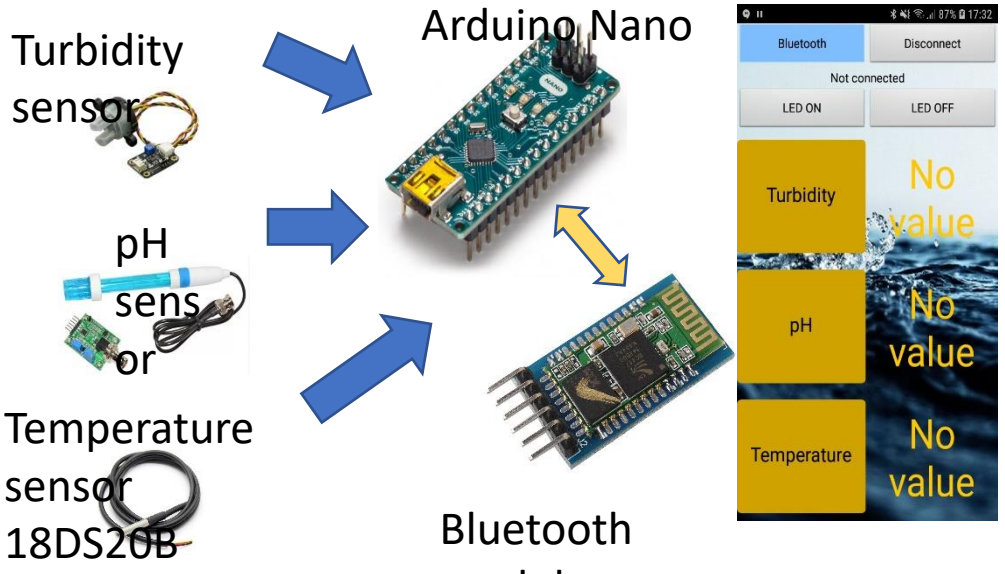








Past Activities



Electrophoresis 2019, *40*, 65–78

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Review

Open source capillary electrophoresis

Open source paradigm is becoming widely accepted in scientific communities and open source hardware is finding its steady place in chemistry research. In this review article, we provide the reader with the most up-to-date information on open source hardware and software resources enabling the construction and utilization of an "open source capillary electrophoresis instrument". While CE is still underused as a separation technique, it offers unique flexibility, low-cost, and high efficiency and is particularly suitable for open

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5. ACKNOWLEDGMENTS

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ACKNOWLEDGEMENTS – MC AND CORE MEMBERS

Monday, 2nd September 2019	
16:40-17:05 KN	**Open source hardware in chemical analysis: Tools or toys?** Guillaume Erny - University of Porto, Portugal
17:05-17:20	**Open source capillary electrophoresis device for quality control of medicines** Olivier Vorlet - Haute école d'ingénierie et d'architecture de Fribourg, Haute Ecole Spécialisée de Suisse occidentale, Fribourg, Suisse
17:20-17:35	**Portable centrifugal microfluidic platforms for on-site analysis of herbicides** Mercedes Vasquez - School of Chemical Sciences, National Centre for Sensor Research, Dublin City University, Glasnevin, Ireland
17:35-17:50	**Digital microfluidics - analytical open-source hardware** Jelena Gorbatsova - Centre of Microfluidics, KBI, TalTech, Tallinn, Estonia
17:50-18:05	**Using portable CE instruments for determining banned compounds in situ** Mihkel Kaljurand - Tallinn University of Technology, Tallinn, Estonia
Tuesday, 3rd September 2019	
10:25-10:40	**Low-cost paper-origami DNA microfluidics for rapid microbial analysis** Zhugen Yang - 1 Cranfield Water Science Institute, Cranfield University, Bedfordshire, United Kingdom
12:40-12:55	**The Development of Portable Illegal Drug of Abuse Analyzer: From Idea to Product** Jekaterina Mazina-Sinkar - Chemistry and Biotechnology Institute, Tallinn University of Technology, Tallinn, Estonia