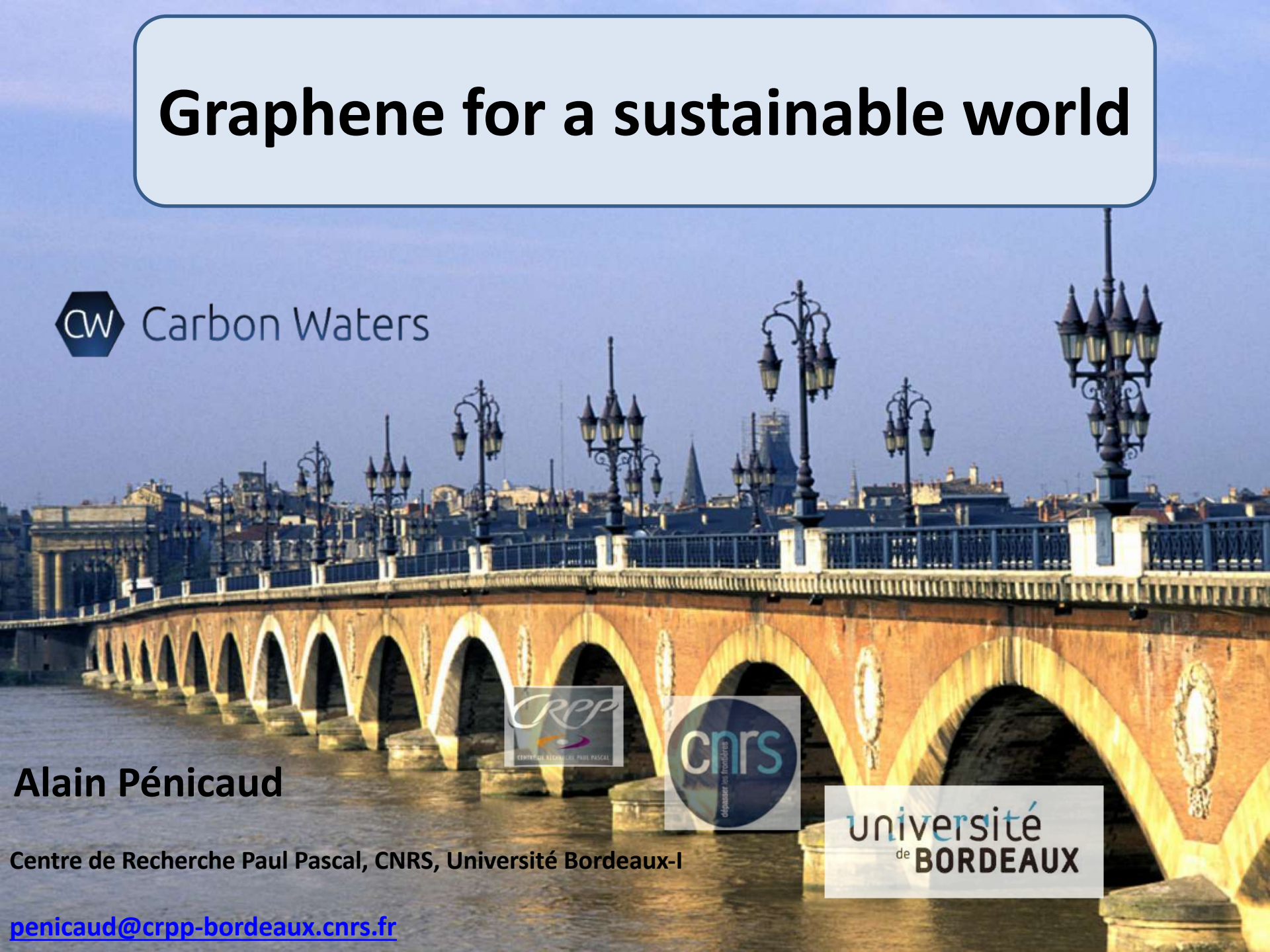
Graphene for a sustainable world



Alain Pénicaud

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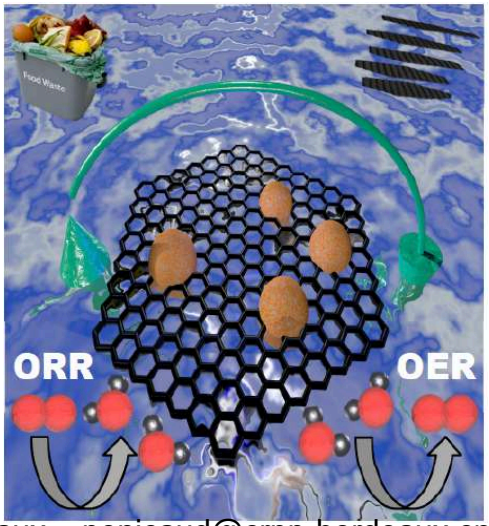
Graphene for a sustainable world

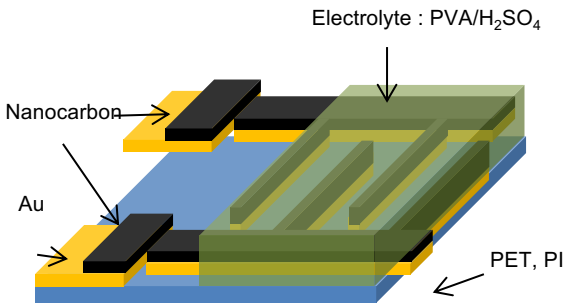
Less pollution

- Replace metals
- No surfactants added
- water based formulations

Energy saving

- anti corrosion coatings
- supercapacitors
- electrocatalysts





Outline

- Eau de Graphène (graphene water):

  Additive free Single layer graphene in water

- Carbon Waters : the Company

- Eau de Nanotubes

- Multi layer Graphene from food waste ?

  - electrocatalysts
  - supercapacitors

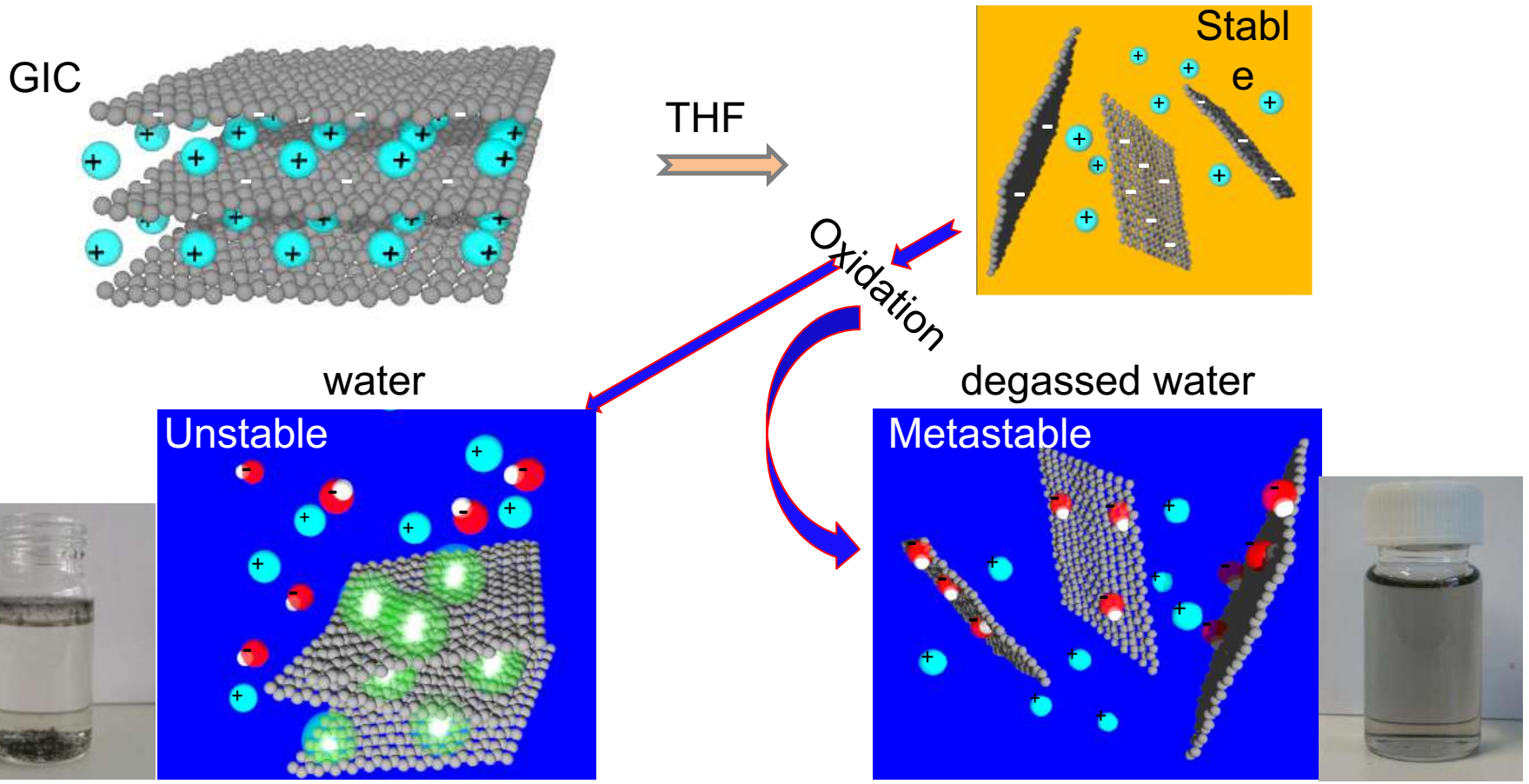
PLAS•CARB

INNOVATIVE PLASMA BASED TRANSFORMATION OF FOOD WASTE INTO HIGH VALUE GRAPHITIC CARBON AND RENEWABLE HYDROGEN

Stabilizing SLG in water : Eau de Graphène

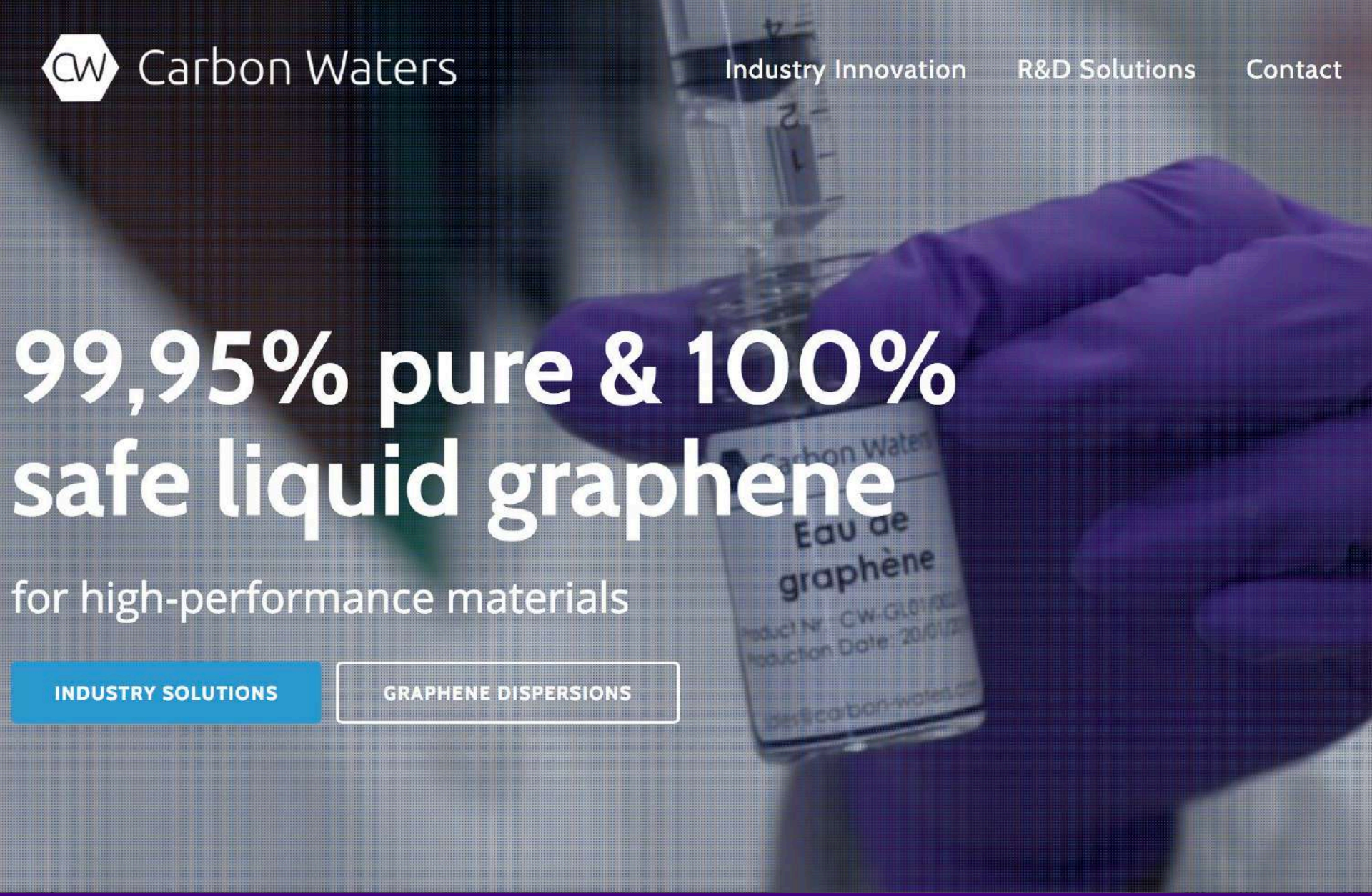
(no surfactant, no organic solvent)

George Bepete



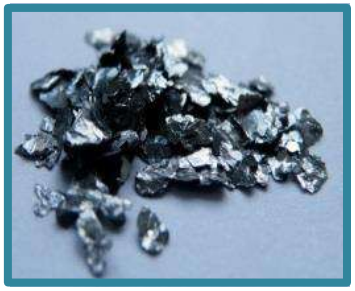
Valles *et al*., JACS. (2008), Catheline *et al.,* Soft Matter. (2012)

Bepete *et al*., Nature Chem, 2017, J. Phys. Chem C, 2016, Phys. Status Solidi RRL 2016



https://www.carbon-waters.com/

Carbon Waters



- No nanoparticles steps
- No additives
- Extremely stable and homogeneous dispersions
- Very strong control on graphene quality
- Industrialization compatible

3 patents

Nature Chemistry 2017

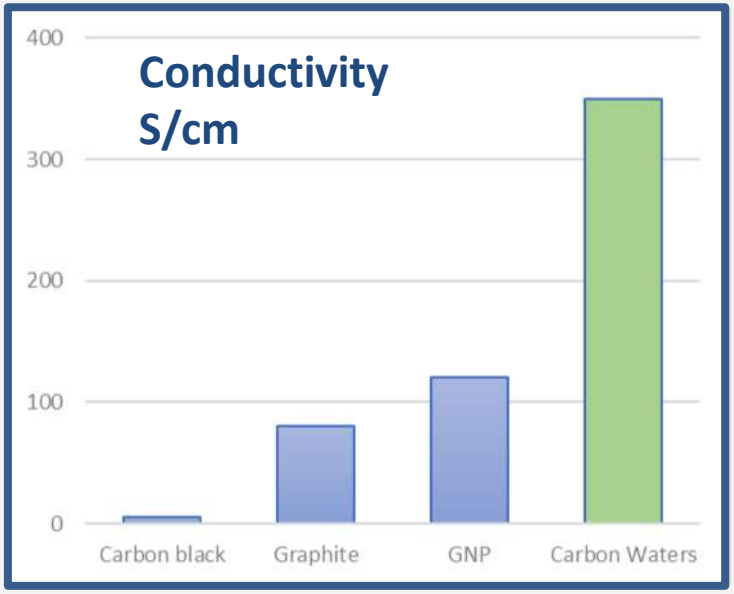
Dispersed nanocarbons in aqueous solution

Surface preparation, printing & treatment

Surfaces with enhanced and reinforced properties

Design and production of graphene dispersions and graphene-treated surfaces

Example of on-going development : liquid dispersions

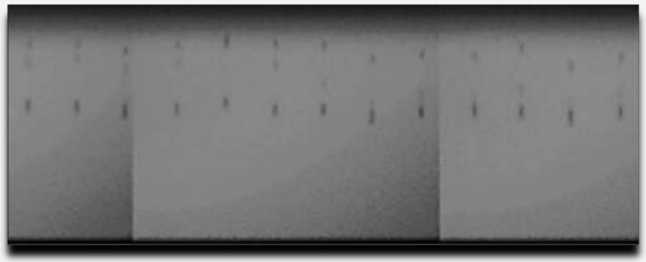


(1) *(2)*

(1) IDTechEx Graphene 2016
(2) In house measurement

Our advantages :

- High conductivity compatible with an EMI Shielding effect
- Stable on epoxy and latex
- Compatible with flexible and transparent substrates
- Fully printable with several processes

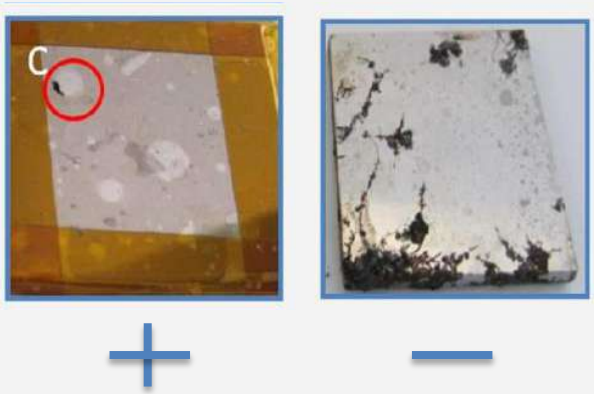


50 µm size drops

We print and develop transparent conductive films for conductive composites and EMI Shielding applications

Example of on-going development : printed surfaces

- Water-based graphene dispersions
- surface deposition analyzed by RAMAN
- Specific pre-treatments
- Filtration or electrodeposition



Steel treated surface

Our advantages :

- Thinnest material known for corrosion protection
- Efficient and time-saving printing
- Resistance to harsh conditions
- REACH compliant (Cr(VI) and cadmium replacement)
- Improved thermal management

We print our nanomaterials on steel surfaces in order to decrease corrosion and aging

Carbon Waters

Operational team

Alban Chesneau
CEO
PhD-MBA
12 yo technology marketing & innovation management

Dr Fabienne Dragin
Application manager
PhD nanotechnology
8 yo in nanomaterials and composites

Dr Julia Messner
Process manager
PhD Chemical engineering
5 yo in chemical processes

Total team of 6 persons

Industrial network

SOLVAY

Patrick MAESTRO
Industrial advisor

Kevin ARTHUR
Serial technological entrepreneur

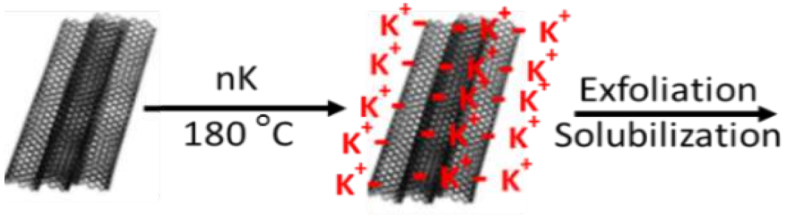
AXELERA
catalyseur de croissance durable

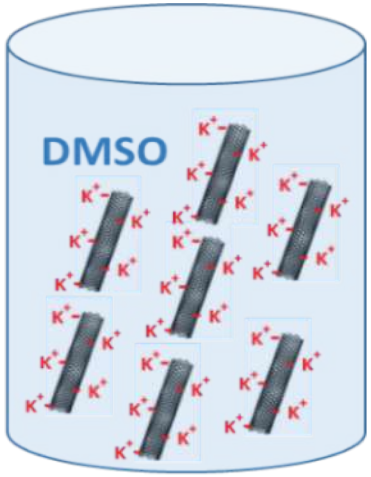
SFGP
SOCIETE FRANÇAISE DE GÉNIE DES PROCÉDÉS

UIC
union des industries chimiques

EUREKA
innovation across borders

Preparation of Eau de Nanotubes





Inert atmosphere

Air

1.

Unstable
Closed SWNTs in *degassed* water

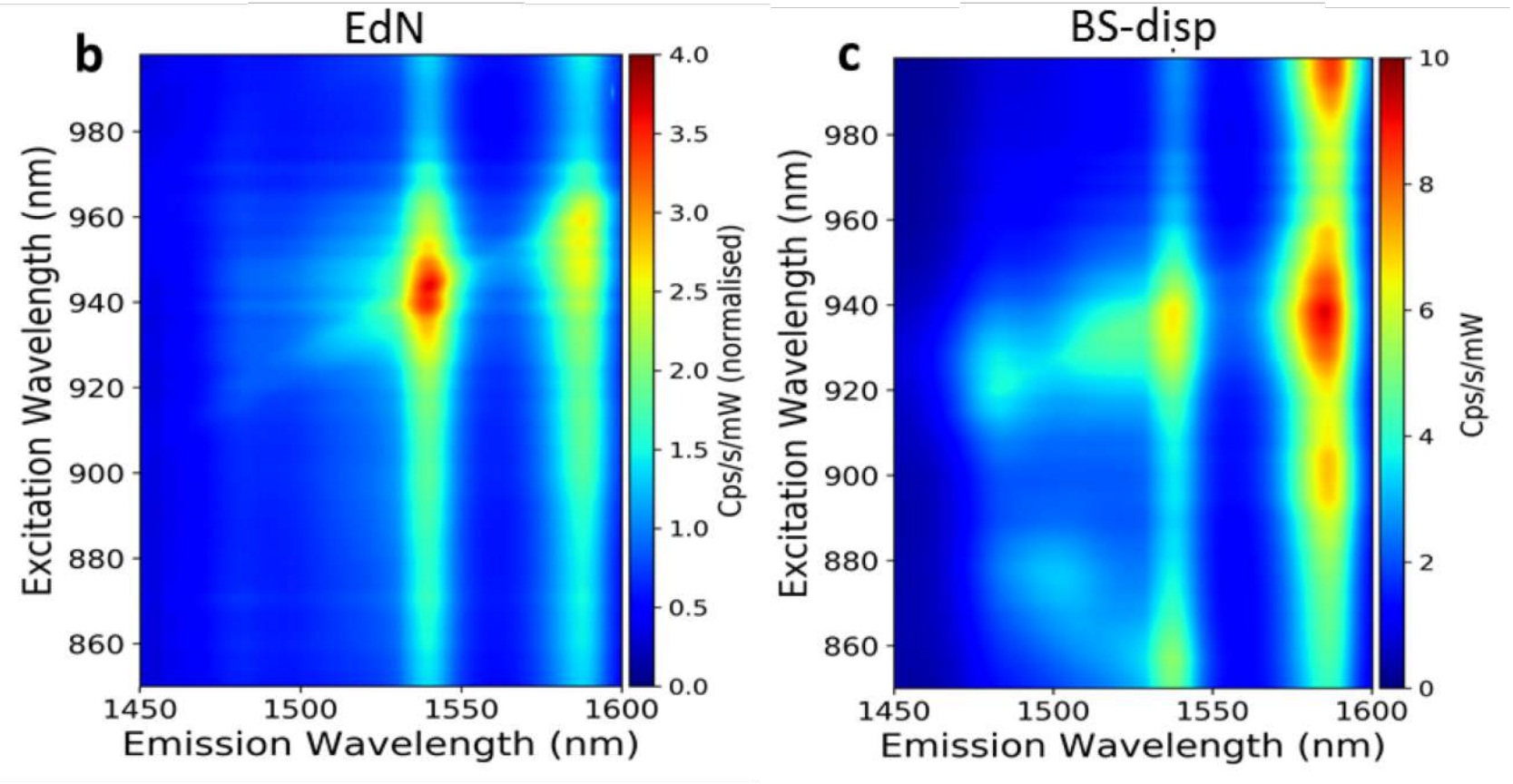
2.

Unstable
in *non degassed* water

3.

"Eau de nanotubes"
Metastable (for months)
in *degassed* water/DMSO (c=25 mg/L)
No surfactant/polymer additives

PL spectroscopy of EdN



PLE profiles are close for EdN and bile salt suspensions

Redshift of ≈ 10 nm of S_{22} peaks for **EdN**→different environments

→ Bepete et al. ACS Nano 2018

Multilayer graphene from food waste

Food Waste

Anaerobic Digestion:
BIOGAS: CH_4 & CO_2

microwave plasma process: biogas to C & H_2

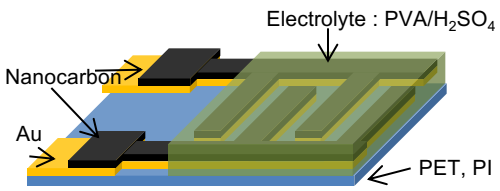
PLAS·CARB

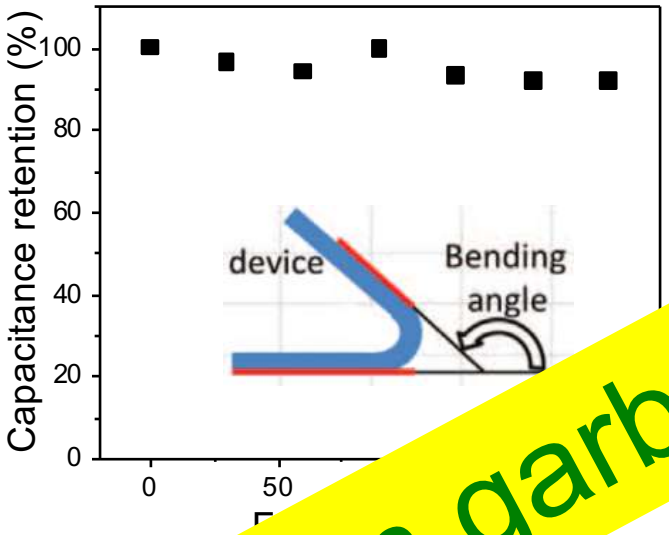
INNOVATIVE PLASMA BASED TRANSFORMATION OF FOOD WASTE INTO HIGH VALUE GRAPHITIC CARBON AND RENEWABLE HYDROGEN

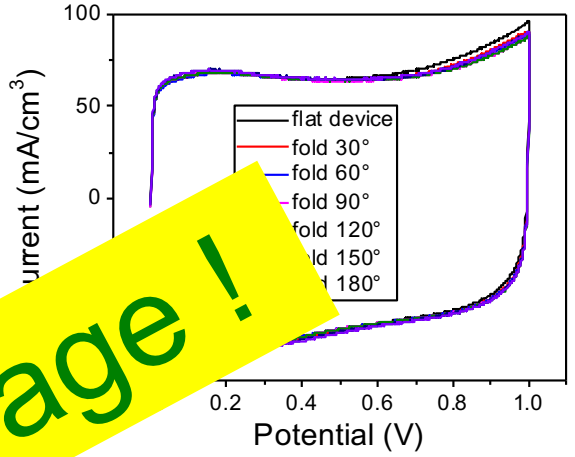
Conducting rubbers
Conducting inks
Supercapacitors
...

Nanocarbon dispersion

Microsupercapacitors

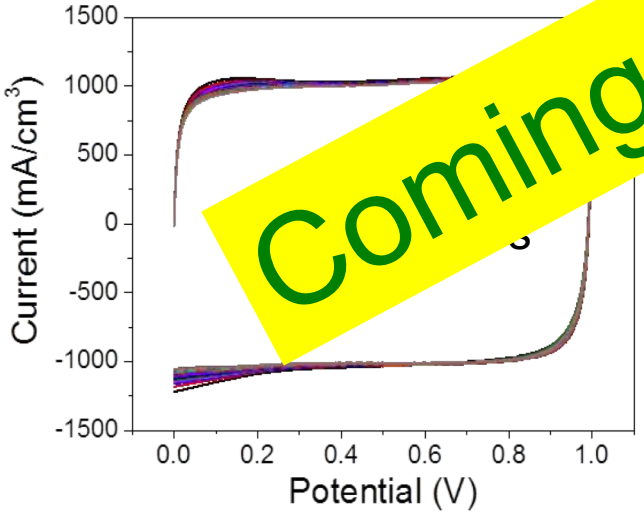


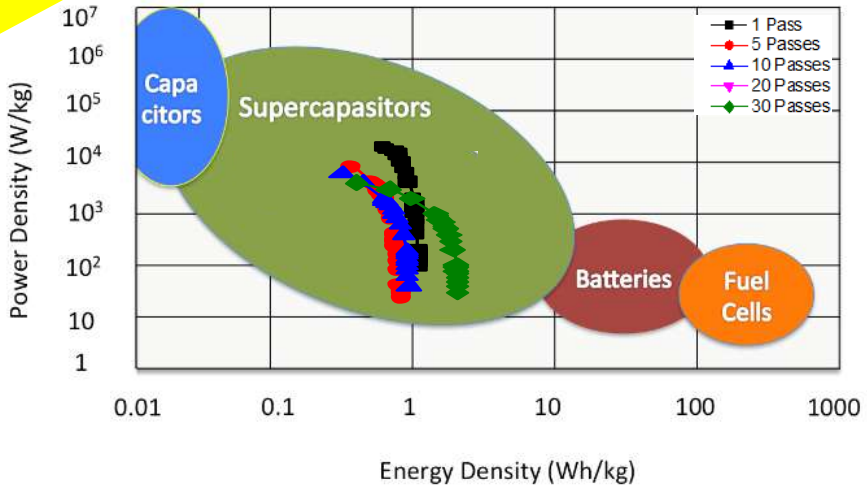




C = 10 F/cm^{-3}

Coming from garbage !





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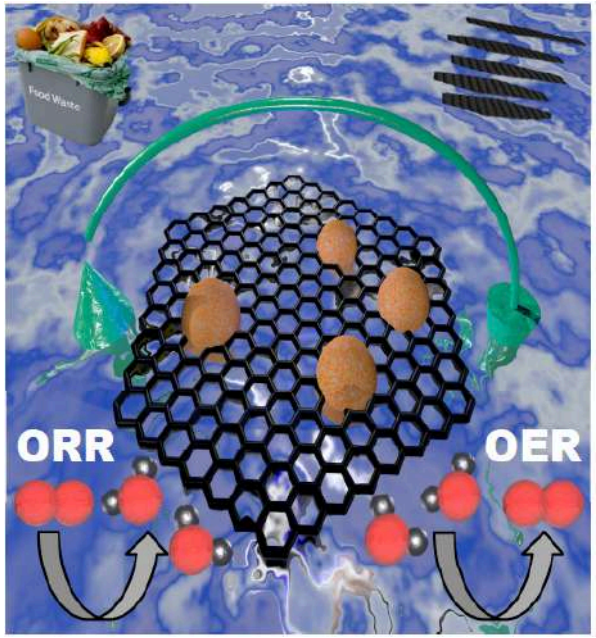
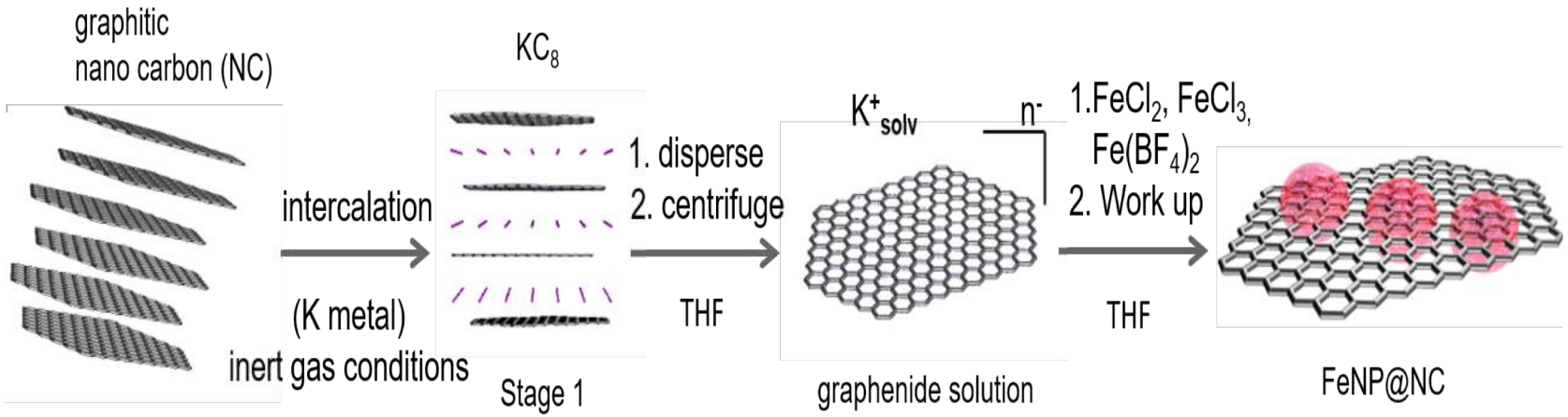


From Food Waste to Efficient Bifunctional Nonprecious Electrocatalyst

Ferdinand Hof

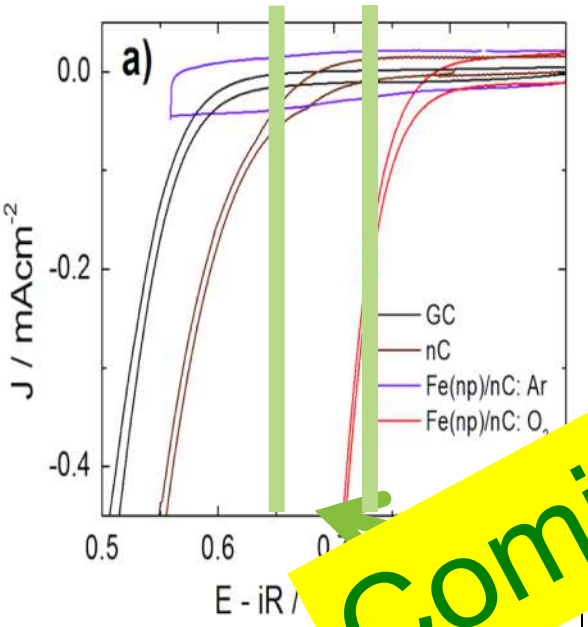


Hof, F. et al. Chem. Eur. J. 2017
Hof, F. et al. Chem. Eur. J. 2018

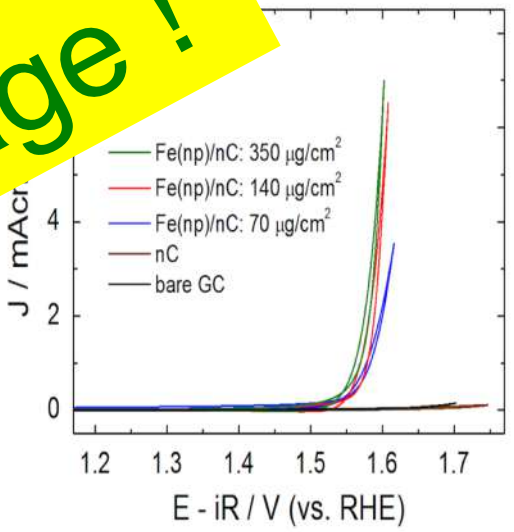
Oxygen reduction reaction (ORR)

Oxygen evolution reaction (OER)

$O_2 + 4H^+ + 4e^-$ $2\ H_2O$



$2\ H_2O$



Coming from garbage !

Commercial Pt catalysts

for fuel cells exhibit an overpotential

of 0.5 - 0.6 V vs RHE

theoretical value: E° = 1.22 V vs RHE

GC bare glassy carbon
nC graphitic nano carbon

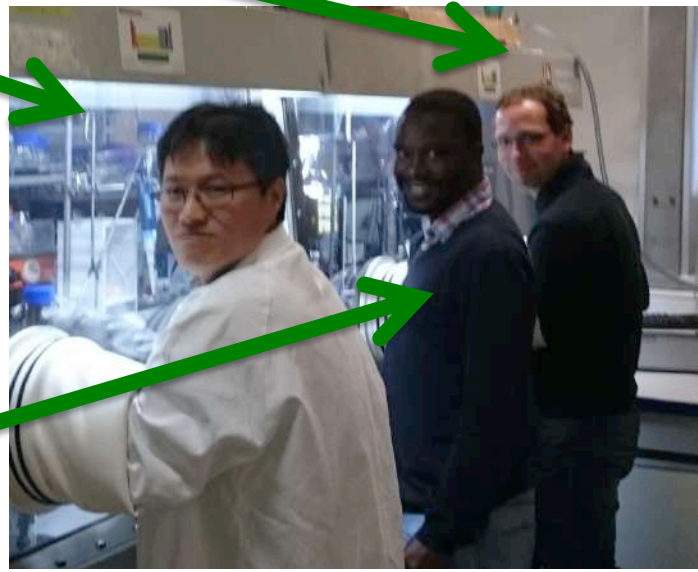
Hof, F. et al. Chem. Eur. J. 2017

Plascarb project :

Dr Katerina Kampioti

Dr Ferdinand Hof

Dr Kai Huang



Rubber composites

Prof. A. Zarbin (Curitiba)

Dr Carolina Matos (“)

Eau de Graphène & nanotubes:

Dr George Bepete

Dr Carlos Drummond

Dr Fernando Torres cañas

Prof. Eric Anglaret (Montpellier University)

Dr Nicolas Izard (“)

Carbon Waters:

Dr A. Chesneau, Dr. F. Dragin, Dr. J. Messner


ChemOnTubes 2020
International Meeting on the Chemistry of Graphene and Carbon Nanotubes
19-23 or 26-30 April 2020
San Sebastián (Spain)
Open Registration from January 2019
Email: acriado@cicbiomagune.es