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Electrochemical biosensor based on magnetic-separation/concentration-signal-amplification in-one method

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Contents



- **Food safety and biosensor**

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Some facts and data about food safety

Foodborne diseases encompass a wide spectrum of illnesses and are a growing public health problem worldwide (WHO, October 2017).

- Over **200** diseases are caused by unsafe food
- 1 in 10 people fall ill every year from eating contaminated food
- 420 000 people die each year as a result
- Children with some
125 000 very year.

Detection!

USDA: U.S. Foodborne Illnesses Cost More Than \$15.6 Billion Annually

Poses major economic risks, especially in a globalized world.

Germany's 2011 E.coli outbreak: US\$ 1.3 billion in losses for farmers and industries; US\$ 236 million in emergency aid payments to 22 European Union Member States.

Our biosensing researches



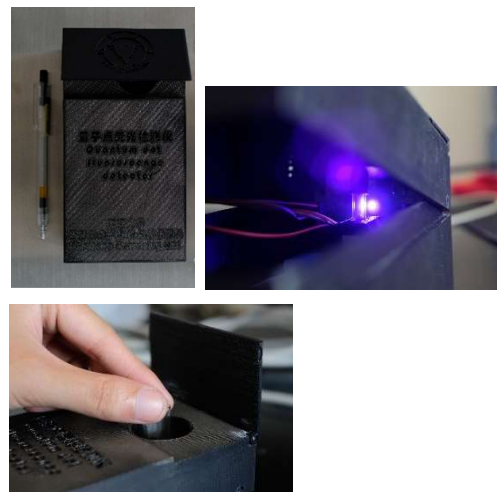
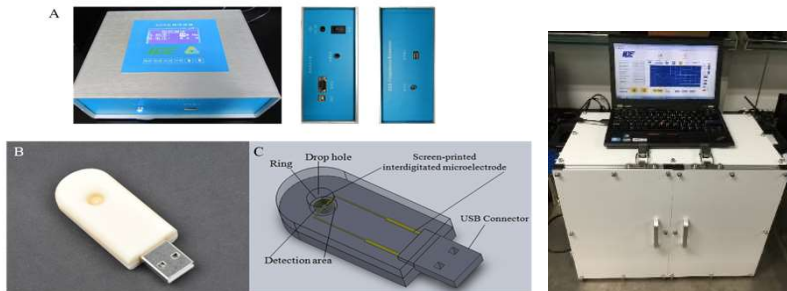
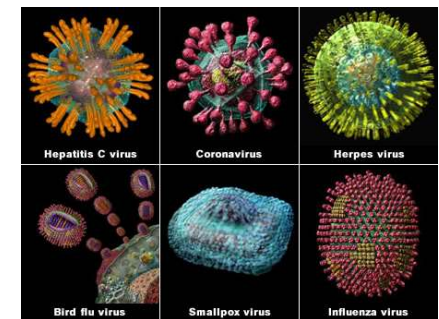
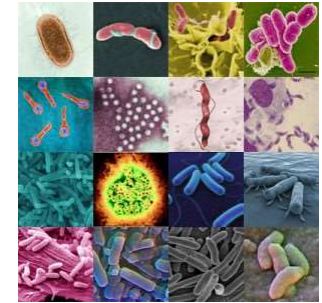
Prof. Yanbin Li

Technologies

Biosensing

Instruments

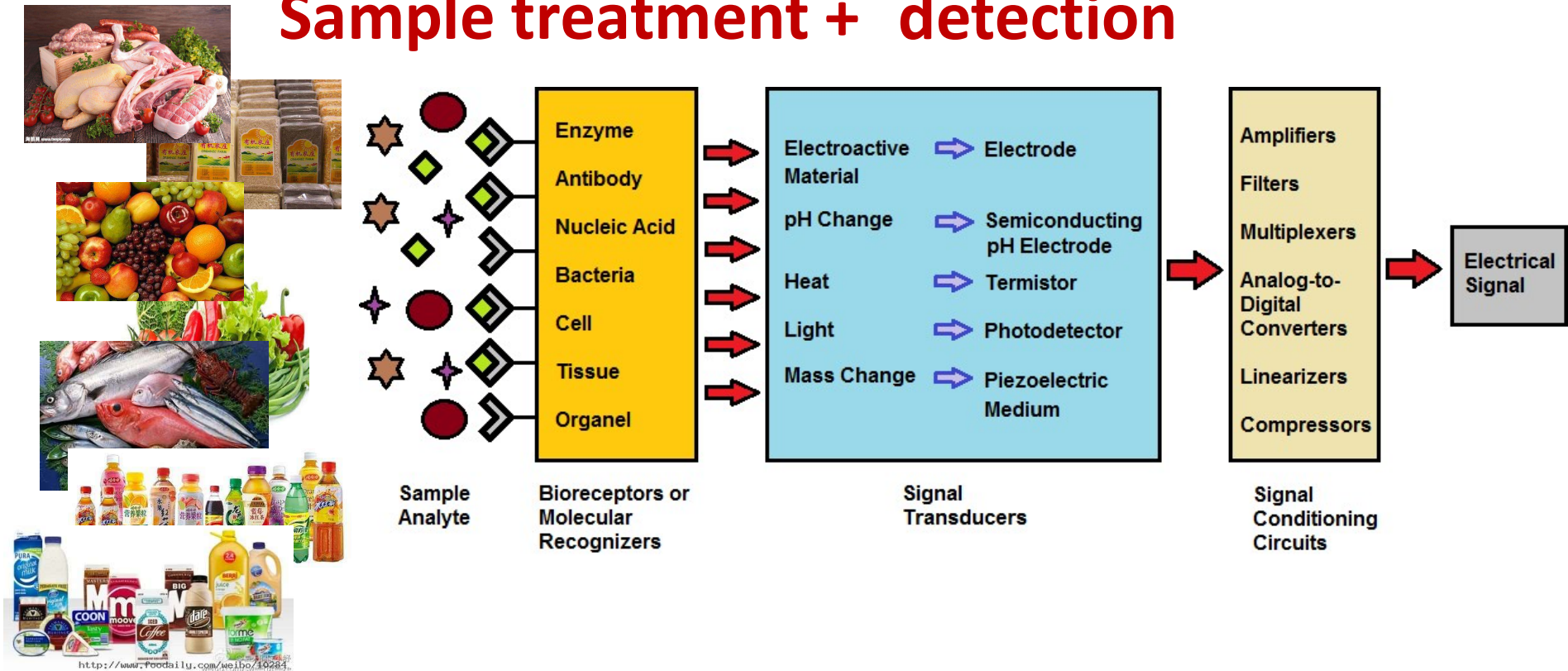
J. Mater. Chem. A, 2018, 6, 3402;
 Anal. Chem., 2017, 89, 12145;
 J. Physical Chem. C, 2017, 121, 6229;
 Anal. Chem., 2016, 88, 8542;
 Sens. Actuat. B-Chem., 2016, 234, 98;
 Analyst, 2016, 141, 1136;
 Food Control, 2015, 56, 135;
 Sci. Rep., 2015, 5;
 Biosens. Bioelectron., 2014, 54, 64;
 Anal. Chem., 2014, 86, 1965;
 Adv. Funct. Mater. 2014, 24, 5011;
 Chem. Eur. J., 2014, 20, 2623;
 ...



Biosensor

Sensitive, specific, rapid, portable, in-field detection

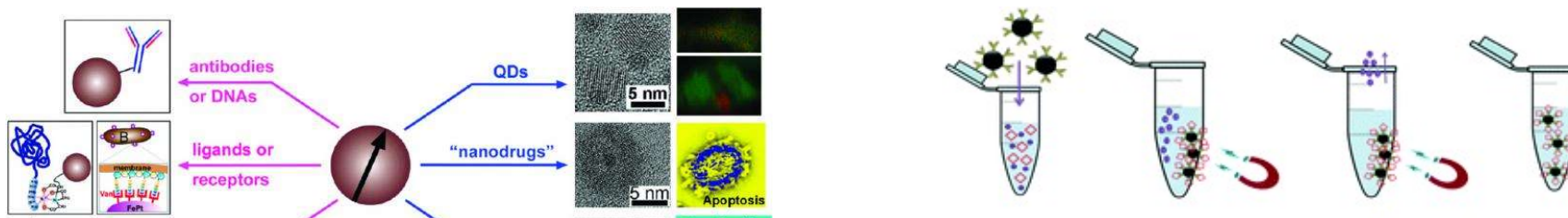
Sample treatment + detection



Make it a system (integrated, multifunctional)

Magnetic nanomaterials

Magnetic separation/concentration



One plays two roles?



Signal generation relying on nano-/bio-labels

Chem. Rev., 2012, 112, 5818; J. Mater. Chem. B, 2015, 3, 7831

Anal. Chem. 2013, 85, 2397; Science, 2003, 301, 1884; Methods Mol. Bio. 2013, 1026, 93

Electrochemical conversion (ECC) of magnetic nanoparticles (MNPs)

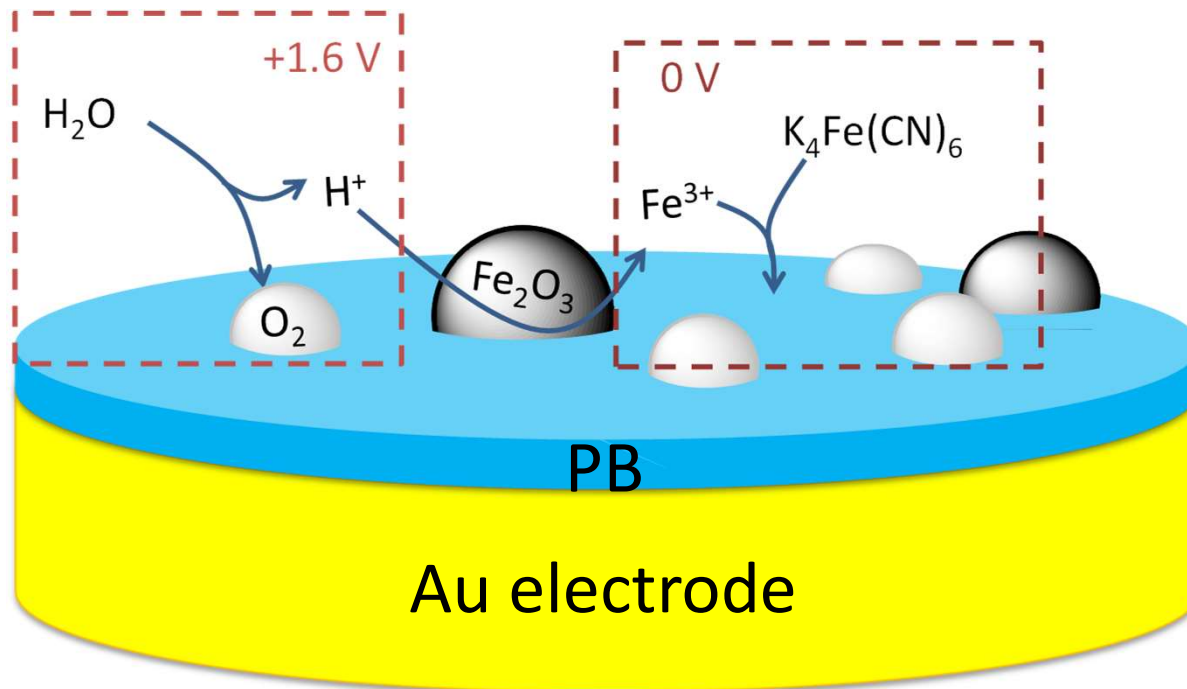
Make MNPs report themselves

High potential:

- Generate H^+
- Release Fe^{3+} by reaction of H^+ and Fe_3O_4

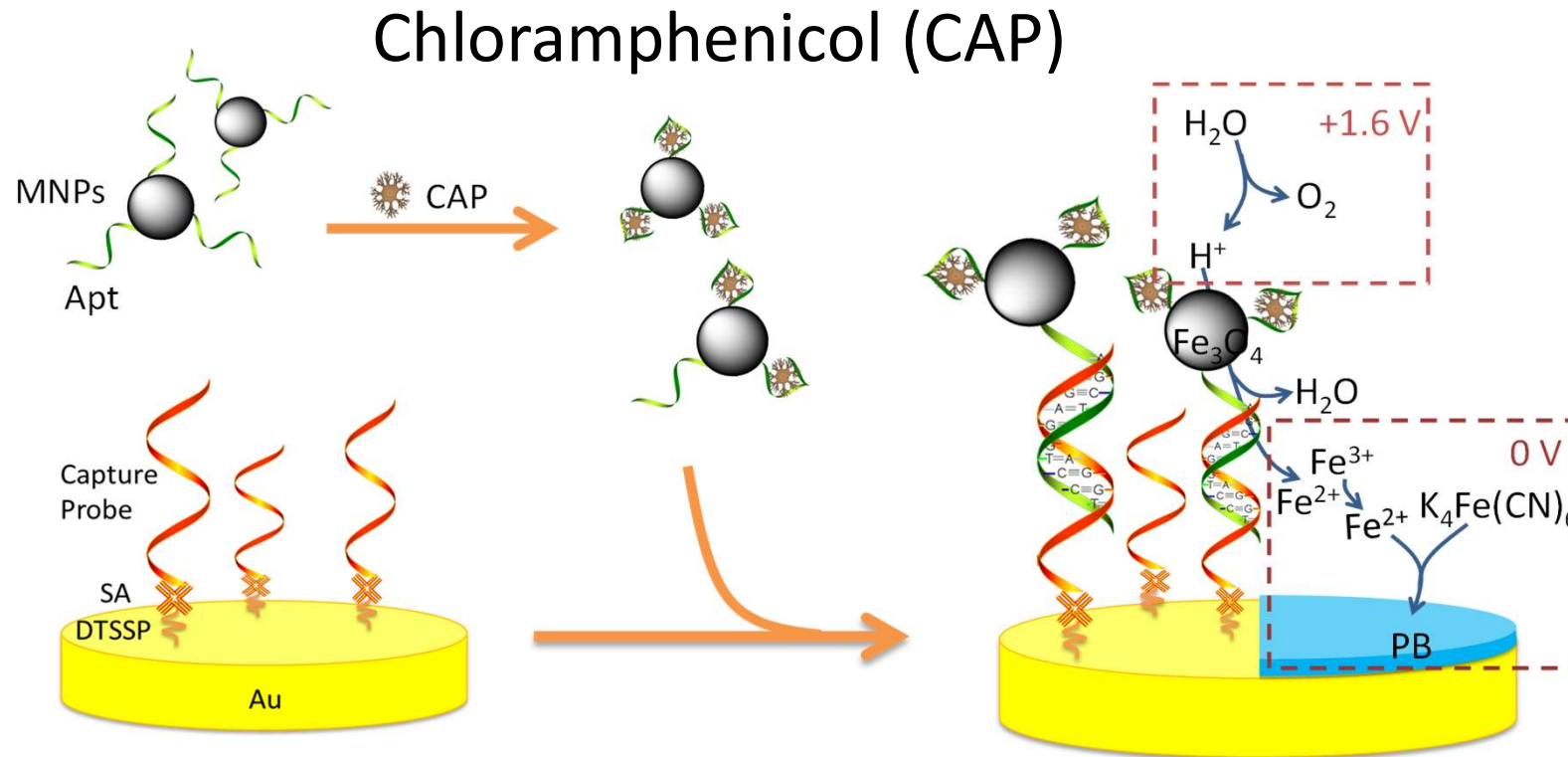
Low potential:

- Generate Fe^{2+} and $Fe(CN)_6^{4-}$
- Produce Prussian blue (PB)



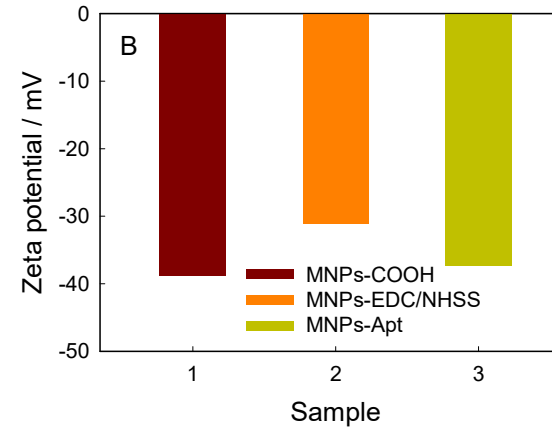
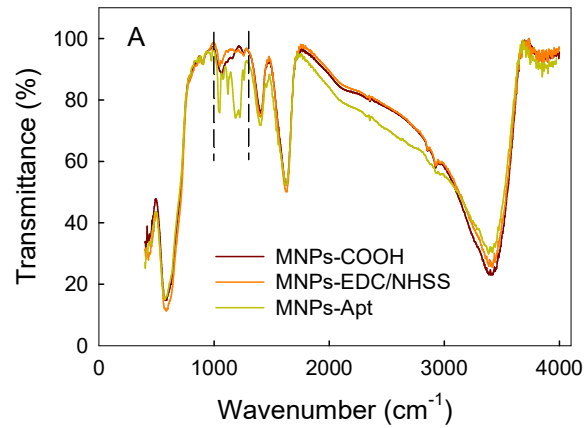
Anal. Chem.,
2017, 89, 12145

Electrochemical biosensing: one-in-all strategy

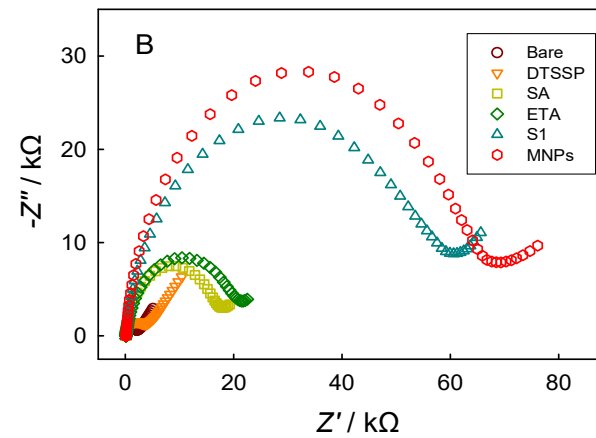
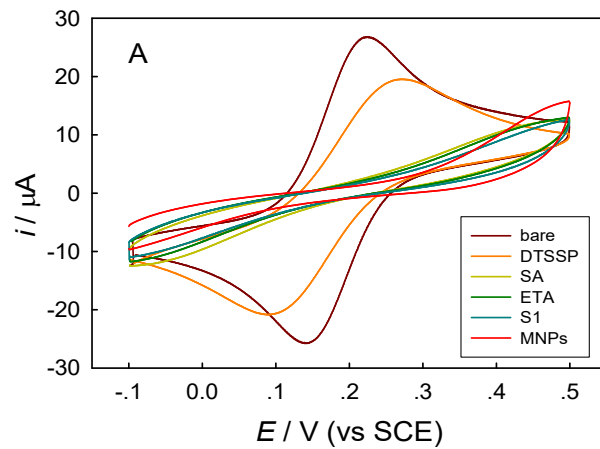


- Multi-role of magnetic nanoparticles: magnetic separation/collection + signal generation/amplification
- No requirement of additional signal labels

Preparation

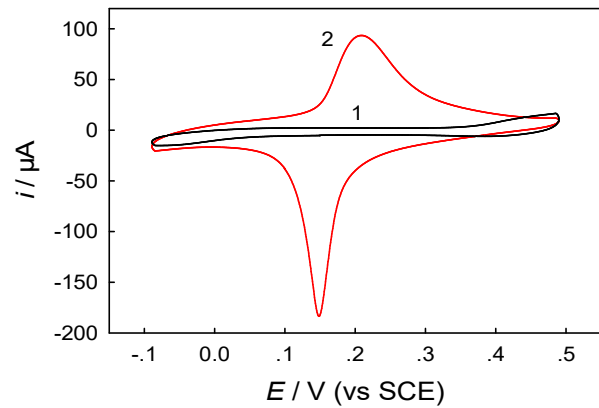


Modification of MNPs with aptamer

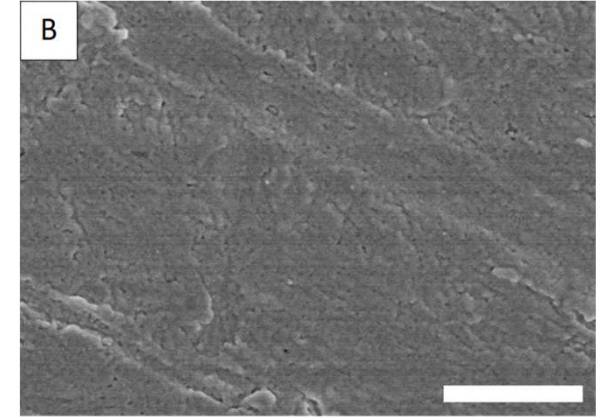
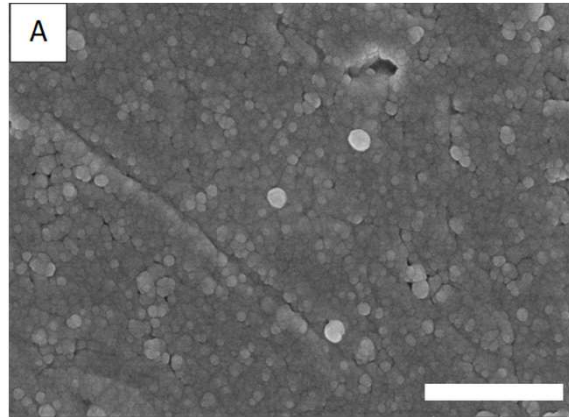


Layer-by-layer modification of electrode

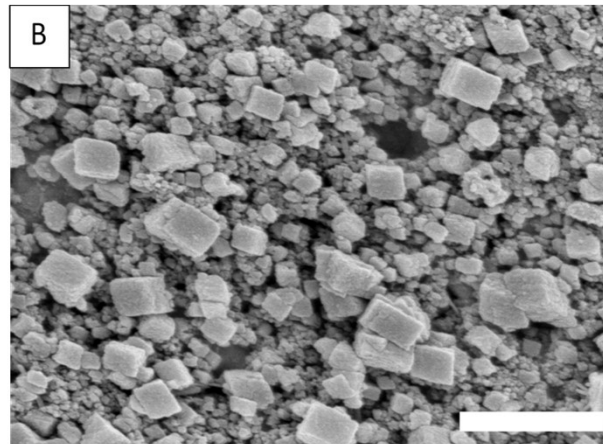
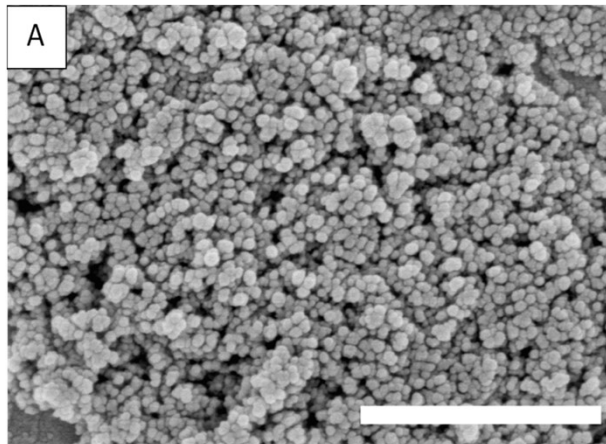
Characterization of ECC: high efficiency in signal generation



Signal generation

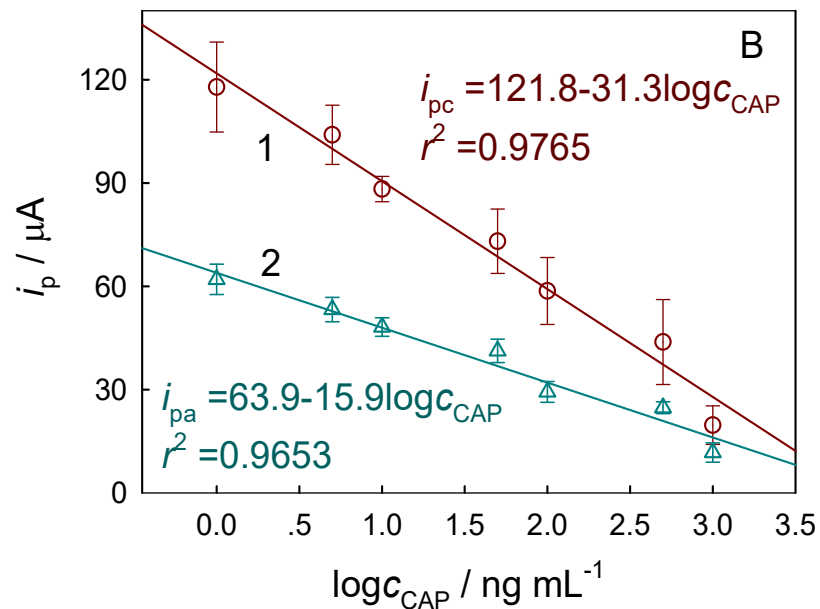
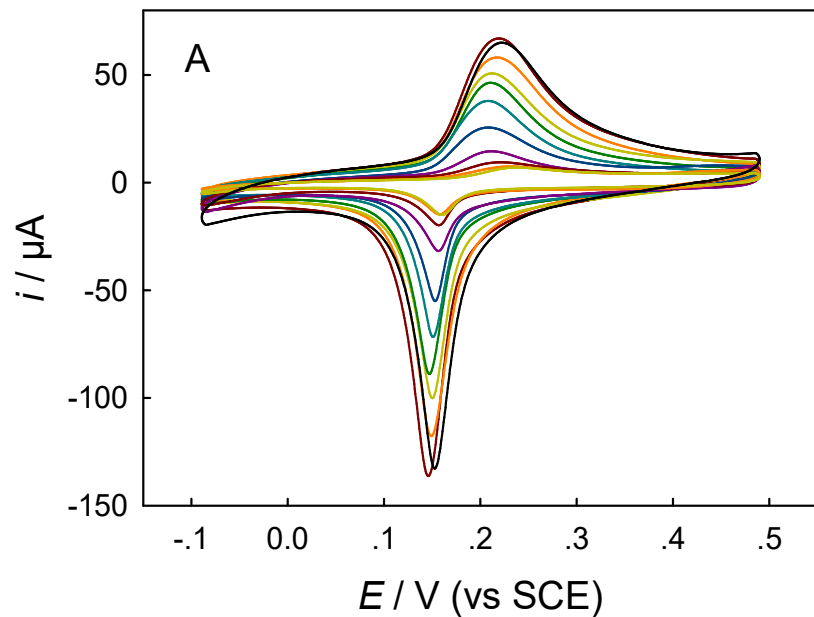


Removal of insulating layers



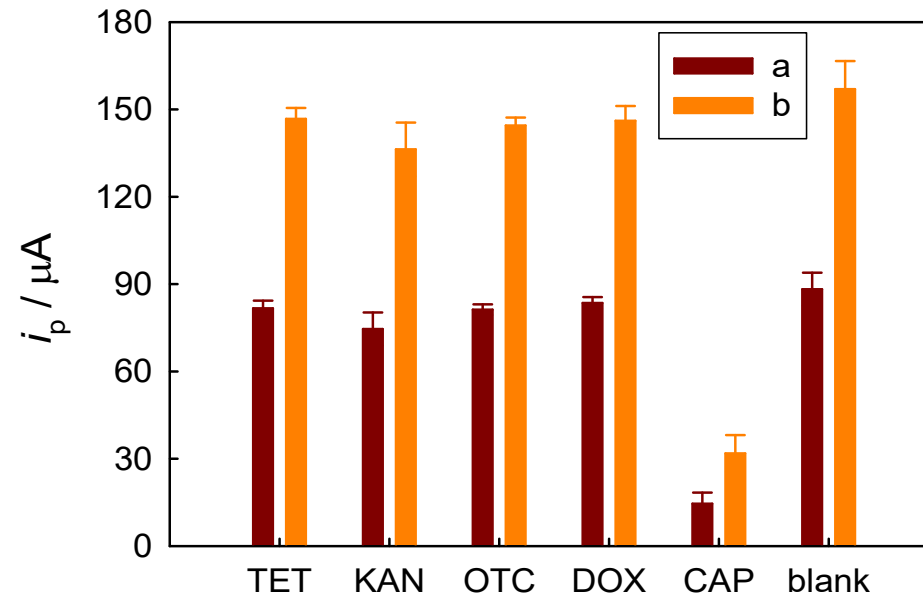
Generation of porous film

Performance: sensitivity



- Linear detection range: 1 ~ 1000 ng mL⁻¹
- Limit of detection: 1 ng mL⁻¹
- **Deriving from ECC**

Performance: specificity



- Good specificity
- Deriving from specificity of aptamer and successful blocking of electrode/MNPs

Performance: real sample tests

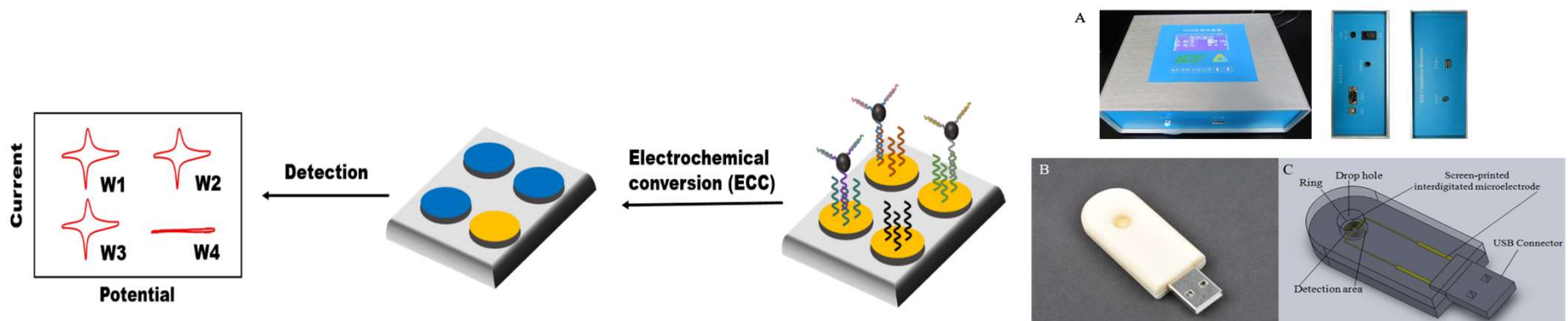
Samples	Added (ng mL ⁻¹)	Found (ng mL ⁻¹)	Recovery (%)
Milk	3.5	3.69	82±10
	51	58.76	113±17
	251	231.84	92±4.6
River water	4.5	5.79	89±6.6
	65	62.98	94±5.4
	305	279.37	91±10

Reliable in real sample detection

Sample-to-signal: less than 2 h

Conclusion and prospective

- ECC-based all-in-one strategy shows significant potential for facile, rapid, low-cost and sensitive biosensing
- Exploitation of new method for (simultaneous) detection of more targets and development for efficient but simplified instrumentation



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...



Funders





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Thank you

