Engineering of nanomaterials and interfaces for water treatment applications

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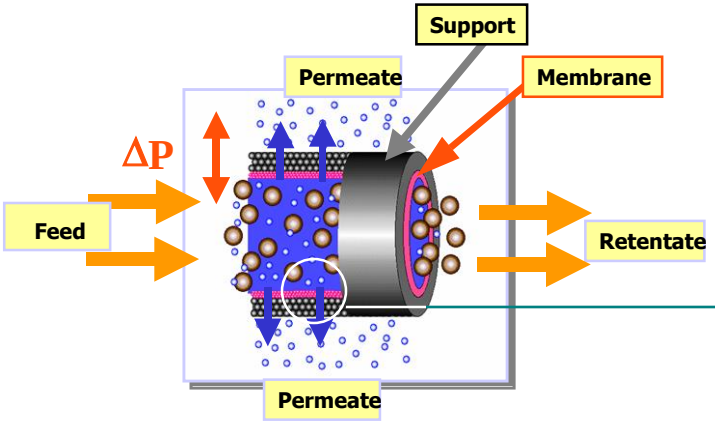
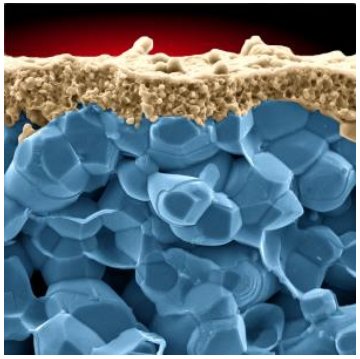
Montpellier

Membrane : definition...

« A film used the one hand to separate two media by avoiding direct contact or mixing and, on the other hand, to favor the exchange of one or several well defined extensive quantities between them. »



Cross-section of membrane



Tubular membranes

➢ ***Researches :***

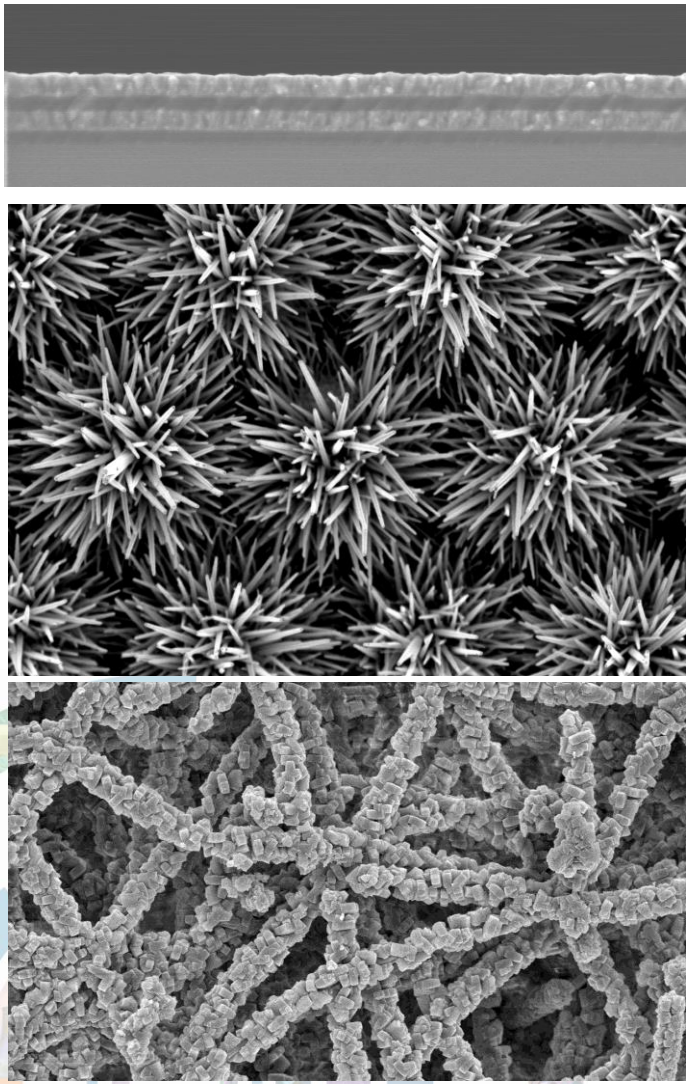
- ✓ Synthesis, Modification, Membrane Characterization
- ✓ Mechanisms & Transport Modeling
- ✓ Prospects in Process Development

➢ ***Implementation Fields of IEM Researches :***

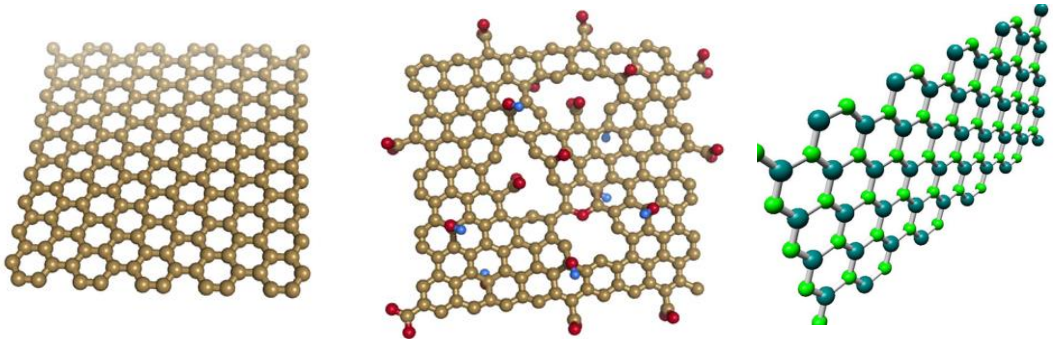
- ✓ Industry & Food Processing
- ✓ Health, Medicine Drug
- ✓ Water and Urban Effluents Treatment
- ✓ Energy
- ✓ Chemistry
- ✓ Environment, Fight against Pollution
- ✓ Gas Treatment and Separation

3 main research areas

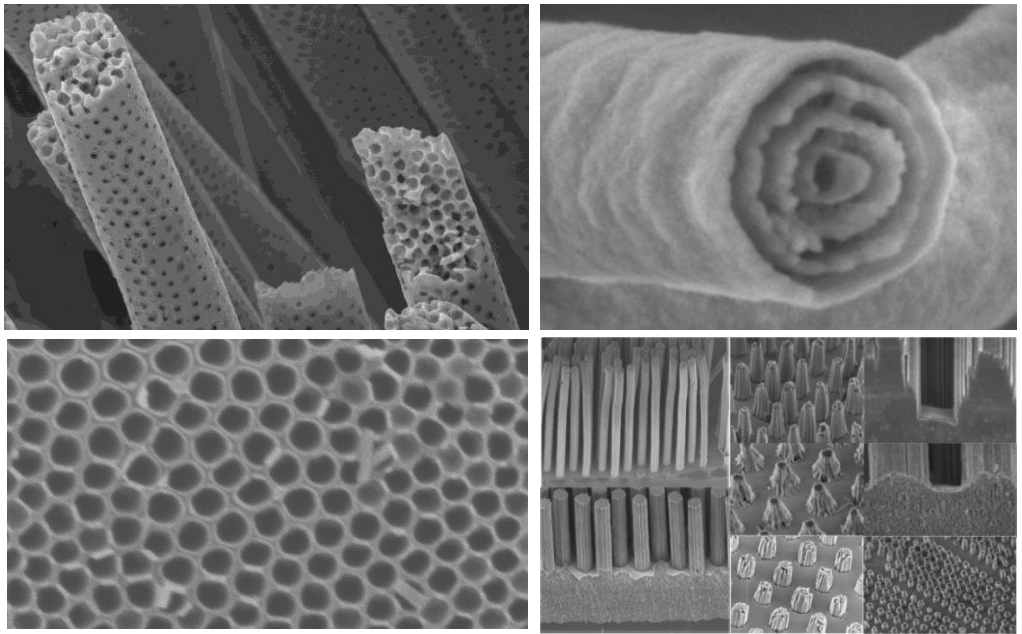
Atomic Layer Deposition



G/GO/h-BN



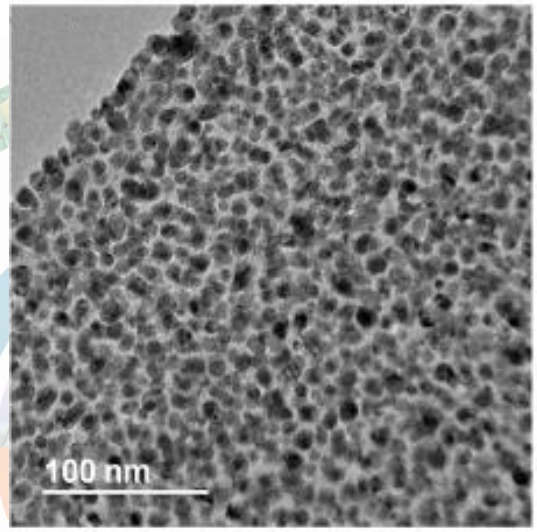
Electrospinning/Electrodeposition/ Anodisation/3D Printing

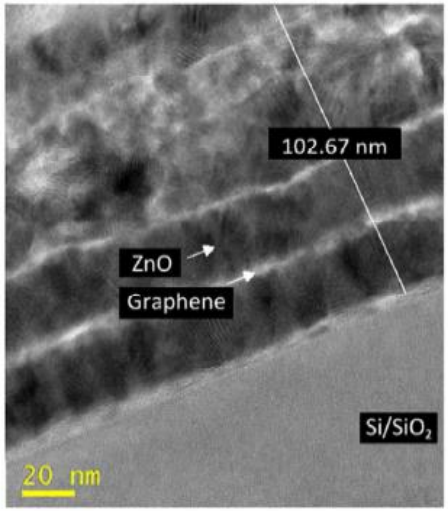


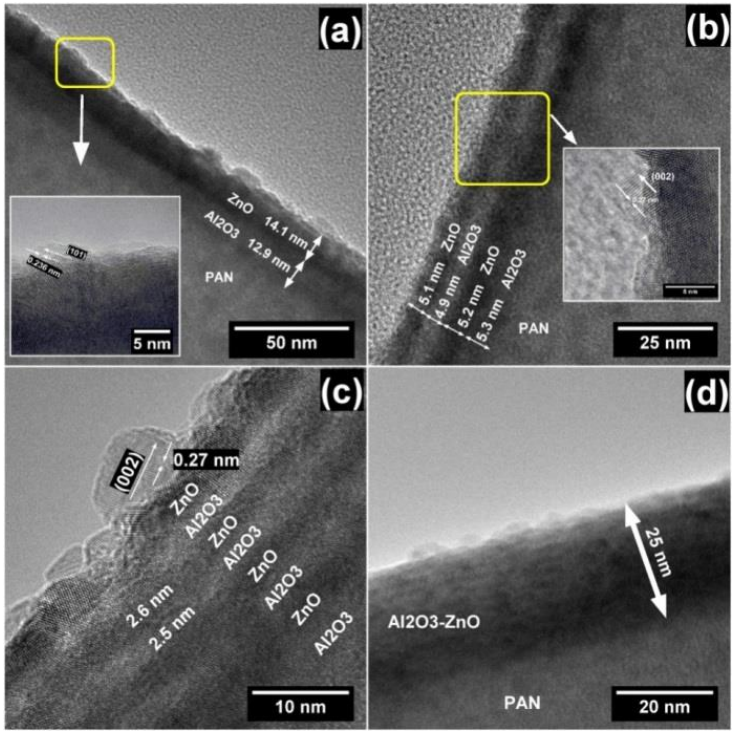
Atomic layer deposition

5 Home-made ALD setups (LTALD, HTALD and PEALD)

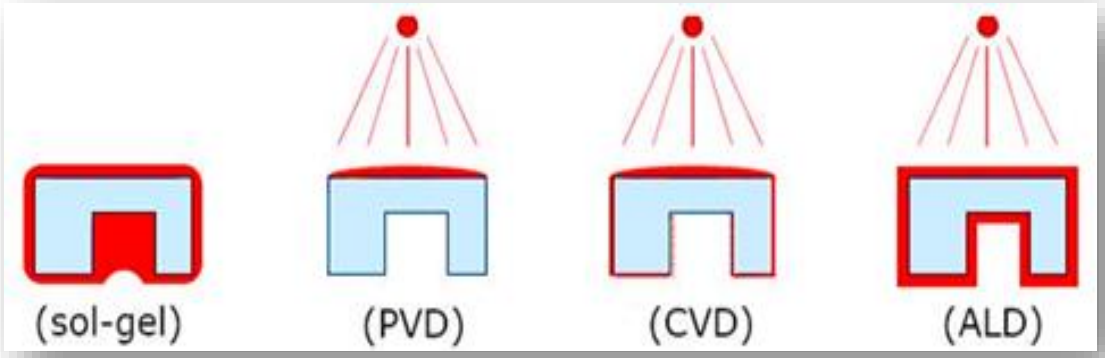
Oxides (*i.e.* ZnO, TiO_2, Al_2O_3, SnO_2 etc.)
Non-oxides (*i.e.* Nitrides: BN, TiN, AlN)
Metallic Nanoparticles (Pt, Pd, Ni, Ir, Ru)







Why Atomic layer deposition?



Conformal coating

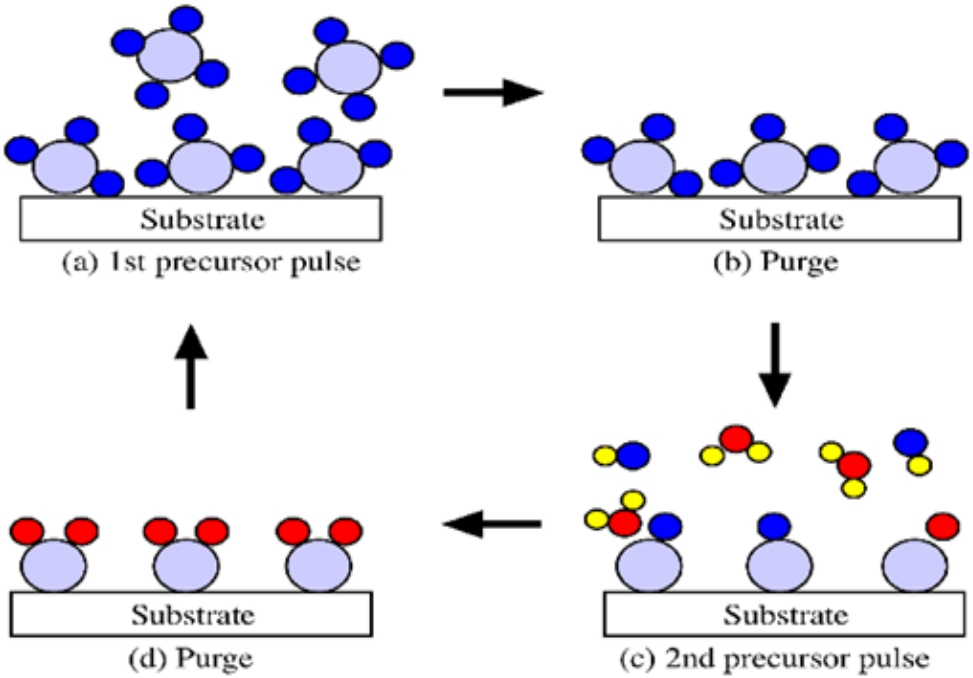
One Cycle of ALD:

Step 1 :Pulse precursor 1

Step 2 : Exposure + Purge

Step 3 : Pulse precursor 2

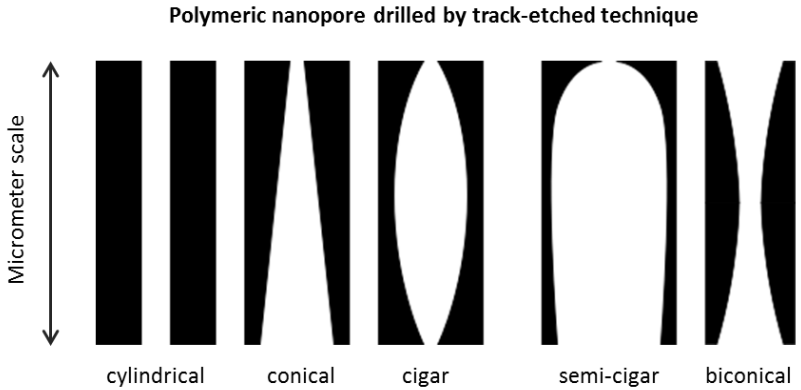
Step 4 : Exposure + Purge

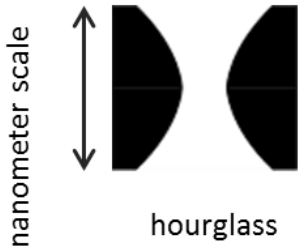


Theoretically ->1 monolayer

Tuning the membranes by ALD

Tubular Membranes





- Pores number (single and multipores)
- Pores length and shape
- **Pores diameter**
- **Different materials (oxides, non-oxides and metals)**
- **Surface charges**
- **Hydrophobic/hydrophilic**
- **Different chemical functions**
  - **-Si-CH_3**
  - **-Si-$(CH_2)_2$-CH_3**
  - **-Si-$(CH_2)_3$-NH_2**

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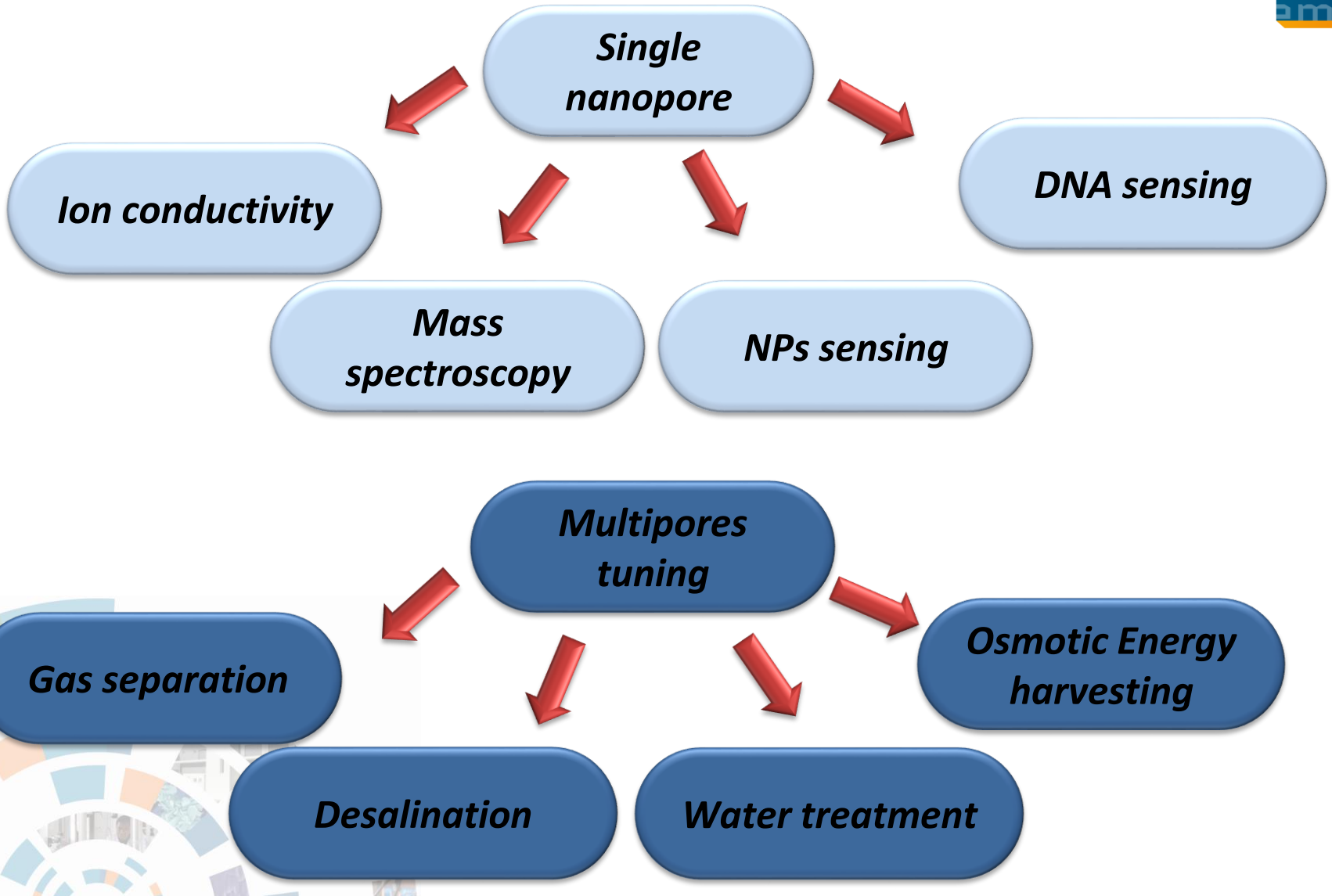
Membrane applications



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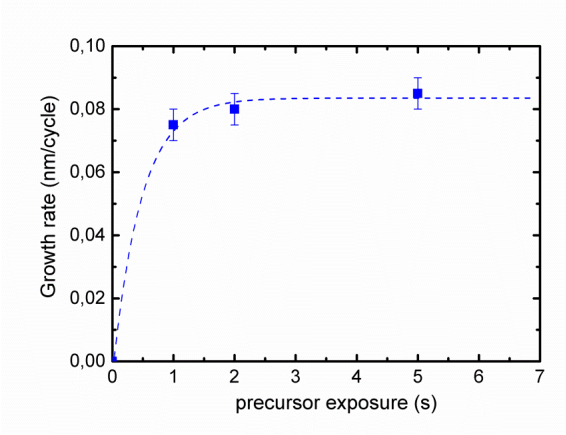
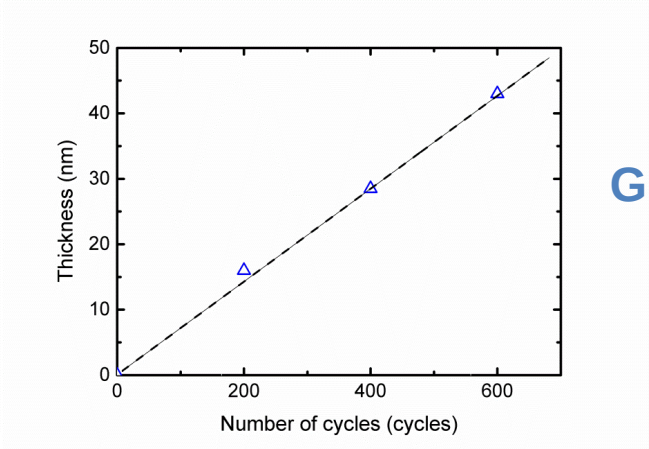
ALD for membrane tuning

Boron nitride by ALD

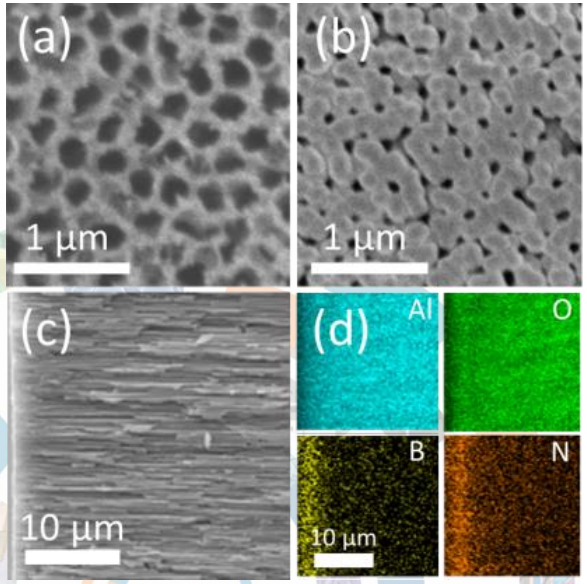
BBr_3 & NH_3 at 750°C





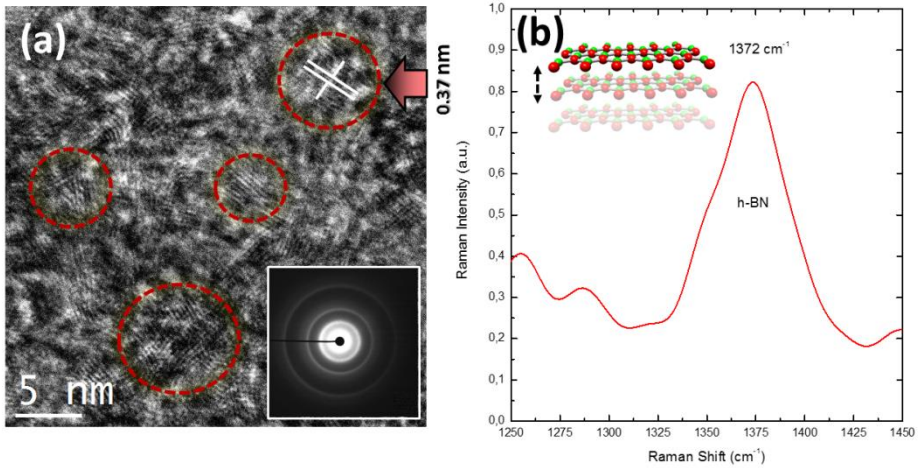
Growth per cycle = 0.08 nm

BN: uniform & conform



Alumina membranes

Turbostratic BN



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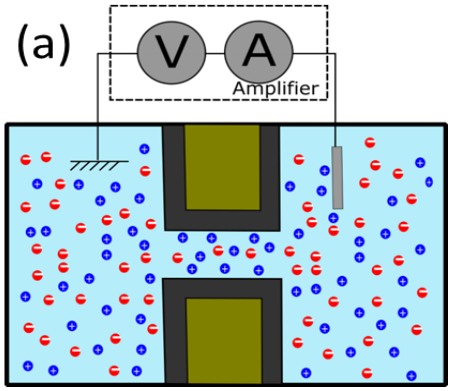
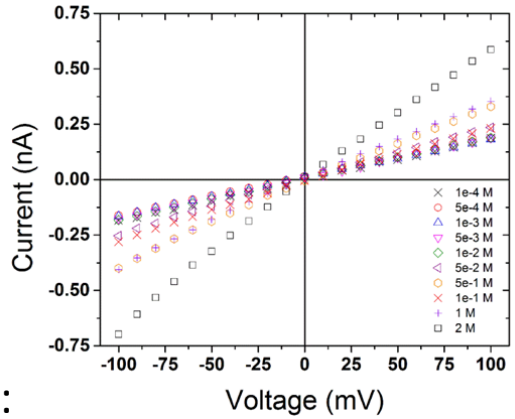
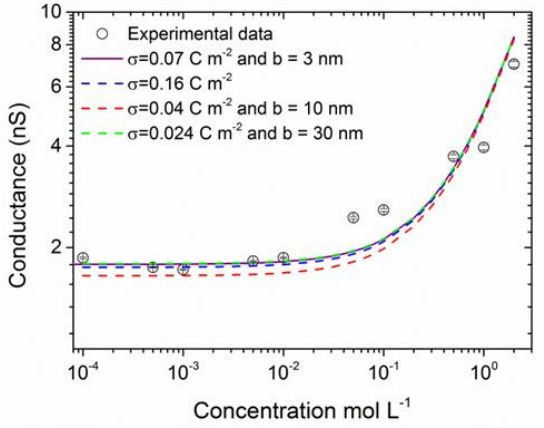
CrystEngComm 2017 **19** 6089

Osmotic Energy







BN nanoporous membranes:

- Surface charge density of 0.1 $C.m^{-2}$

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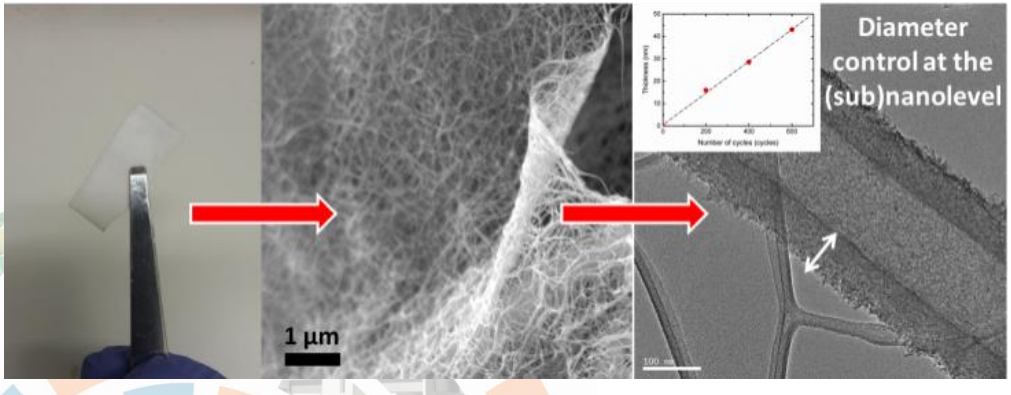
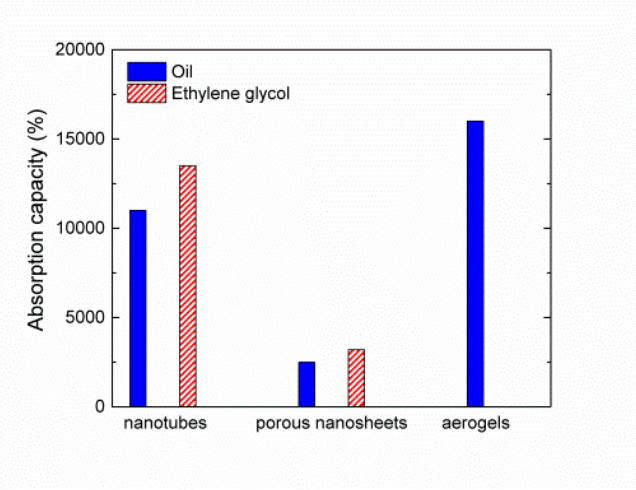
BN NTs for water purification





Tunable BN NTS:

- BN nanotubes with controllable diameters
- NTs absorb up to 110 times their weight in oil while repelling water

Adv Mater Interfaces 2018 1800056

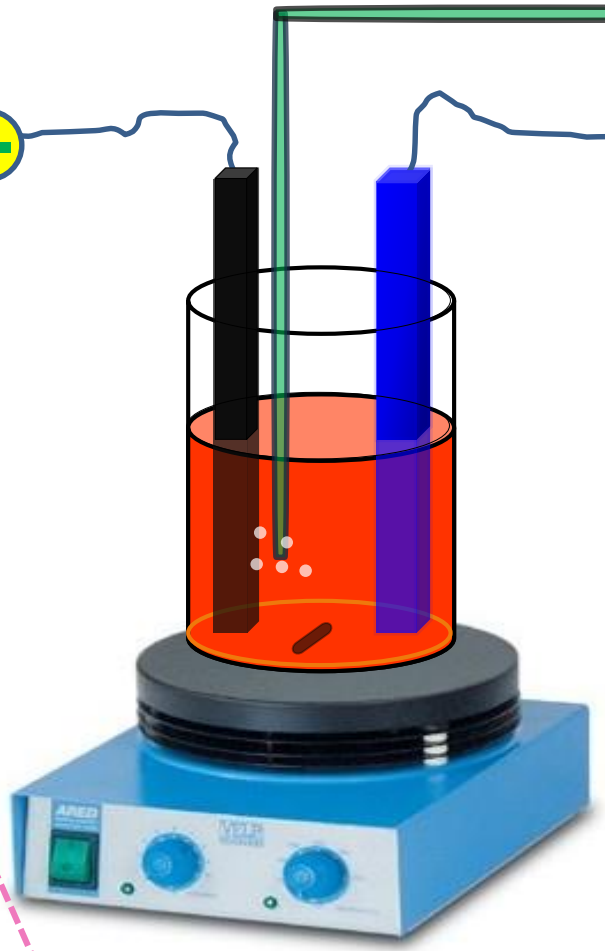
ALD for conductive carbon membranes

Fuel Cell-Fenton system

Oxygen

Cathode: (Carbon Felt)

Anode: Pt



$O_2 + 2H^+ + 2e^- \rightarrow H_2O_2$

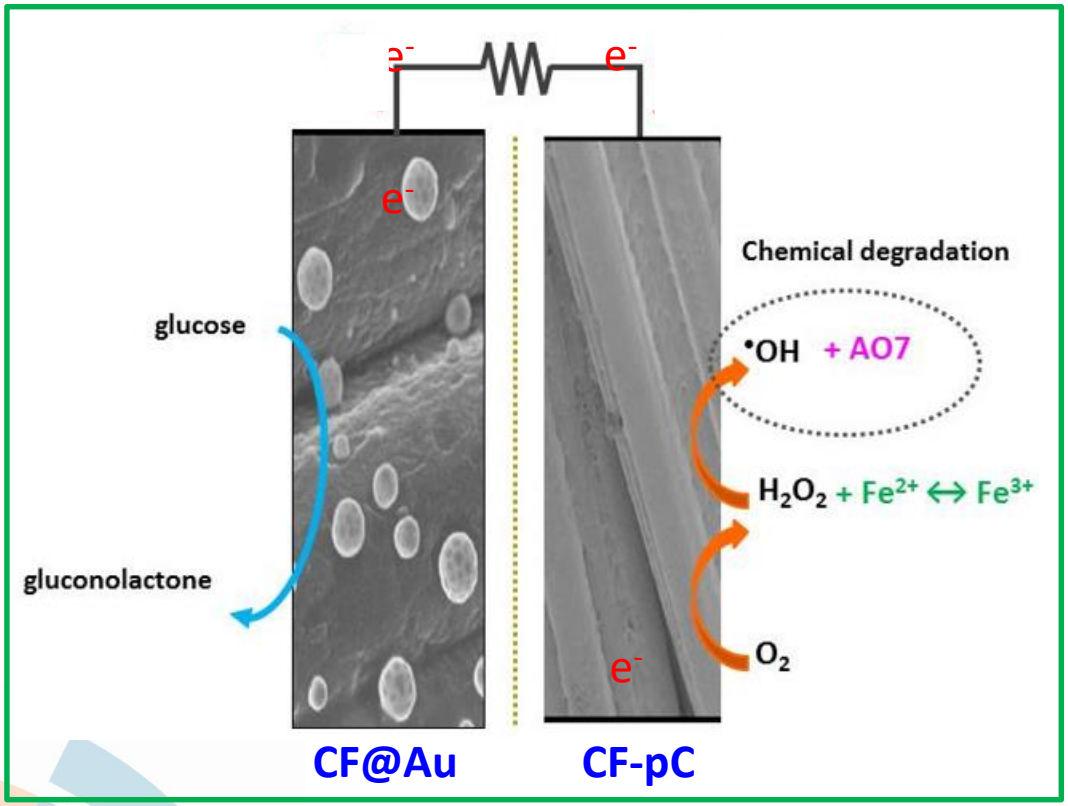
- **•OH powerful oxidant for mineralization of persistent organic pollutants**

Biorefractory pollutants

Fenton reaction: $Fe^{2+} + H_2O_2 \rightarrow Fe(OH)^{2+} + {}^{\bullet}OH$

Carbon 2017 **122** 564

Fuel Cell-Fenton system



Carbon felt (CF)

- **CF@Au anode** presents electrocatalytic properties for **glucose oxidation**
- **CF-pC cathode** presents electrocatalytic properties for **O_2 reduction into H_2O_2**

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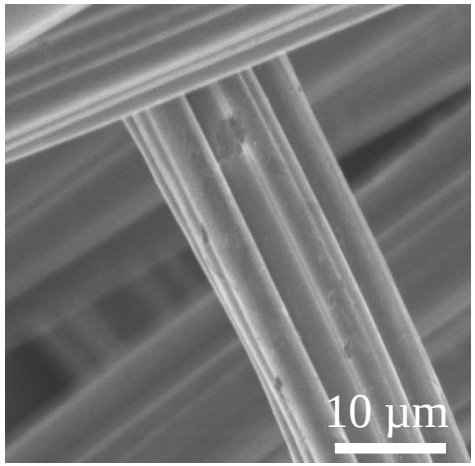
Cathodic electrode (CF@pC)

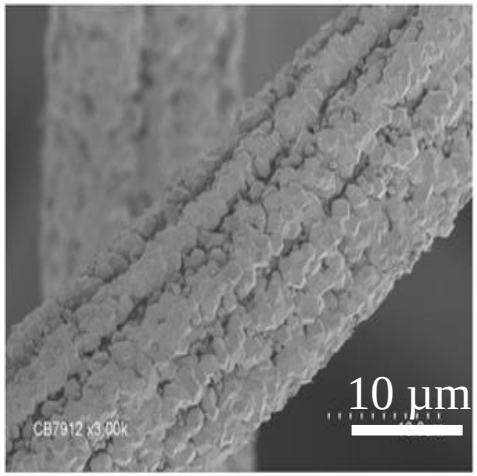
Raw-CF



1) ALD of ZnO

2) Solvothermal conversion of ZnO

CF-ZIF-

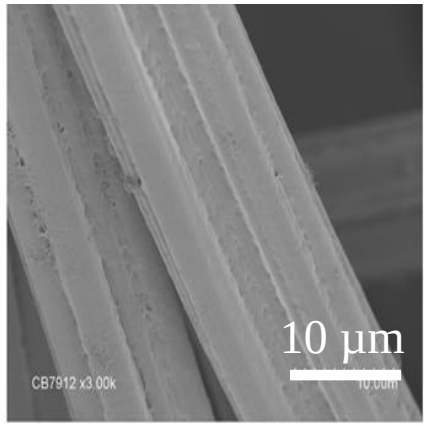


3)

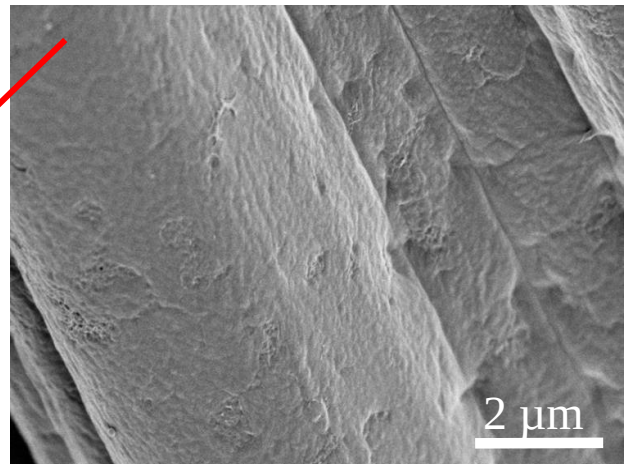
1000°C, 10h

N_2

CF-pC

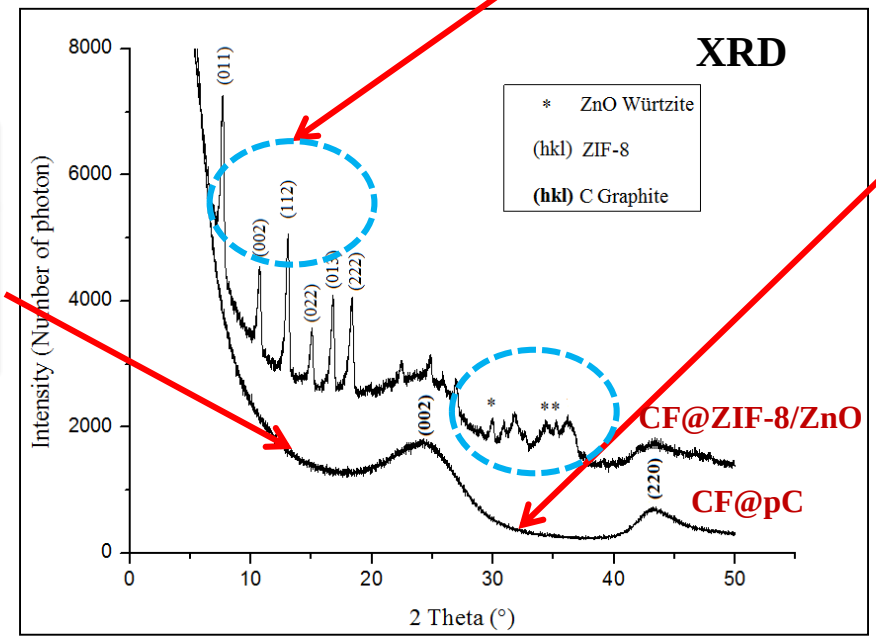


Magnification



Element	at % CF-pC
C	96
O	4
Total:	100.00

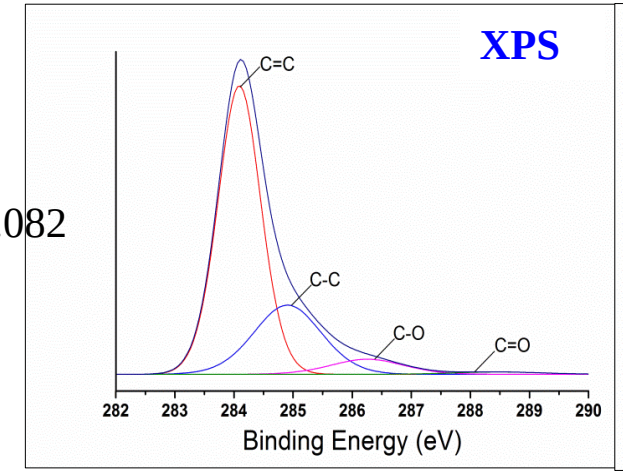
EDX results prove Zinc evaporation

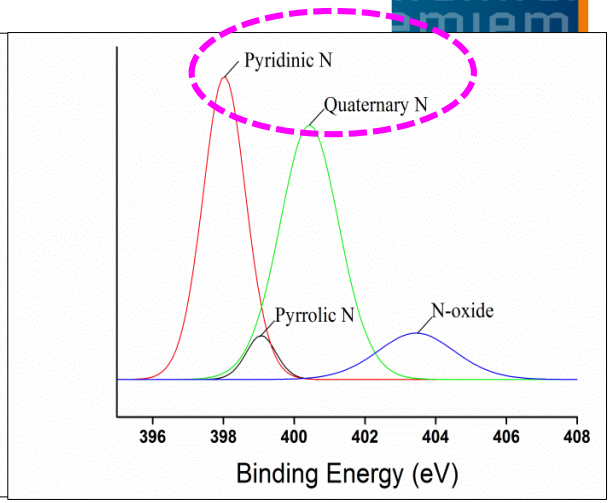


Cathodic electrode (CF@pC)

Volumetry Gas Adsorption of N_2:

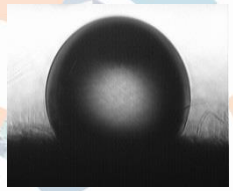
- Raw-CF: 0.0915 m^2/g
- **CF-pC: 64 m^2/g** (pore volume =0.082 cm^2/g) → 700 times higher

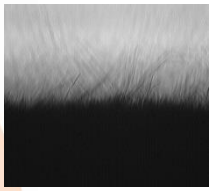




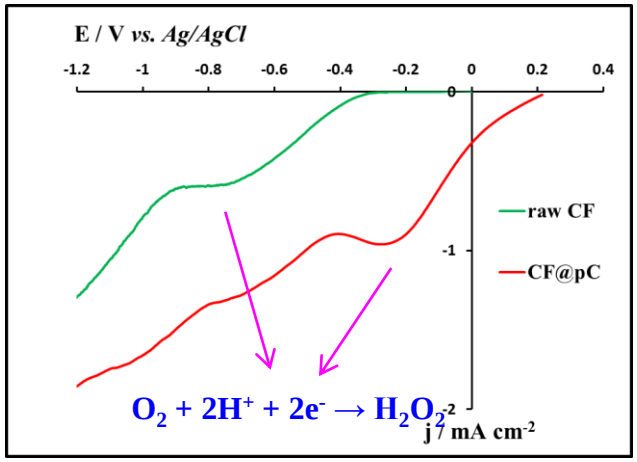
Contact angle measurements of water drop

Sample	raw-CF	CF-pC
Angle (°)	89.9	0
Propertie	Hydrophobic	**Hydrophilic**





Polarization curves



Positive shift for ORR (0.4V)

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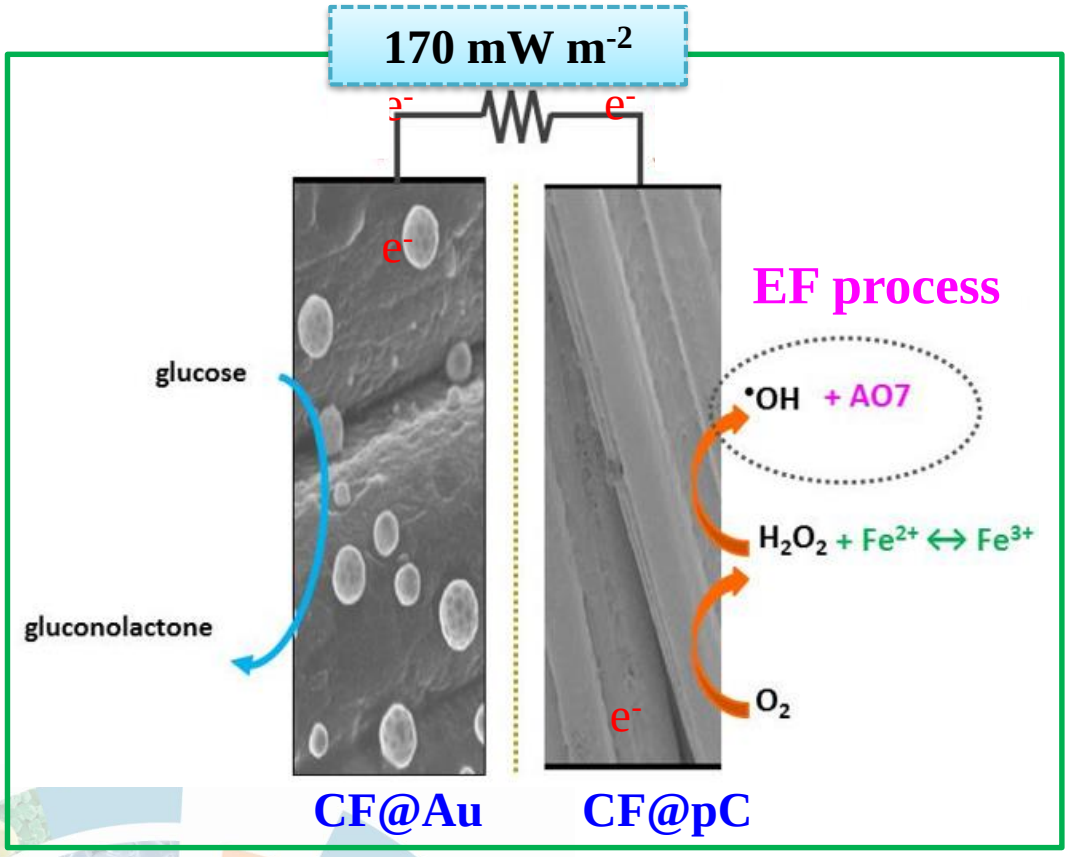
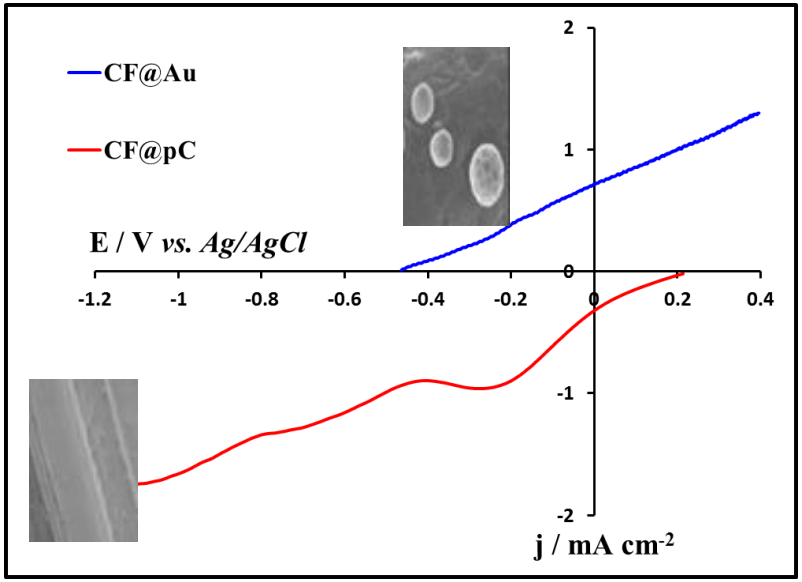
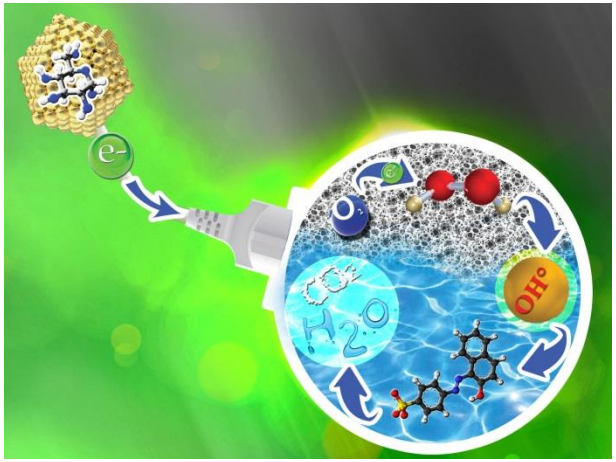
Fuel Cell-Fenton system







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Collaborations & Funding

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