Sensitive Detection for Food Safety based on Micro-Nano Sensors

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中国农业科学院农业质量标准与检测技术研究所

Contents

Innovation Team of Feed Safety

CNFQC

Department of Feed Safety

Staff 21

Department of Dioxin Contamination

Staff 9

Advanced instrument include HRGC-HRMS, LC-MS/MS, LC-Q-TOF, GC-MS/MS and so on. The team focuses on analysis and toxicology of hazardous substances in feed and animal products, such as beta-agonists, mycotoxins and POPs etc.

Innovation Team of Feed Safety

Team Members

Prof. Xiaoou Su

Dr. Peilong Wang

Dr. Xia Fan

MS Rong Song

Prof. G. Zhao

Prof. D. Suo

Dr. X. Li

Dr. W. Zhang

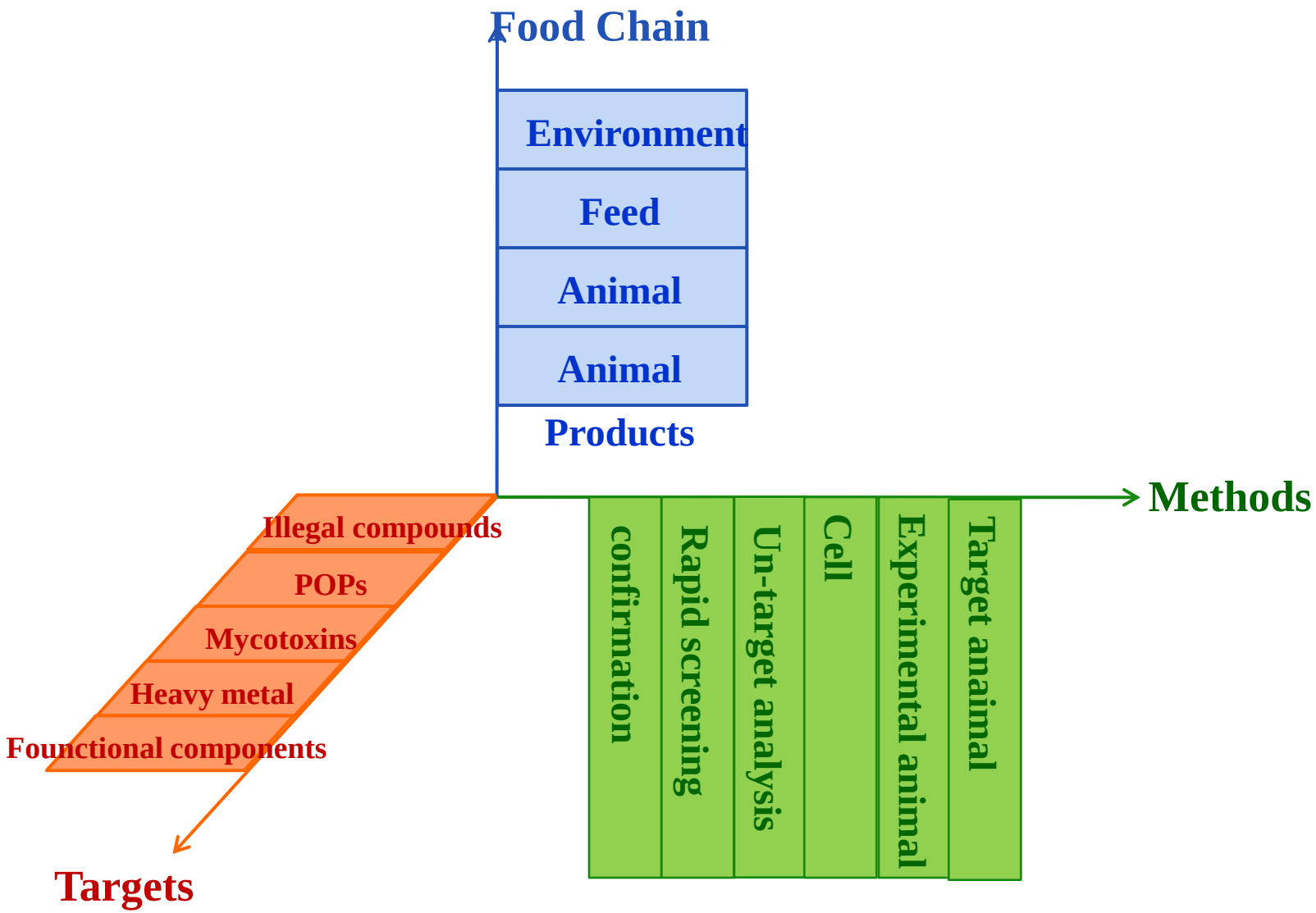
Dr. Z.Q. Zhang

Dr. R. Wang

Dr. J. Cheng

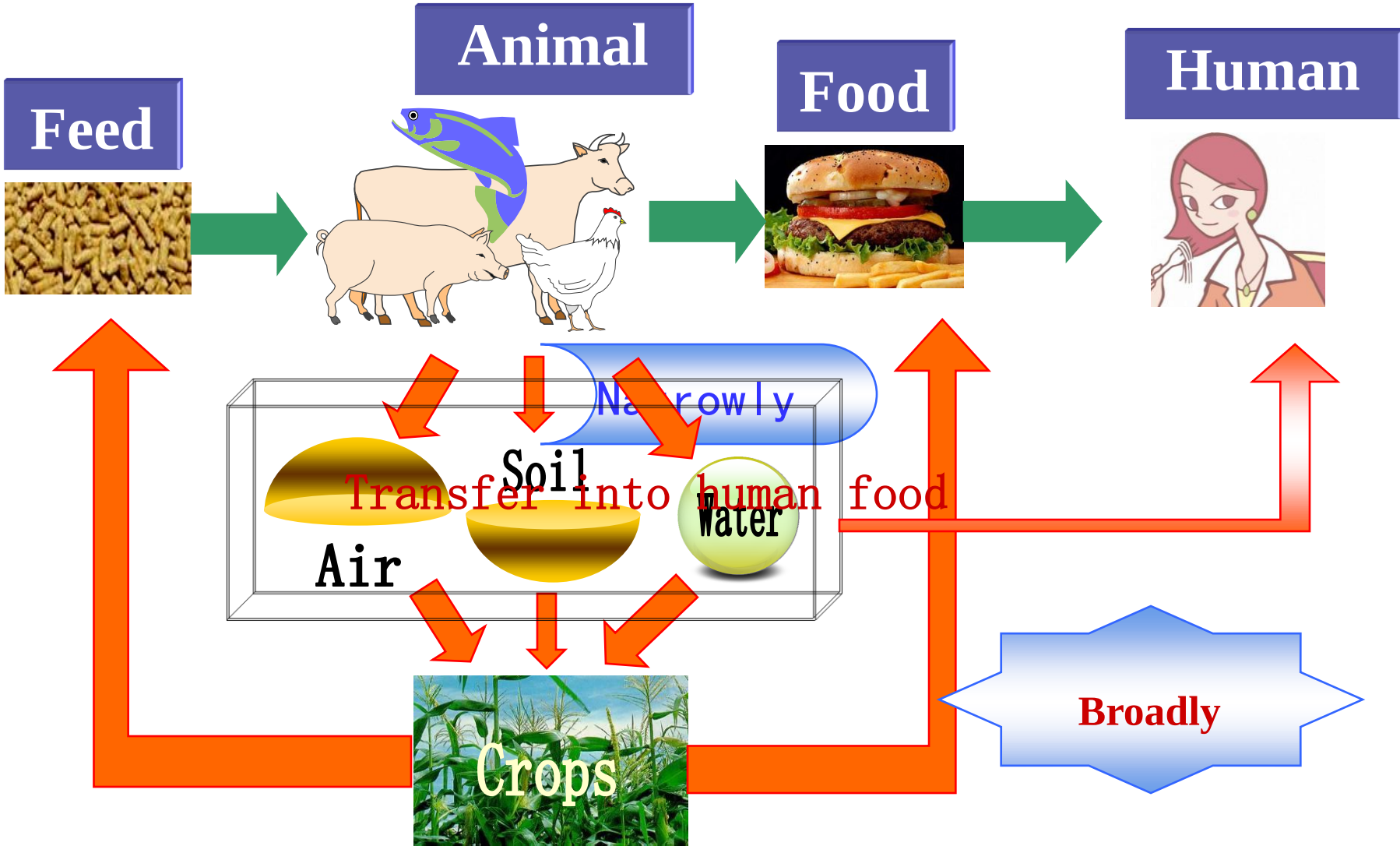
Dr. Y. Li

Innovation Team of Feed Safety



Background

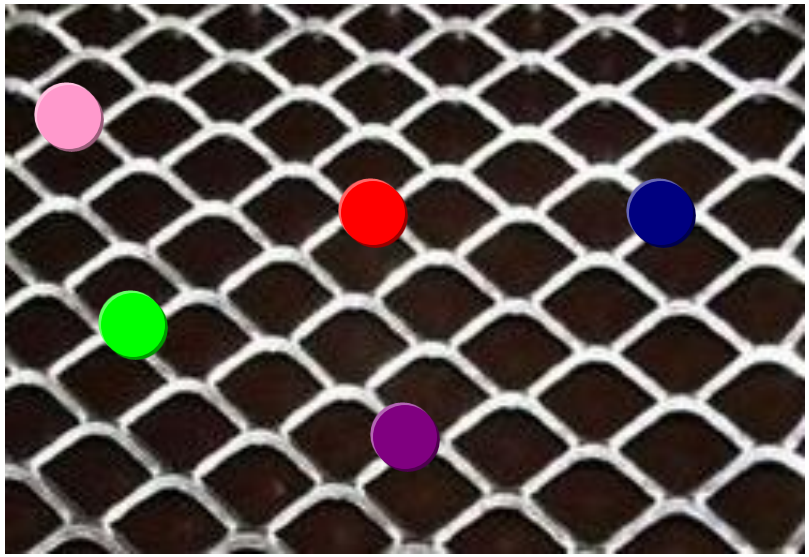
Feed safety = Food Safety

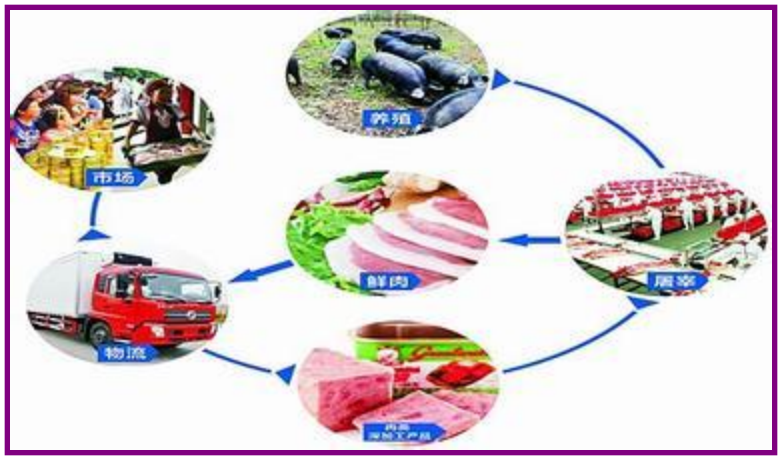


Background

Background

How to realize the monitor of food safety based on Internet +





Sensors sensing!

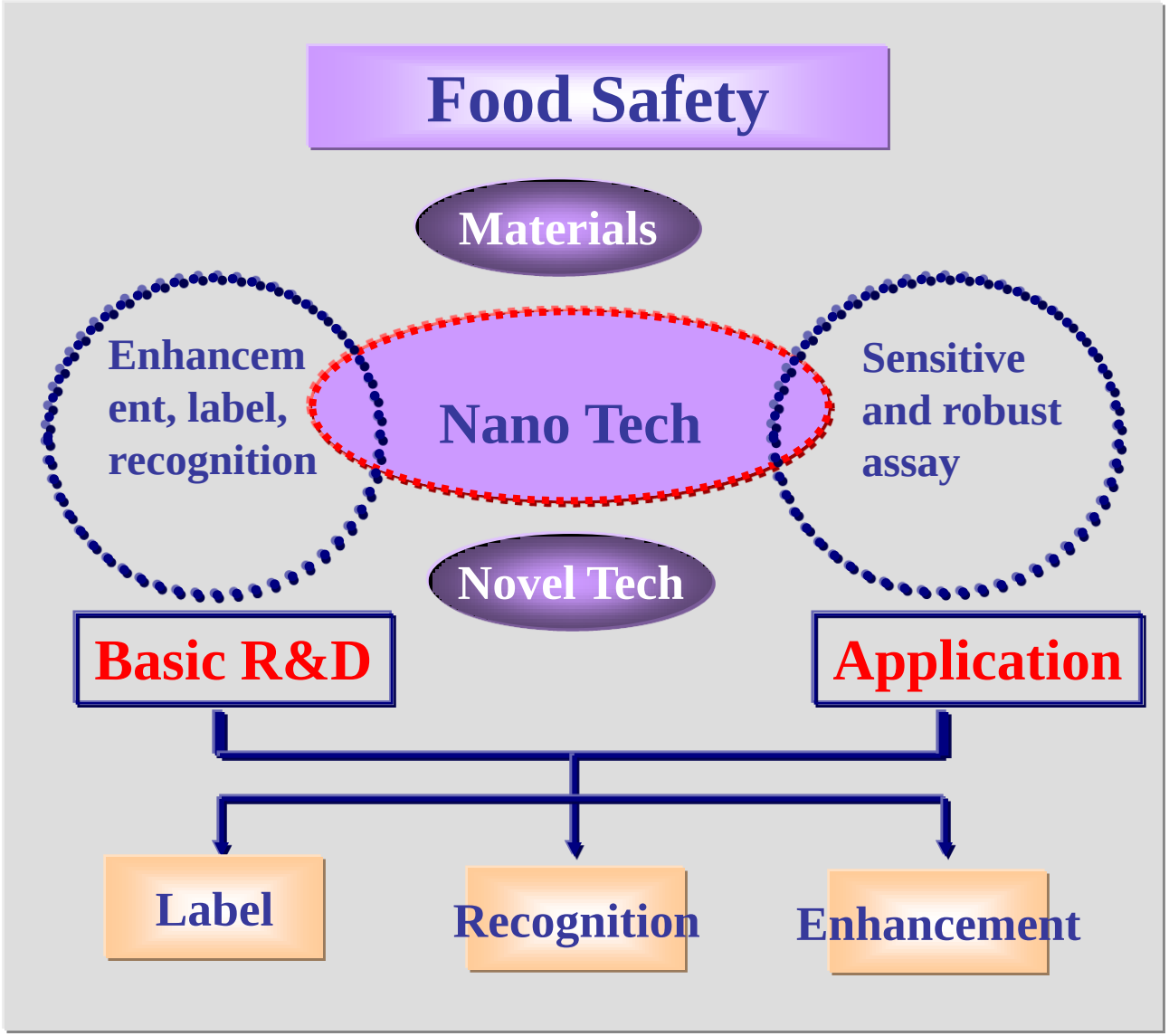
Background

Questions

- Low sensitivity
- Single or multiplex assay?
- Difficult to quantitative detection.
- Selectivity

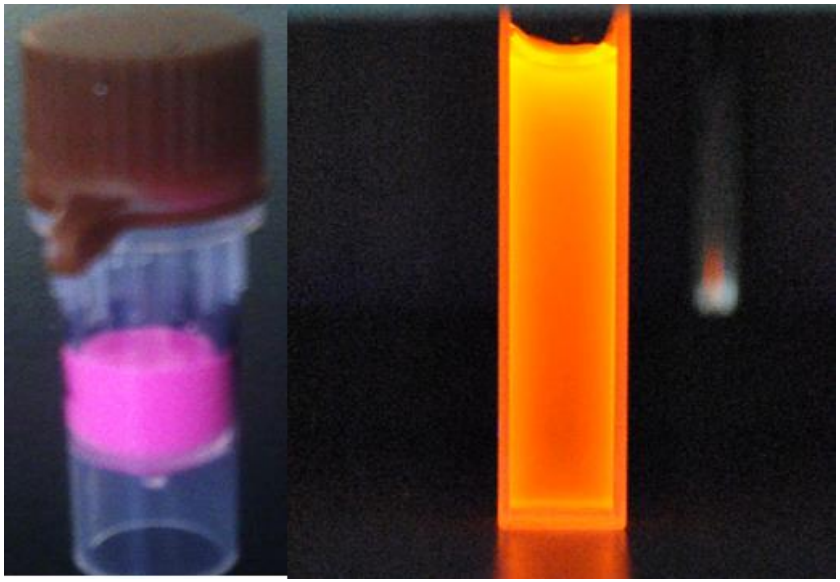
For the sensors

Our solutions

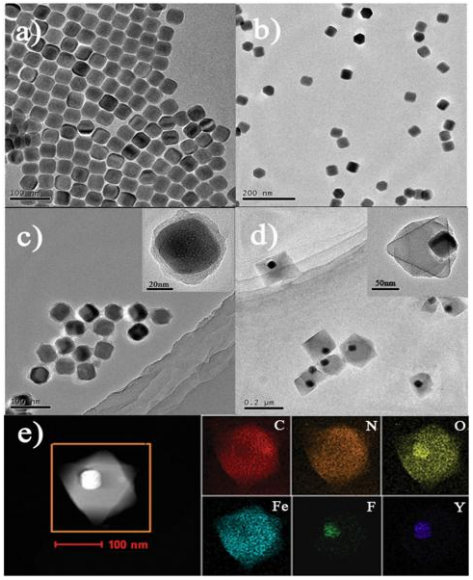


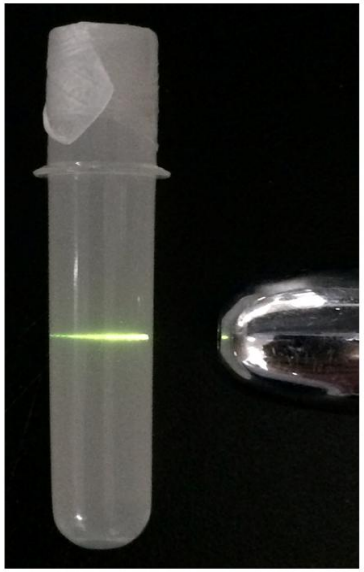
Progress

Florescent and UCP label materials



Florescent Nano materials



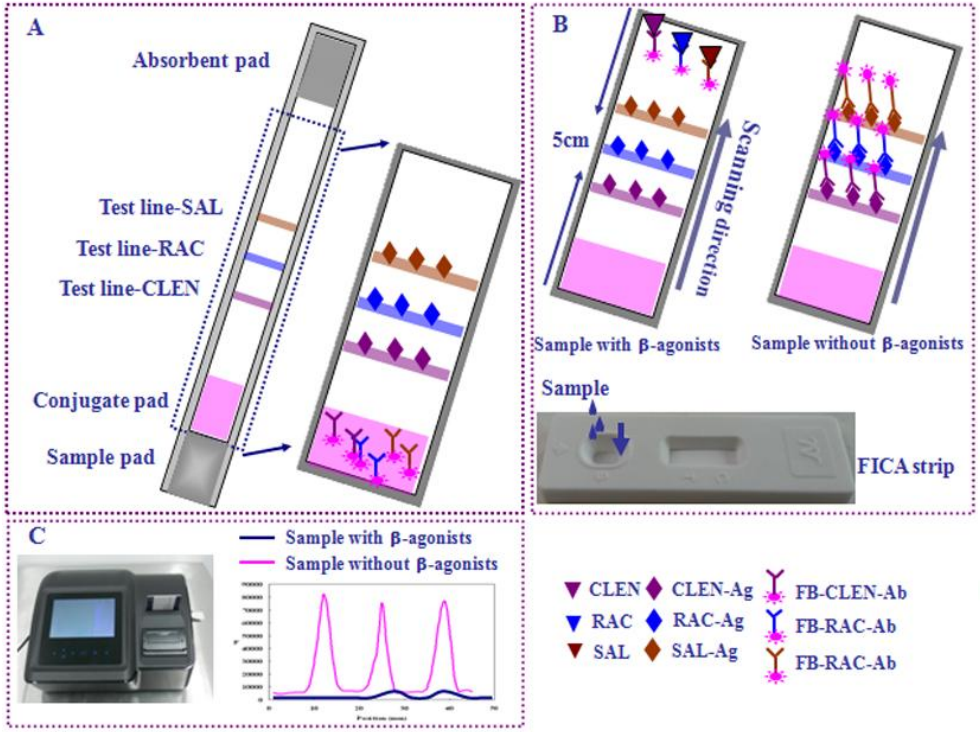


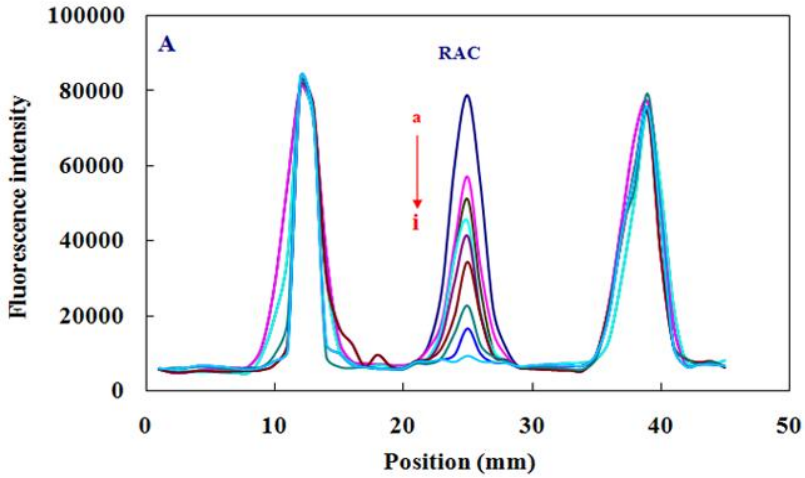
UCP nano materials

Progress

1.Fluoresenct lateral FLICA for detection of 3 kinds of beta-agonists

High sensitivity，
0.1ng/g；
Multiplex assay；
Quantification。





Wang et al. Biosensors and Bioelectronics, 2015

Progress

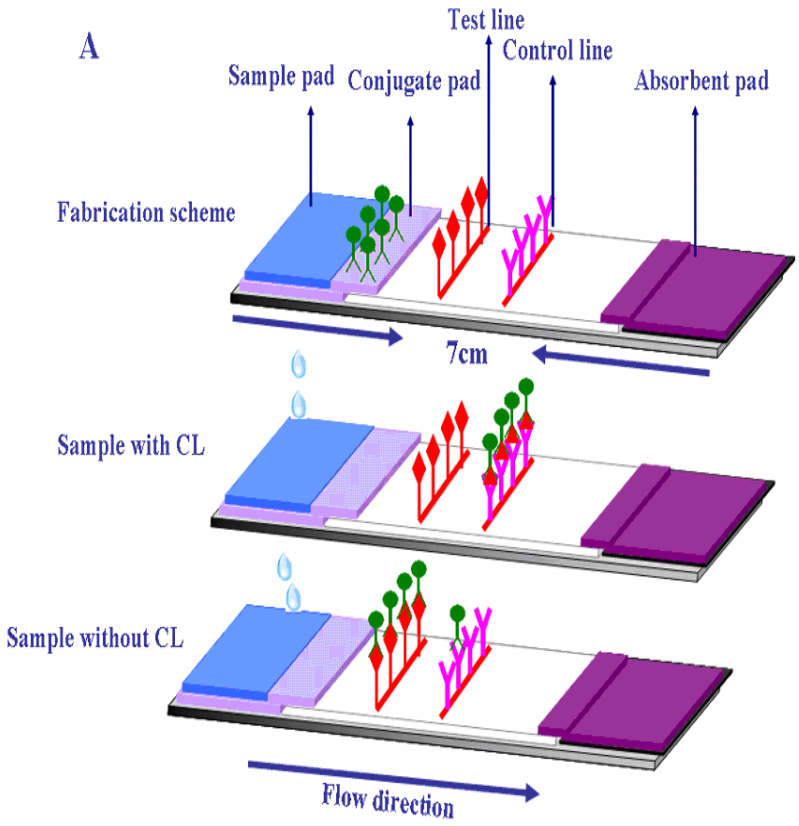
1. Fluoresenct lateral FLICA for detection of 3 kinds of beta-agonists

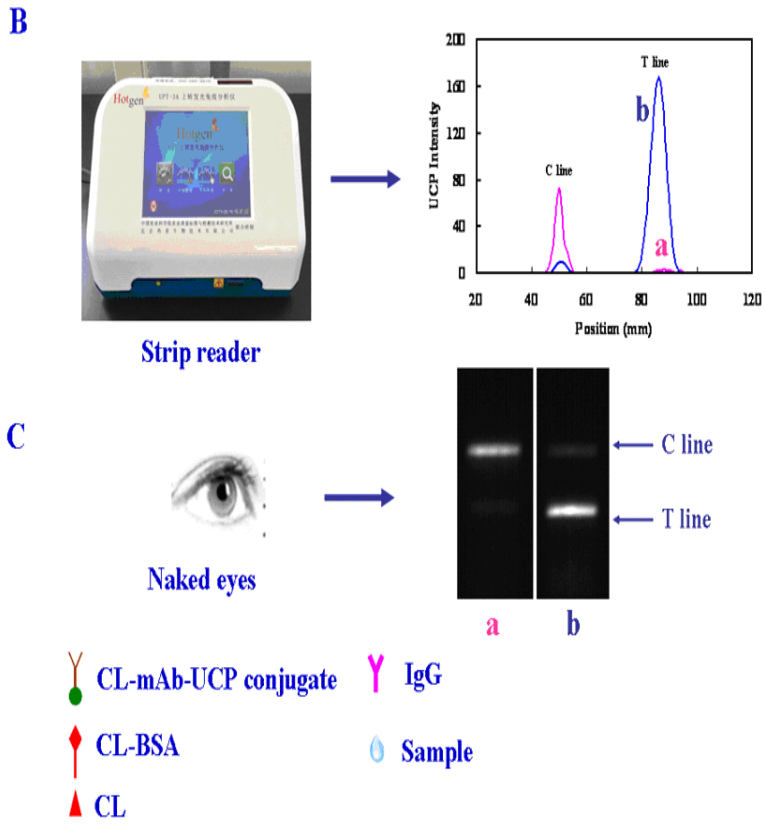
Sample	CLEN (ng/mL or ng/g)			RAC (ng/mL or ng/g)			SAL (ng/mL or ng/g)		
	Added	Found	Recovery (%)	Added	Found	Recovery (%)	Added	Found	Recovery (%)
Urine	0.5	0.41	80.2±4.32	0.5	0.38	76.0±6.77	0.5	0.35	70.0±4.26
	1.0	0.82	82.0±9.27	1.0	0.79	79.0±5.52	1.0	0.86	86.0±6.37
	4.0	3.16	79.0±4.55	4.0	4.02	100.5±4.28	4.0	3.81	95.3±8.21
Tissue	1.0	0.91	91.0±10.2	1.0	0.83	83.0±5.73	1.0	0.75	75.0±4.93
	2.0	1.71	85.5±5.42	2.0	1.64	82.0±6.47	2.0	1.62	81.0±6.51
	4.0	3.56	89.0±7.61	4.0	3.41	85.3±5.17	4.0	3.26	82.3±5.36
Feed	1.0	0.84	84.0±8.53	1.0	0.79	79.0±6.25	1.0	0.71	71.0±6.30
	2.0	1.83	91.5±6.74	2.0	1.74	87.0±3.69	2.0	1.79	89.5±6.28
	4.0	4.35	87.0±5.29	4.0	3.19	79.8±4.74	4.0	3.51	87.8±7.46

Wang et al. Biosensors and Bioelectronics, 2015

Progress

2.UCP label LICA for detection of CLEN

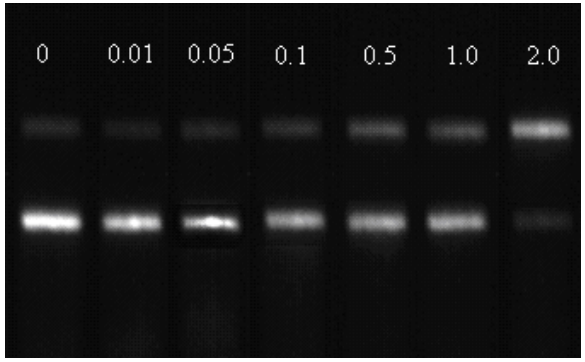


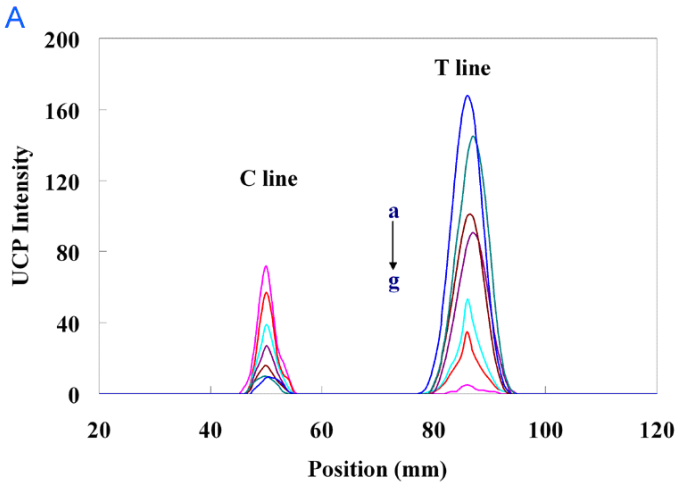


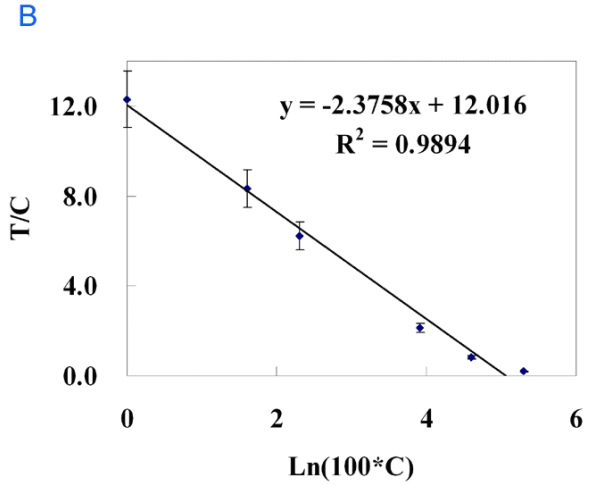
High sensitivity，0.01ng/g；
Quantification，Low background；
UCP-LICA for small molecules, firstly。 *Wang et al. Biosensors and Bioelectronics, 2016*

Progress

2.UCP label LICA for detection of CLEN







Sample	UCP-ICA		LC-MS/MS	
	C (ng/mL or ng/g)	RSD (%)	C (ng/mL or ng/g)	RSD (%)
Urine 1	2.26	6.9	2.49	3.1
Urine 2	0.31	9.4	0.42	4.2
Pork tissue 1	0.54	10.4	0.51	5.6
Pork tissue 2	3.59	5.2	3.96	4.7

Wang et al. Biosensors and Bioelectronics, 2016

Progress

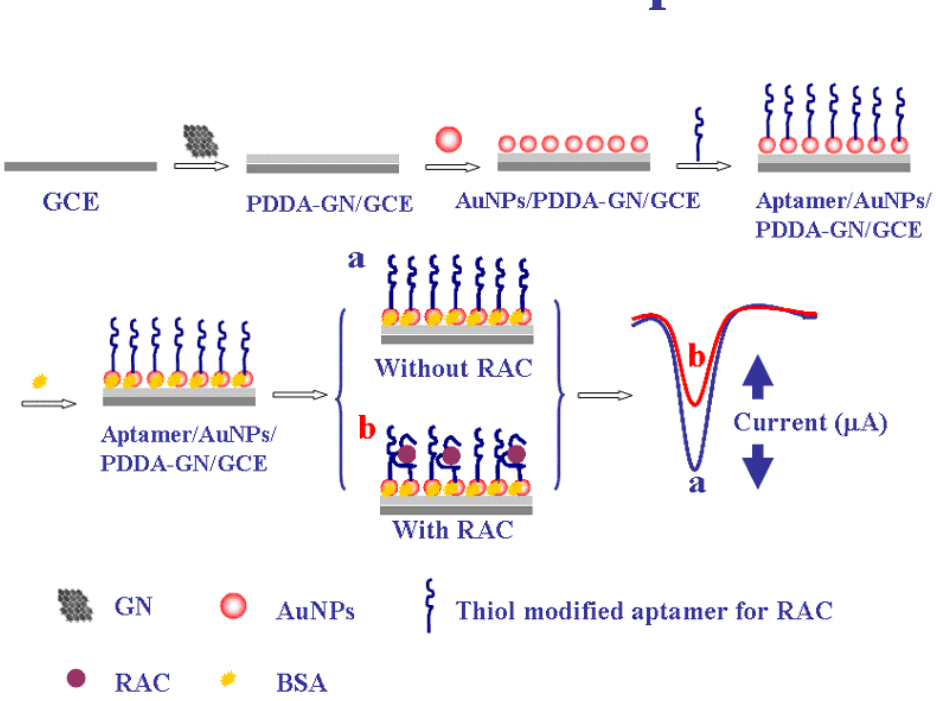
The instruments and detection regents have been developed。

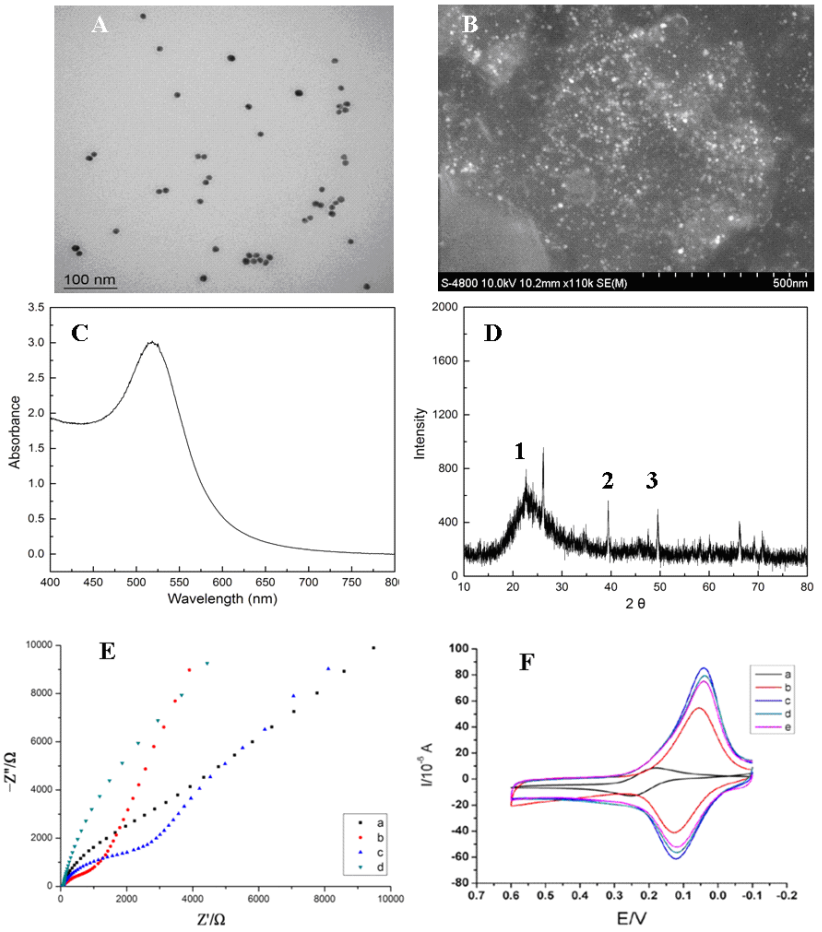
▲ **UCP instrument**

▲ **Fluorescent instrument**

Progress

3. Electrochemical aptasensor for RAC



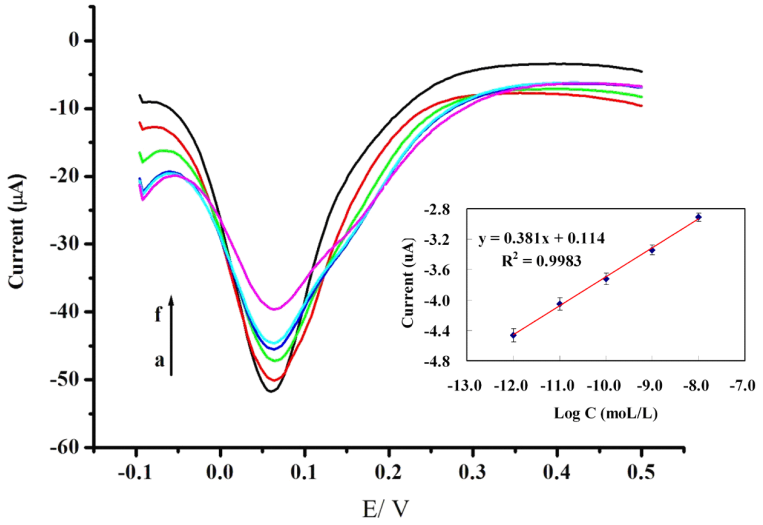


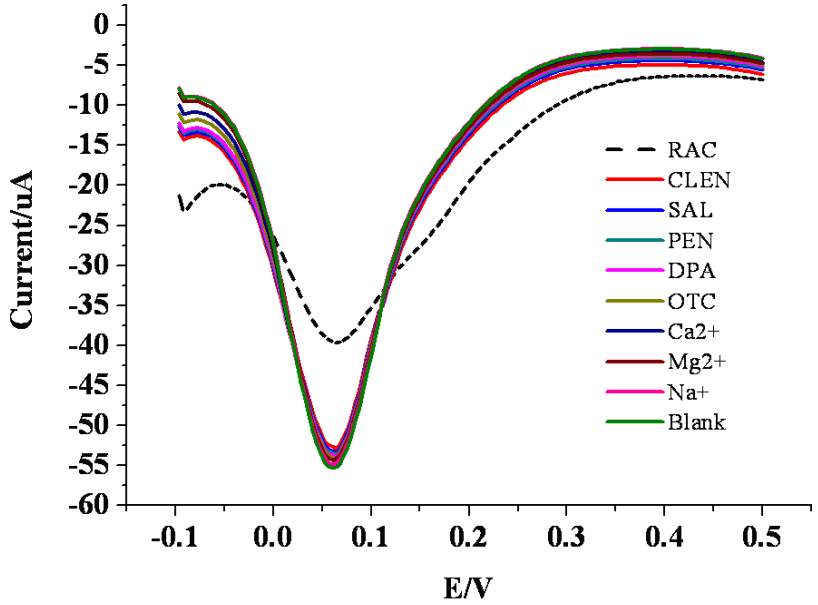
The composite membrane of AuNPs and Graphe was applied in the EC aptasensor。

Yang, Wang and Su et al. Biosensors and Bioelectronics, 2016

Progress

3. EC-aptasensor for RAC

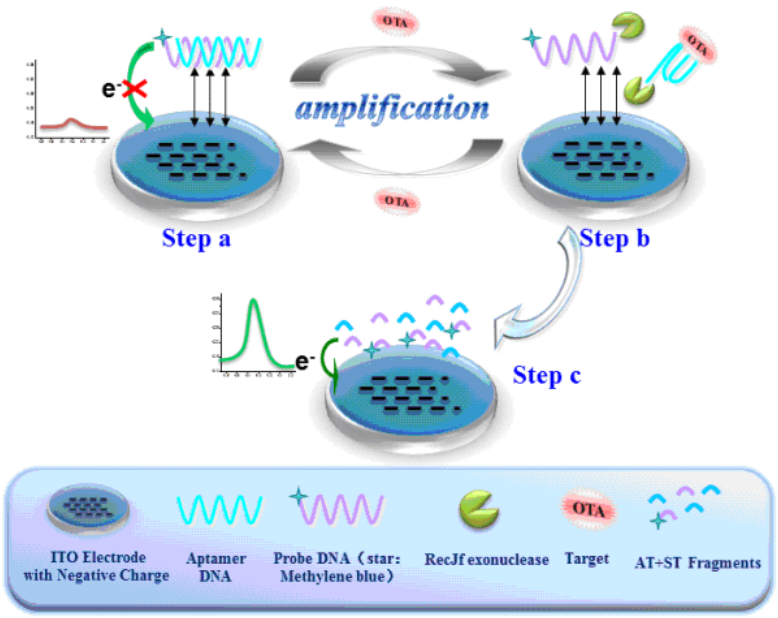


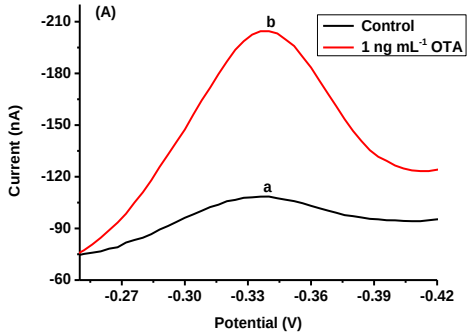


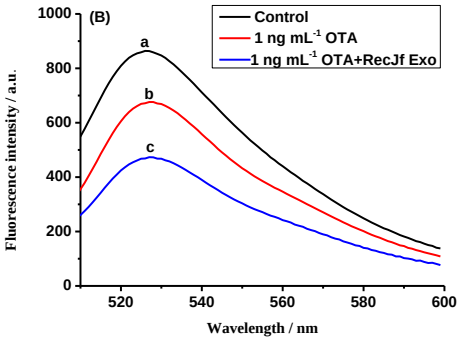
Sample	Added（moL/L）	Found（moL/L）	Recovery（%）	RSD（%）
1	1.0×10^{-8}	1.03×10^{-8}	103.0	3.7
2	1.0×10^{-9}	9.72×10^{-8}	97.2	4.3
3	1.0×10^{-10}	9.57×10^{-9}	95.7	5.5
4	1.0×10^{-11}	9.26×10^{-10}	92.6	5.1

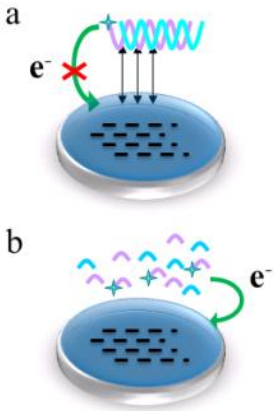
Progress

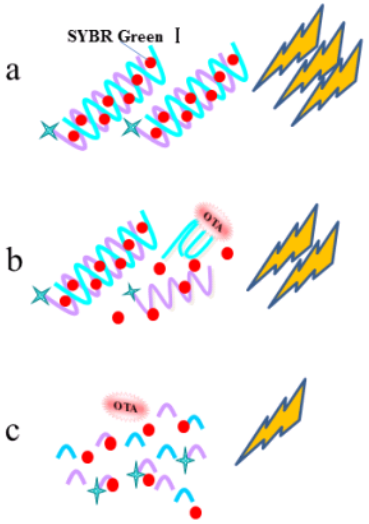
4. ITO sensor for OTA









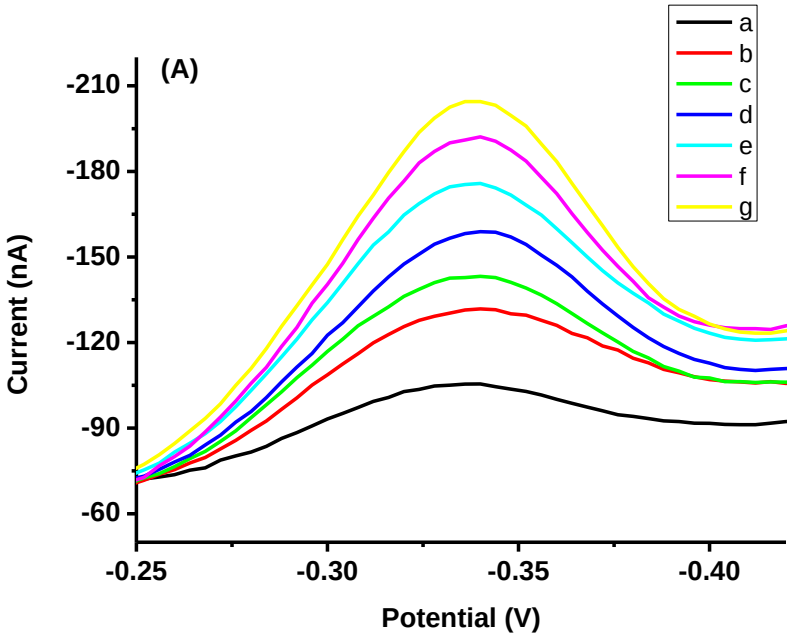


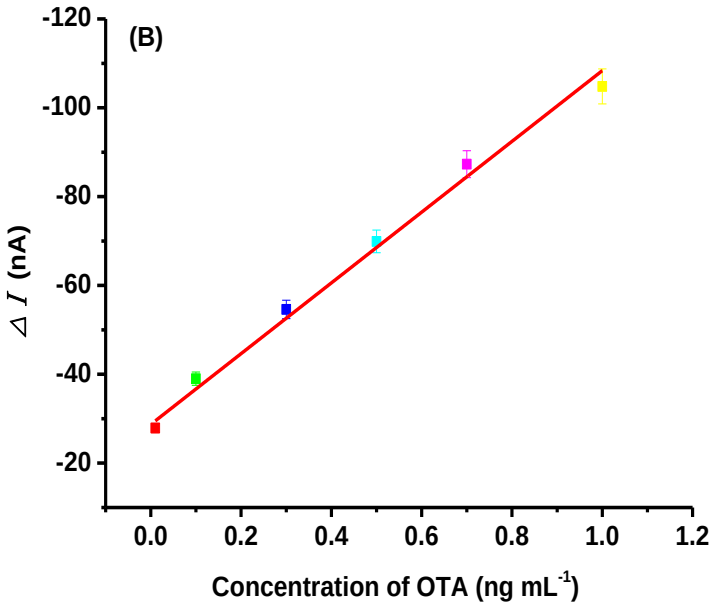
Signal amplification based on Un-modified ITO electrode 。

Tan and Wang et al. Analytical Chemistry, 2015

Progress

4. ITO sensor for OTA

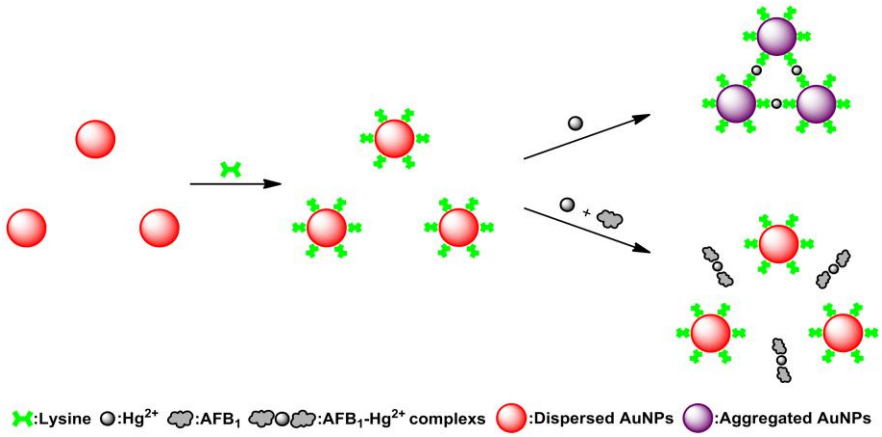


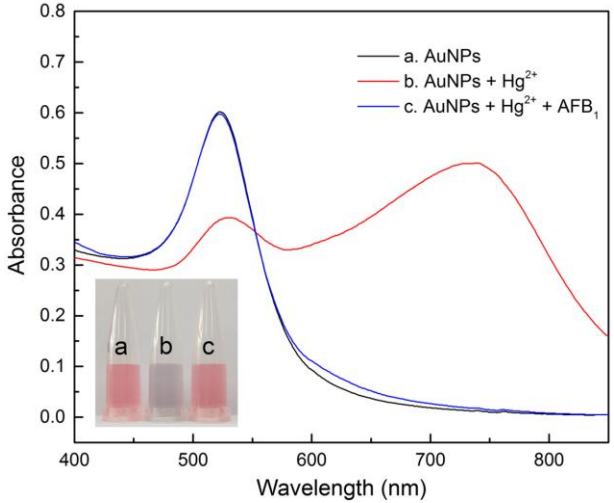


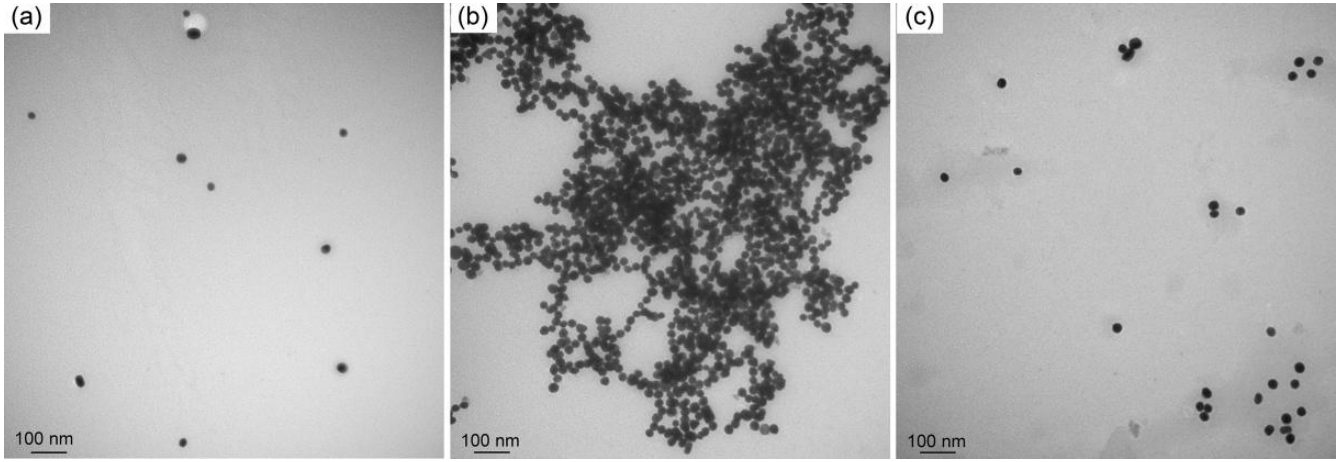
Sample	Detected (ng mL^{-1})	Reference (ng mL^{-1})	Spiked (ng mL^{-1})	Total found (ng mL^{-1})	Recovery (%)	RSD (%)
1	47.9	54.2	10.0	57.4	95.0	4.9
2	48.6	54.2	20.0	67.9	96.5	5.1
3	49.1	54.2	40.0	88.2	97.8	5.6

Progress

5.Visual nano probe for detection of aflatoxins





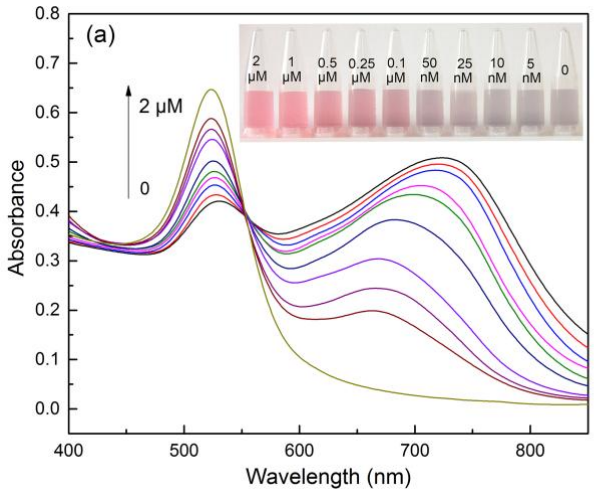


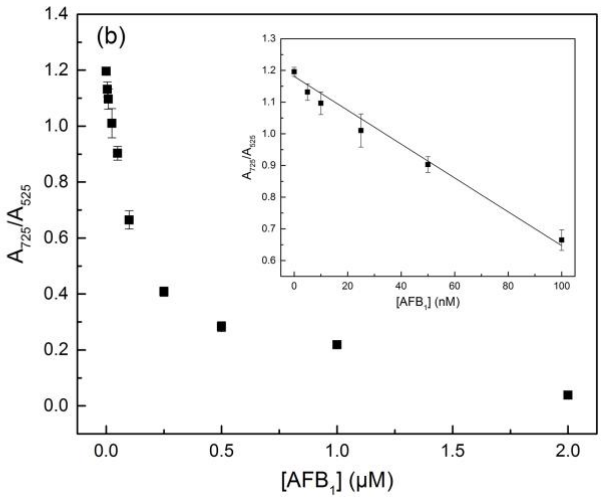
Easy operation;
Without instrument;
Visual。

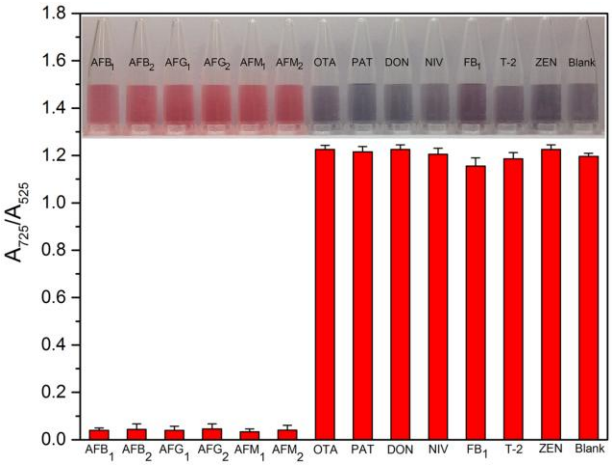
Du, Wang and Su et al. Microchimica Acta 2016
Zhou, Wang and Su et al. Talanta. 2013

Progress

5.Visual nano probe for detection of aflatoxins



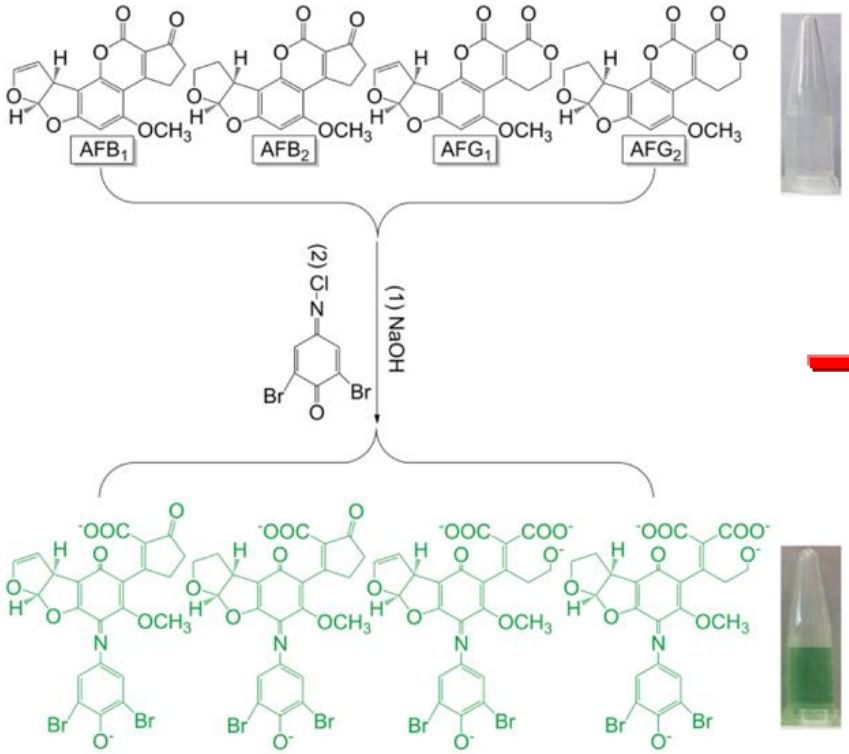


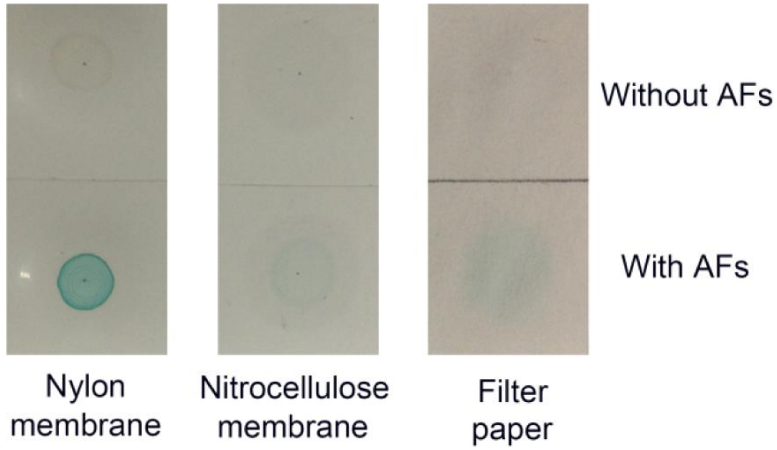


sample	Concentration of AFB_1 (nM)		recovery (%)	RSD (%)
	spike level	amount found		
1	10	8.57±0.46	85.7	5.4
2	50	51.35±1.69	102.7	3.3
3	100	109.76±4.14	109.8	3.8

Progress

6. Visual chemical probe for detection of aflatoxins

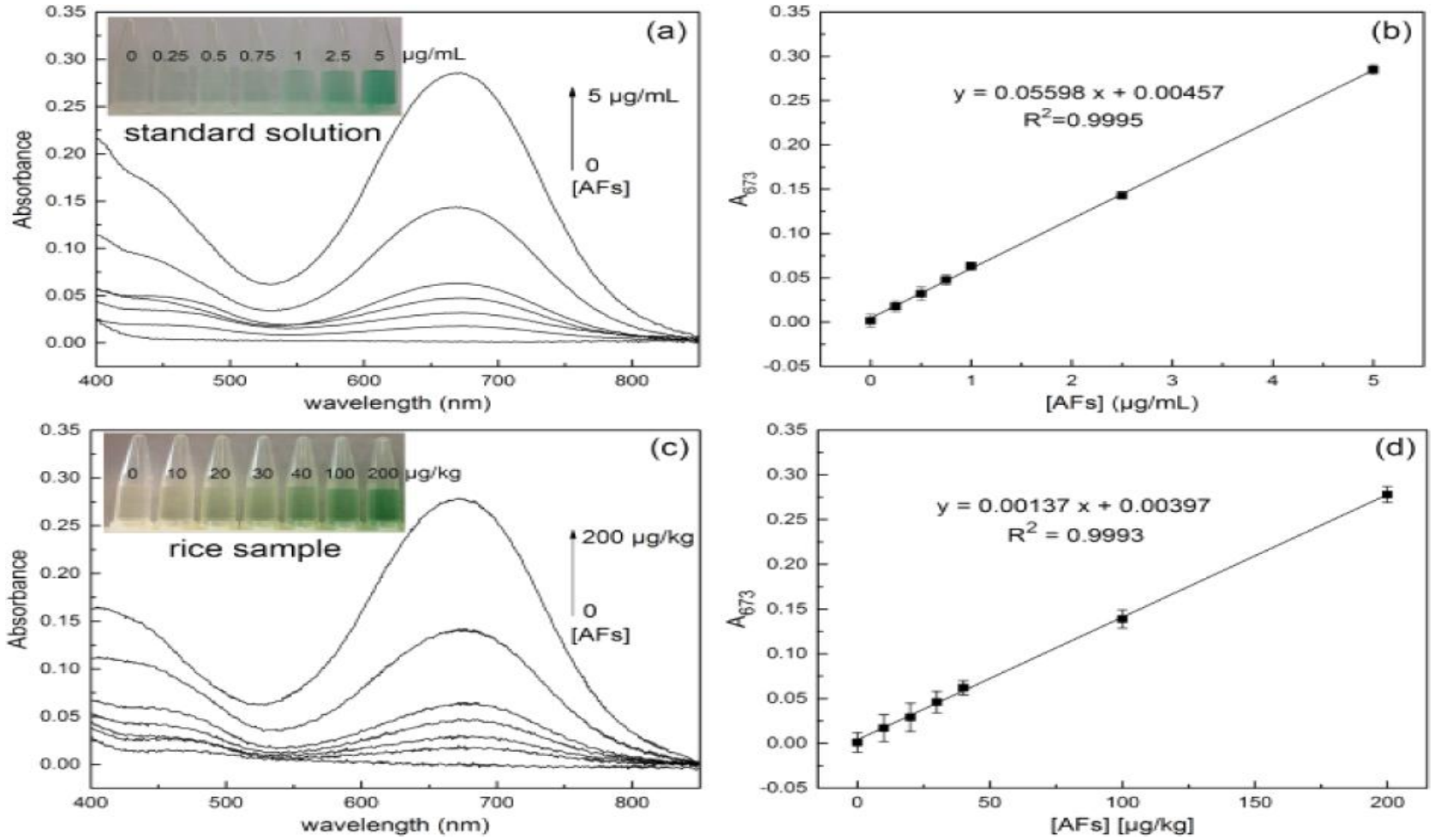




Du, Su and Wang et al. Analytical Chemistry 2016

Progress

6. Visual chemical probe for detection of aflatoxins

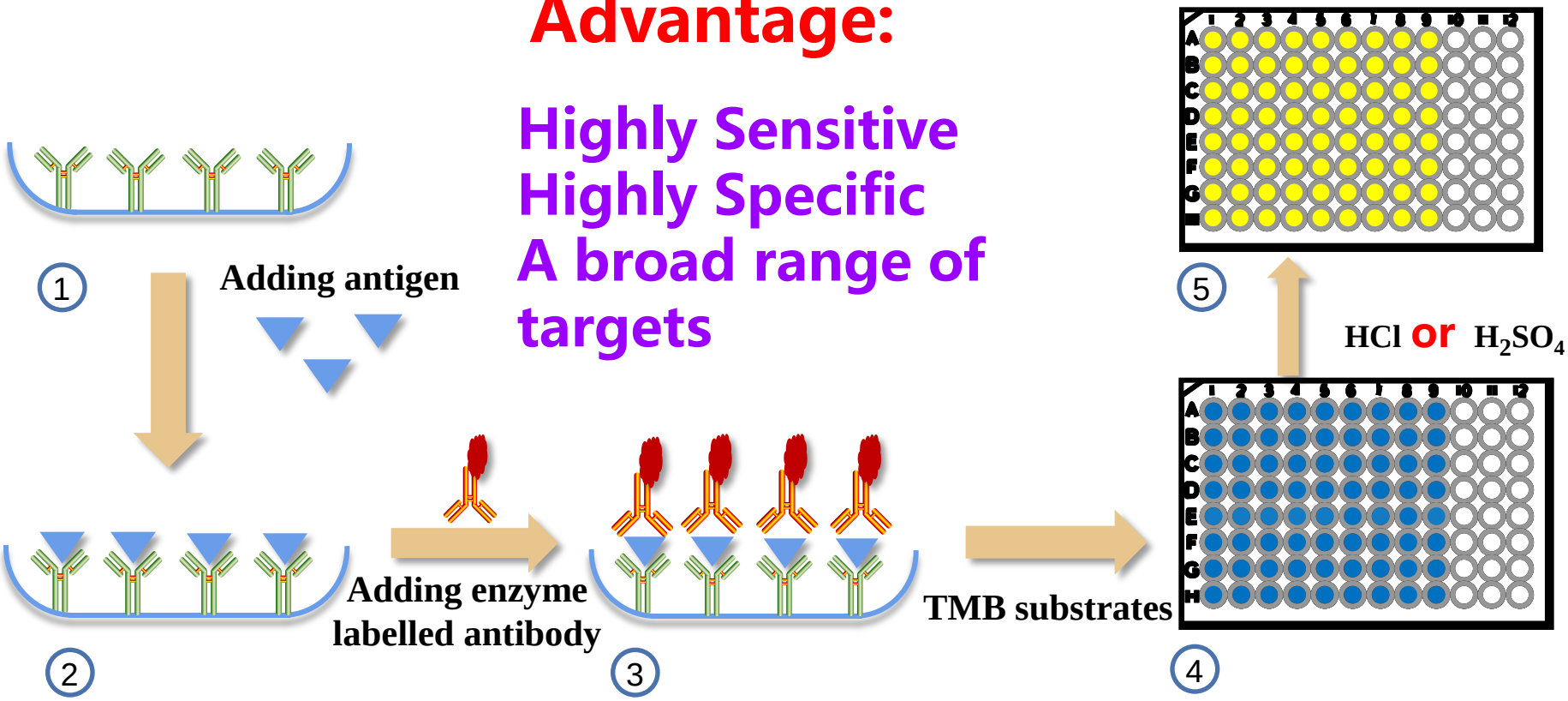


7.Visual ELISA based on AuNRs

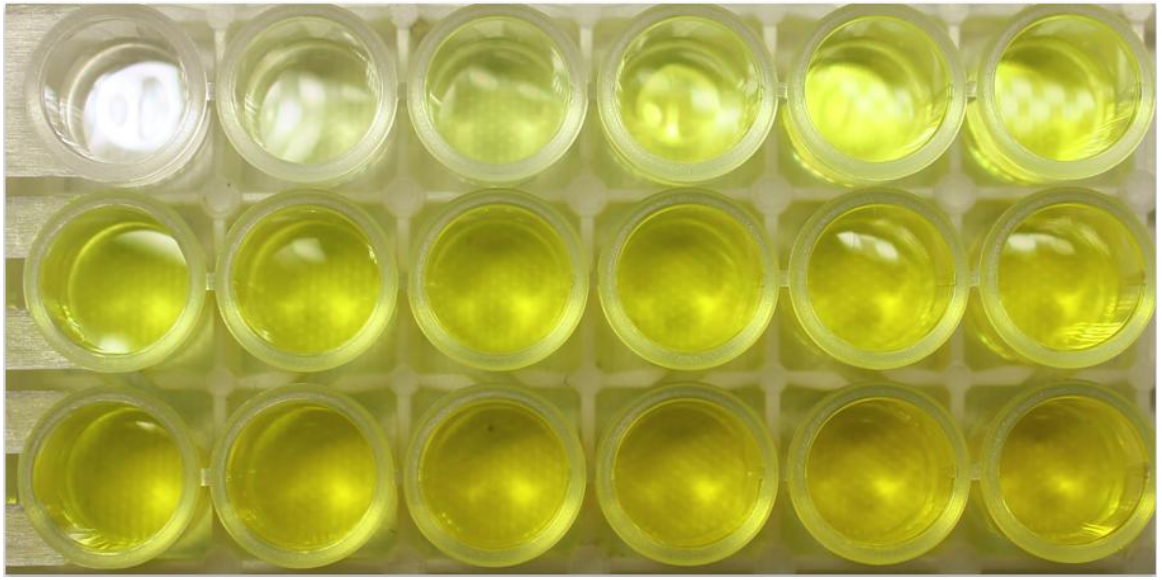
传统ELISA

Advantage:

Highly Sensitive
Highly Specific
A broad range of targets



Limitation of current commercially available ELISA



Microplate reader
(~10,000$)

- **Naked eye:**

qualitative detection

- **Microplate reader:**

quantitative detection

Limitation:

Costly & Poor Portability

How to detect a broad range of targets with portable devices?

Multicolor

Toxic standard substances

ELISA:

Thousands of targets

✓ A broad range of targets

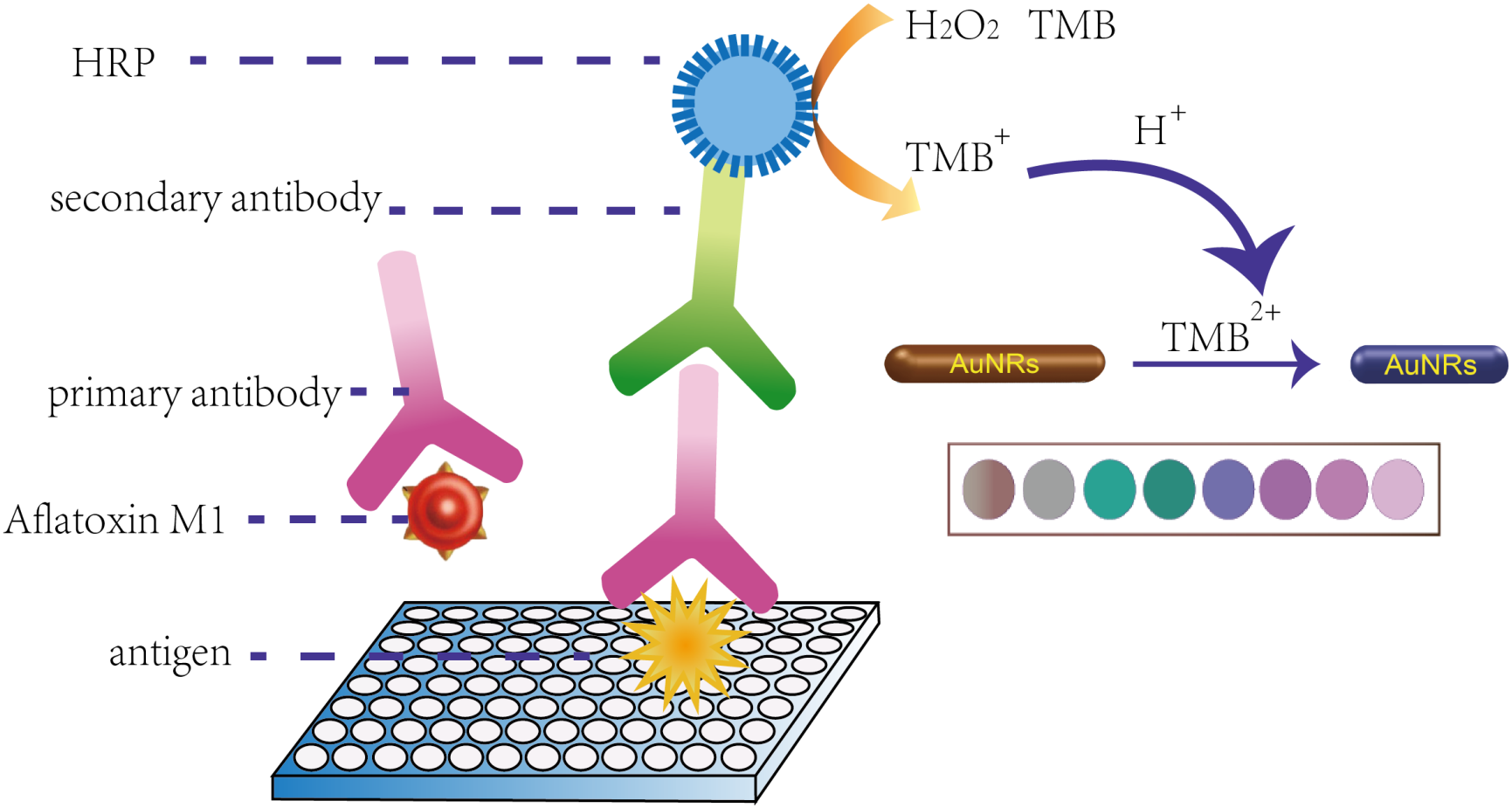
Multicolor:

Visual detection with naked eye

✓ Portable devices

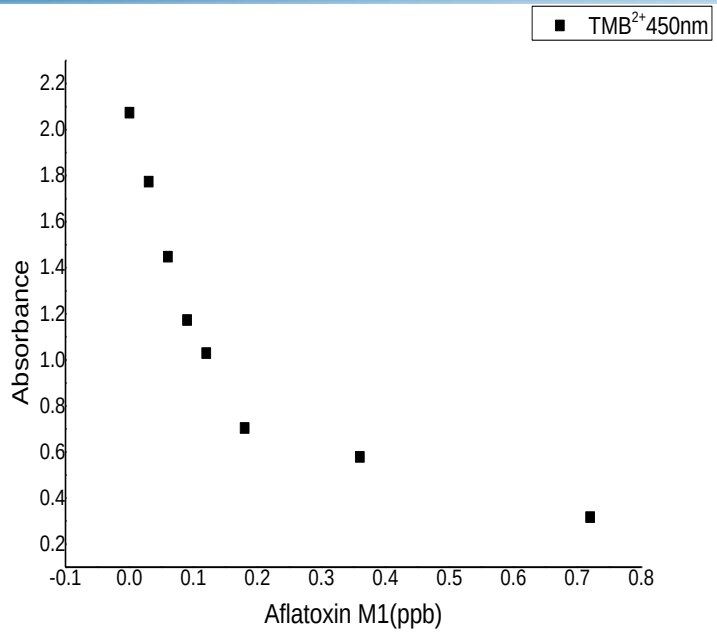
7. Visual ELISA based on AuNRs

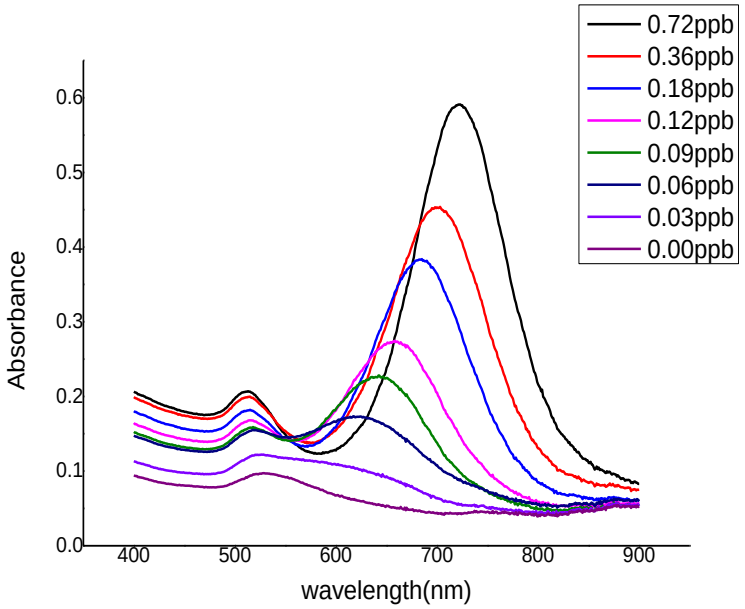
7.1 Detection of AFB1

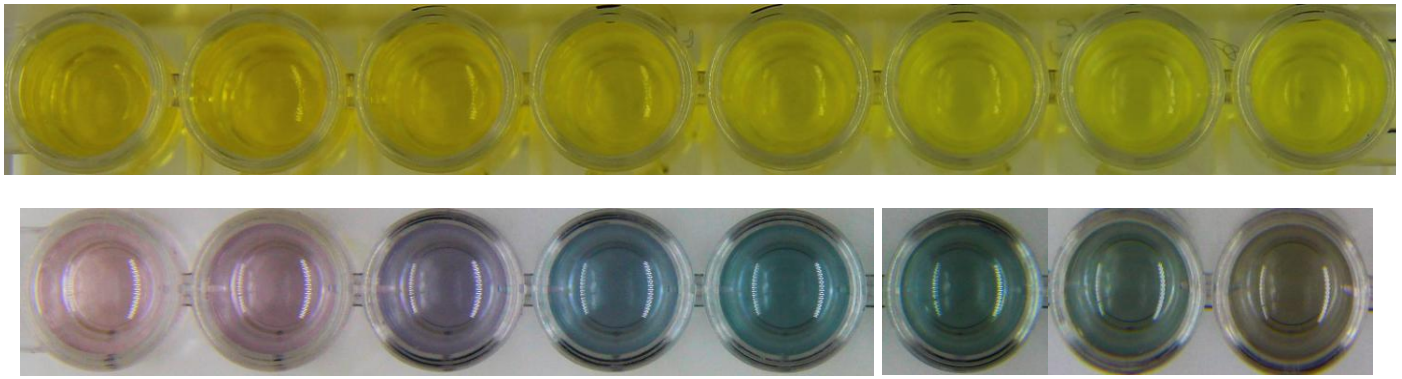


7.1 Detection of AFB1

Unpublished data



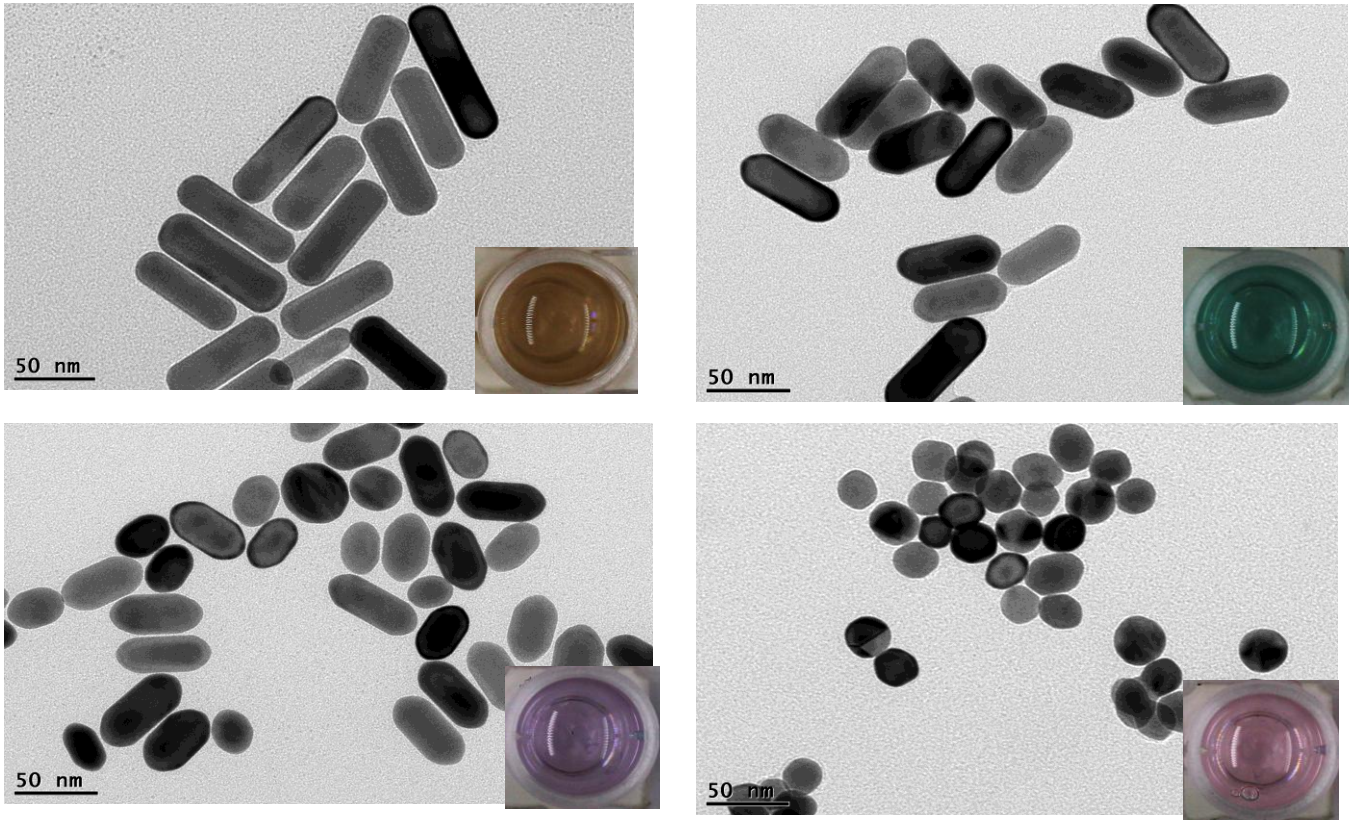




0.00ppb 0.03ppb 0.06ppb 0.09ppb 0.12ppb 0.18ppb 0.36ppb 0.72ppb

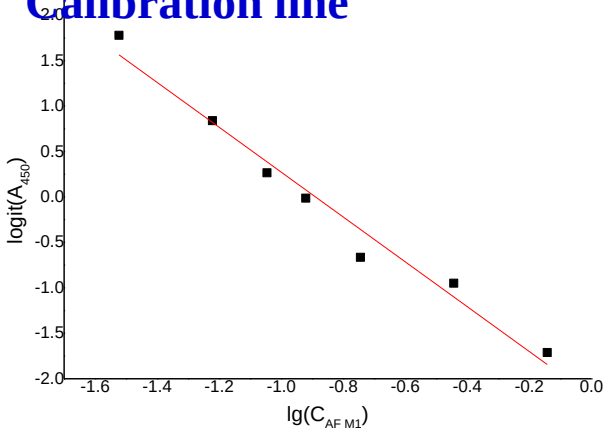
7.1 Detection of AFB1

Mechanism of multi-color



Application in Real Samples

Calibration line

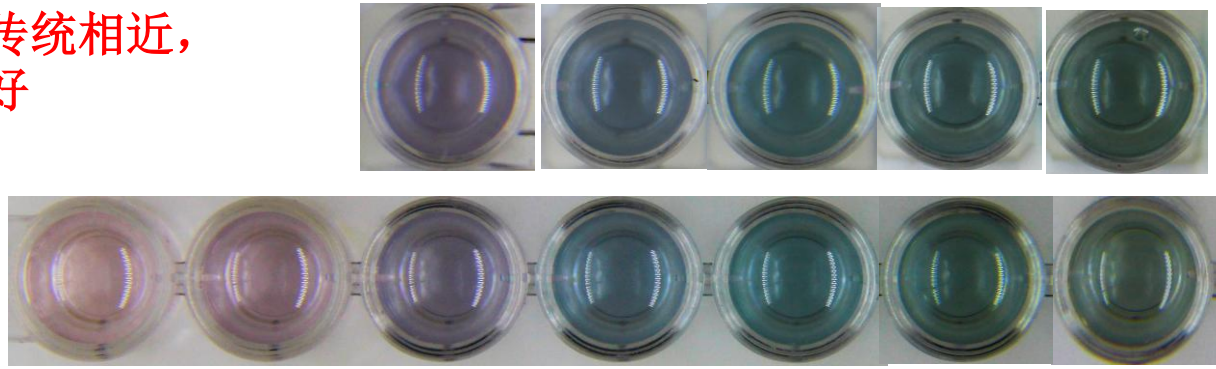


Comparison of ELISA and MELISA

样品	吸光度值（450nm)	$C_{AFM1}/2$（ppb)
伊利纯牛奶	1.188702	0.097871
蒙牛纯牛奶	1.420214	0.062452
酸奶	0.96818	0.145891
奶粉	1.081538	0.11893
营养快线	0.928056	0.156905

与传统相比可产生比较多的颜色实现可视化，且测量结果与传统相近，说明准确度较好

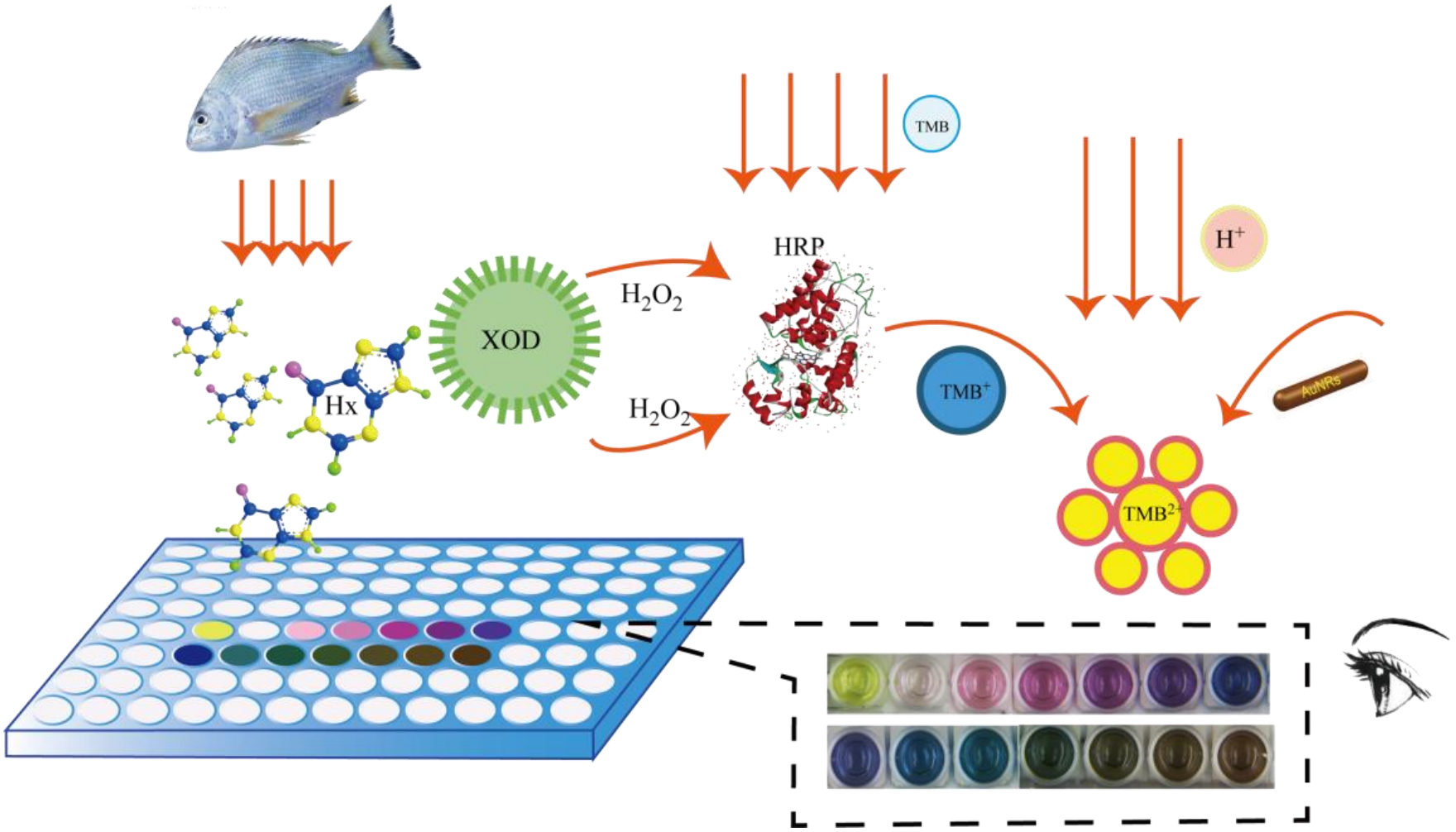
1 2 3 4 5



0.00ppb 0.03ppb 0.06ppb 0.09ppb 0.12ppb 0.18ppb 0.36ppb 0.72ppb

Application in Real Sample

Visual ELISA for detection of freshness of Fish-Hypoxanthine



Application in Real Sample

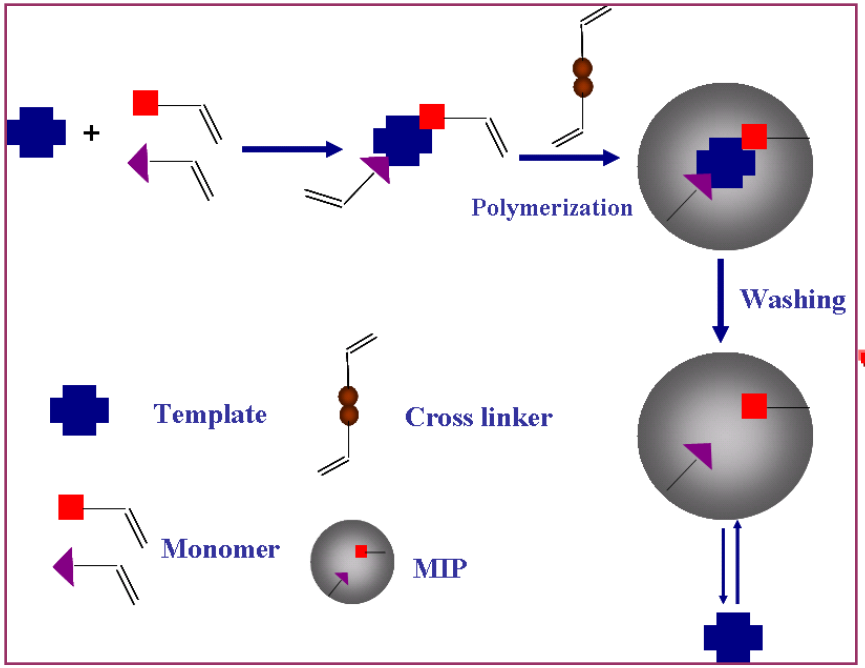
Visual ELISA for detection of freshness of Fish-Hypoxanthine

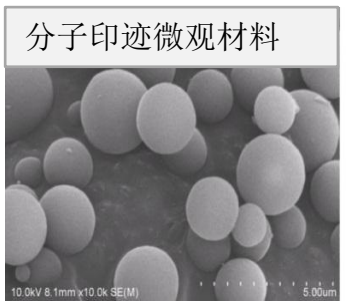
样品	溶液颜色	Hx(mM)		
		计算值	可视化所得	新鲜度
鲅鱼		0.2768	0.15~0.3	新鲜
银鱼		0.3321	0.3~0.4	新鲜

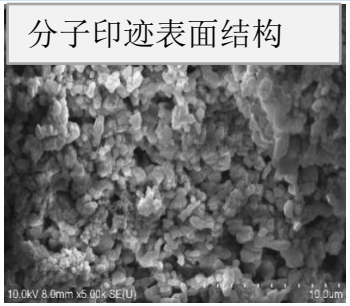
样品	溶液颜色	Hx(mM)		
		计算值	可视化所得	新鲜度
鲅鱼		0.7160	0.7~0.8	次新鲜
银鱼		0.8436	0.8~1.0	腐烂

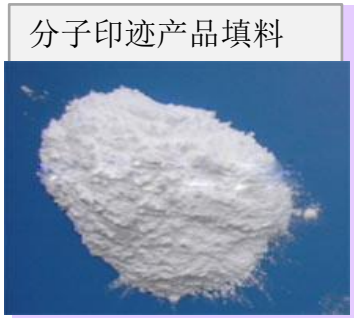
Progress

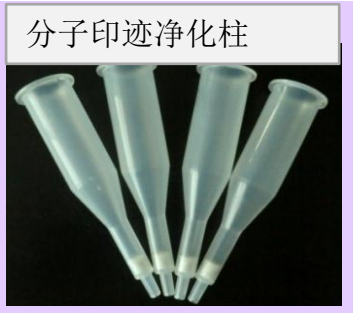
1. MIP materials for sample preparation

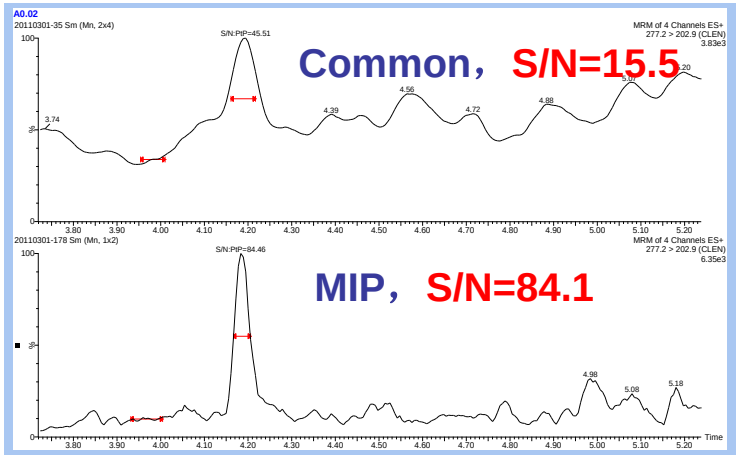












Wang and Su et al. Food Chem. 2015

Wang and Su et al. J. Sep. Sci. 2013

Wang and Su et al. Anal. Lett. 2012

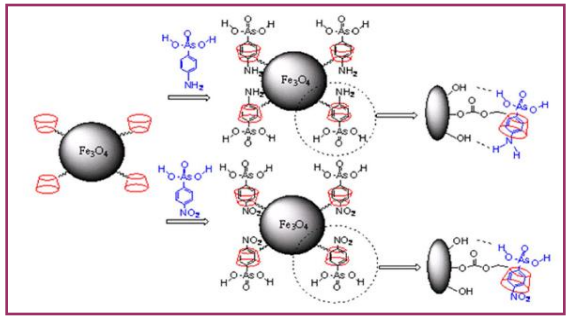
Wang and Su et al. Chin. J. Anal. Chem. 2007 and 2012

Wang and Su et al. Analyst 2016

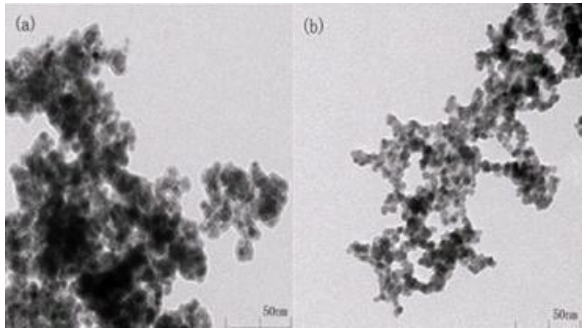
Progress

2.Host-guest recognition materials

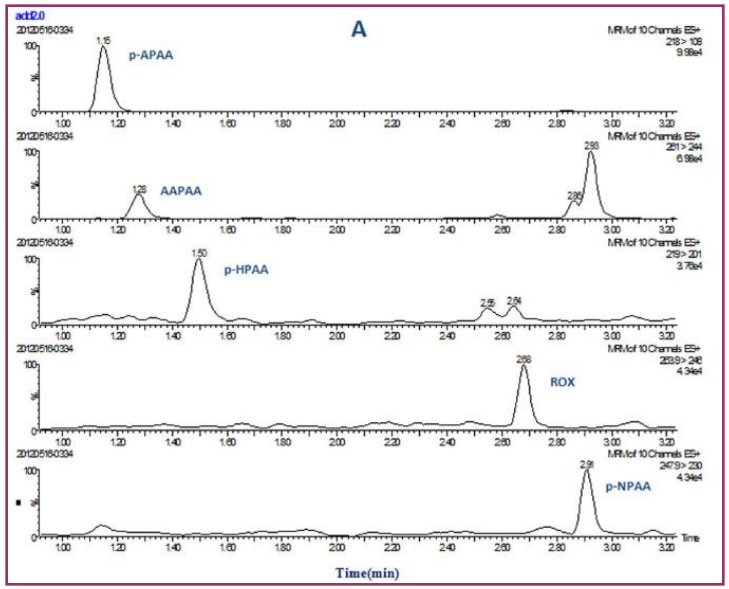
Alpha-cyclodextrin was used as recognition elements, the Alpha-cyclodextrin was modified on the magnetic beads.



▲Schematic of magnetic beads



▲ TEM of magnetic beads



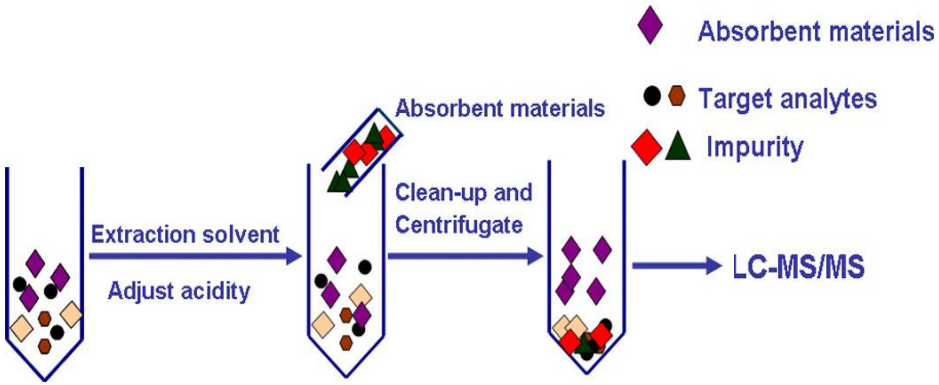
▲ Chromatogram of organic arsenic with LC-MS/MS

Jia and Wang et al.PLOS one 2014

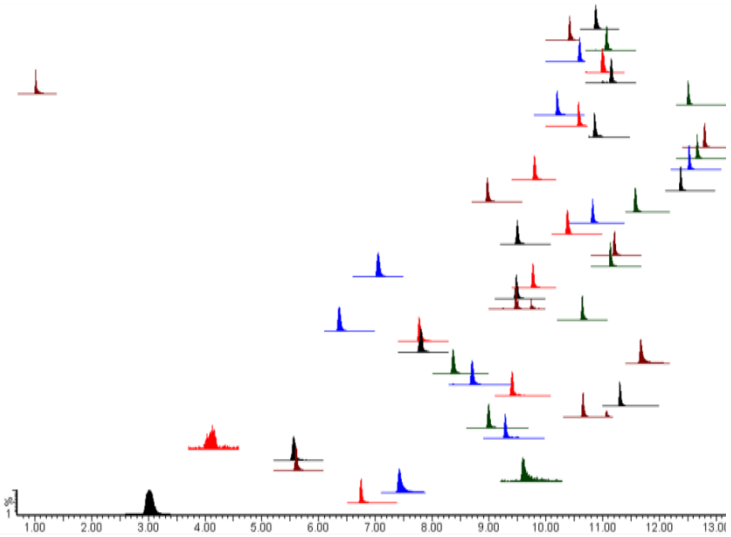
Progress

3.Multi-functional impurity adsorption (MFIA)

For the purpose of multi-class detection of target analytes, the MFIA clean-up method has been developed with C18, PAX and carbon nano tube. The method has been applied into detection of beta-agonists, mycotoxin, sadetives and sulfa-drugs. ***Wang and Su. Journal of Chromatography B, 2014,947-948,192。***



▲ Schematic of MFIA

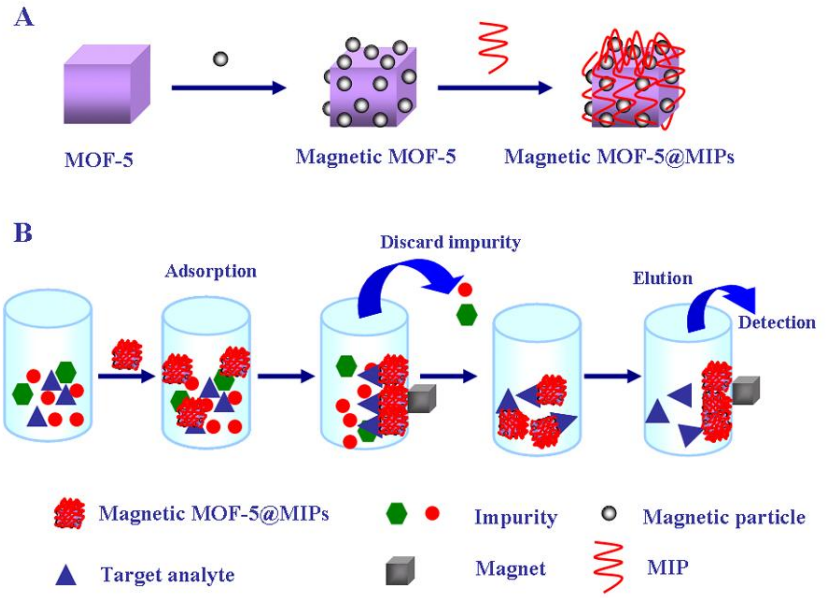


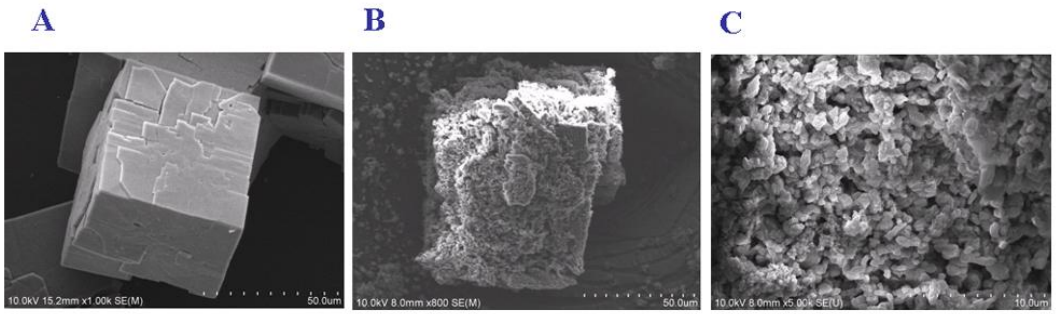
▲ Clean-up results of MFIA

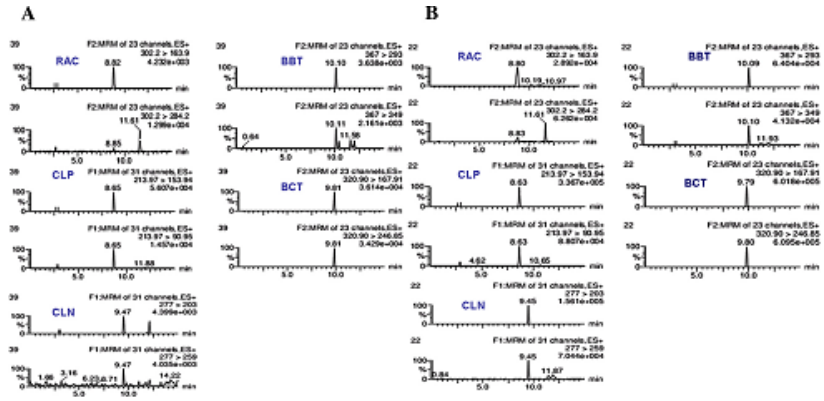
Progress

4.M-MOFs@MIP sample preparation

Well defined structure；
Large specific area；
Clean-up effects；
Convenient operation。







Conclusions

- **Some novel sensor based on nano materials for food safety has been developed.**
- **The developed sensing methods possess some advantages such as high sensitivity, robust and achieved quantification results and so on.**
- **Novel recognition materials present great promising application in food safety.**

Acknowledgement

- Professor Su, the leader of innovation team；
- Financial support by Special project of agriculture；
- Prof. Zhiyong Tang, Prof. Zhenyu Lin and Prof. Yujian He；
- Students：Feiyang, Rinan Wang, Bibai Du and Yue Tan and so on.

谢谢
敬请批评指正！

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