生活化學

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化學是一門研究物質的性質、組成、結構、及變化規律的基礎自然科學。化學研究的對象涉及物質之間的相互關係，或物質和能量之間的關係。

例如: 碳氫氧三種原子可結合成許多不同性質的化合物。
固體於水中的溶解度?吸熱或放熱?

化學是一門貼近生活的科學。
例如: 藥物、清潔劑、塑膠等等

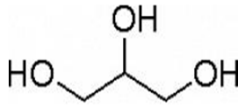
生活中的化學

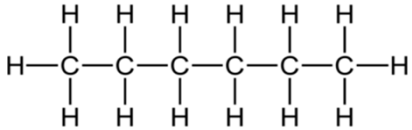
1.溶液的性質
2.酸(Acid)與鹼(Base)
3.沉澱反應
4.氧化還原反應
5.界面活性劑
6.感測器
7.綠色化學

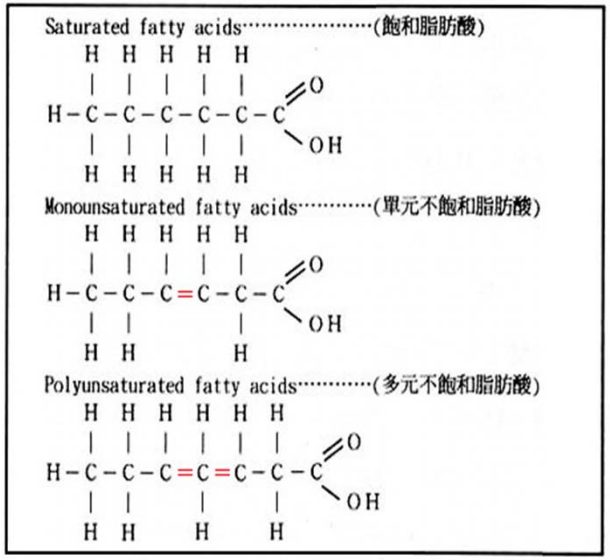
極性溶液: Hydrophilic solvent
非極性溶液: Hydrophobic solvent

Like-dissolve-like

H_2O





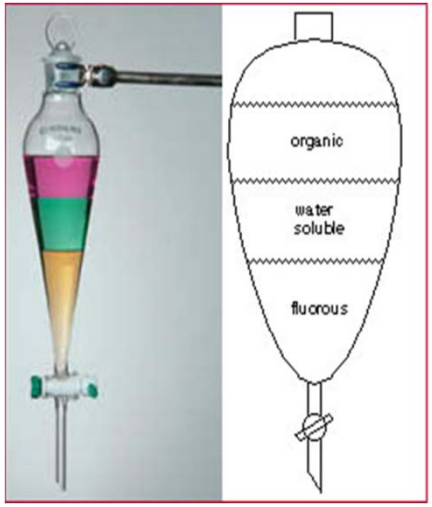


萃取: 濃縮和減少基質干擾

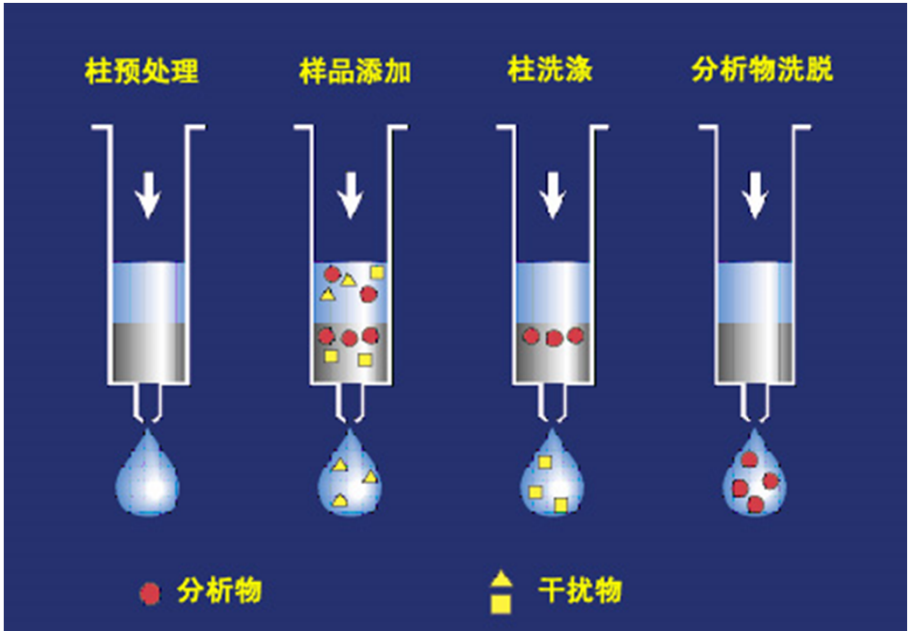
液相萃取

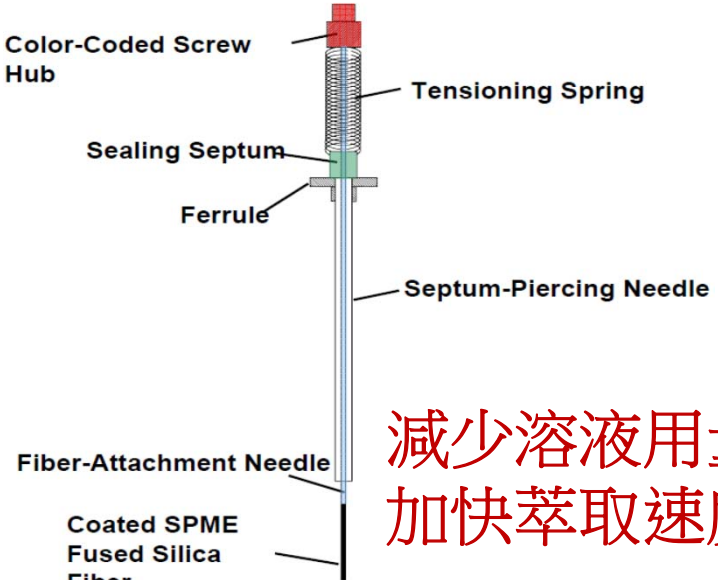
固相萃取

超流體萃取



微萃取光纖

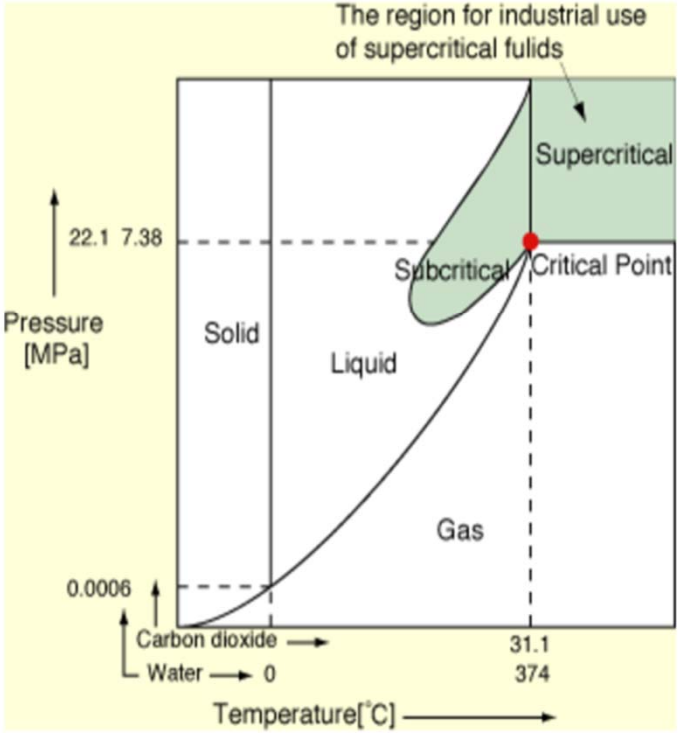




減少溶液用量

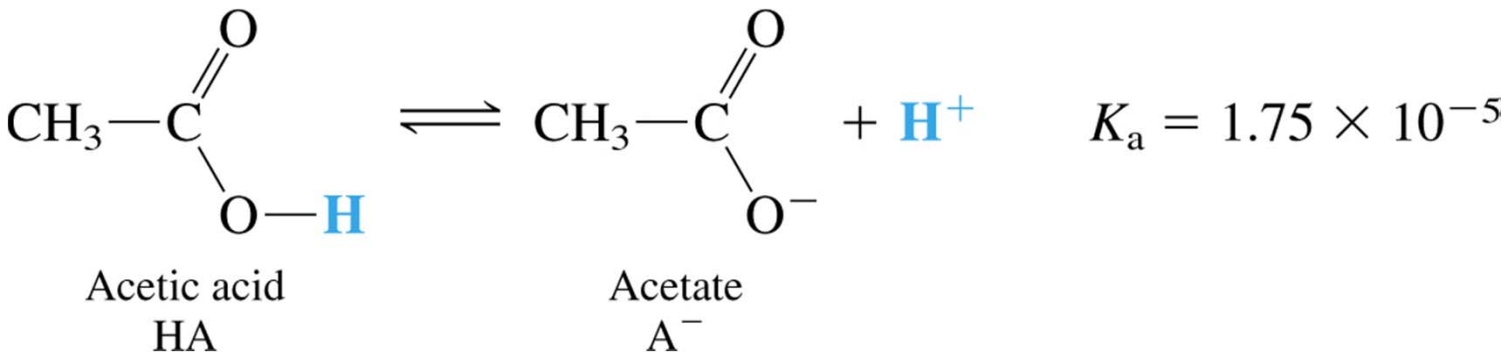
加快萃取速度

Supercritical Fluid Extraction

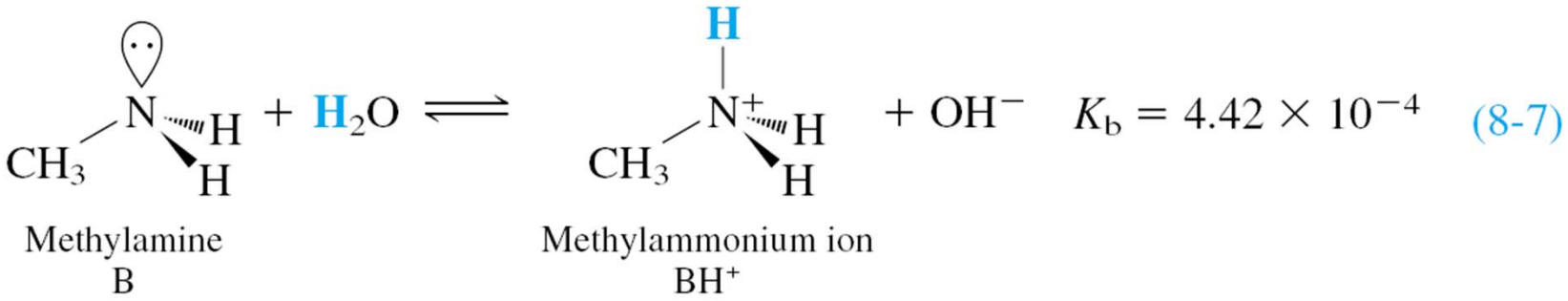


CO_2超流體從咖啡中萃取咖啡因

酸: 解離



鹼: 水解



弱酸的共軛鹼是強鹼嗎?

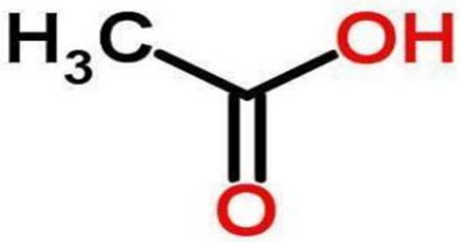
隨著有機酸碳鏈增長，
那些性質會改變?

CH_3COOH
CH_3CH_2COOH
$CH_3(CH_2)_4COOH$
$CH_3(CH_2)_{10}COOH$
$CH_3(CH_2)_{16}COOH$

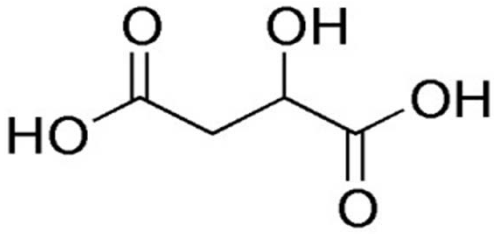
碳鏈越長:

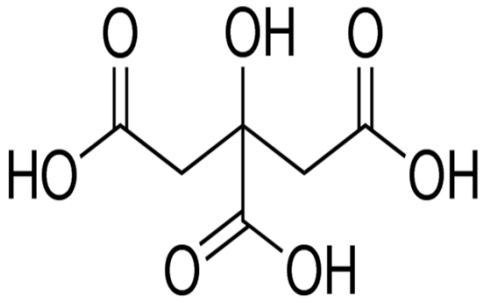
水溶性越差
分子作用力增加
揮發性遞減 (固體性質增加)

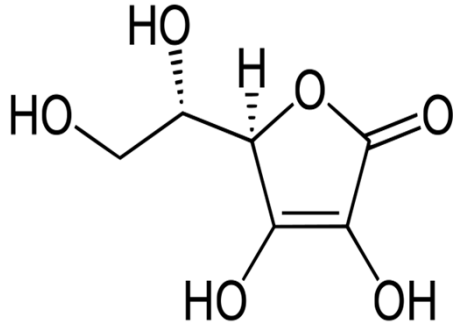
如何增加油水互溶性?


H3C
OH
O

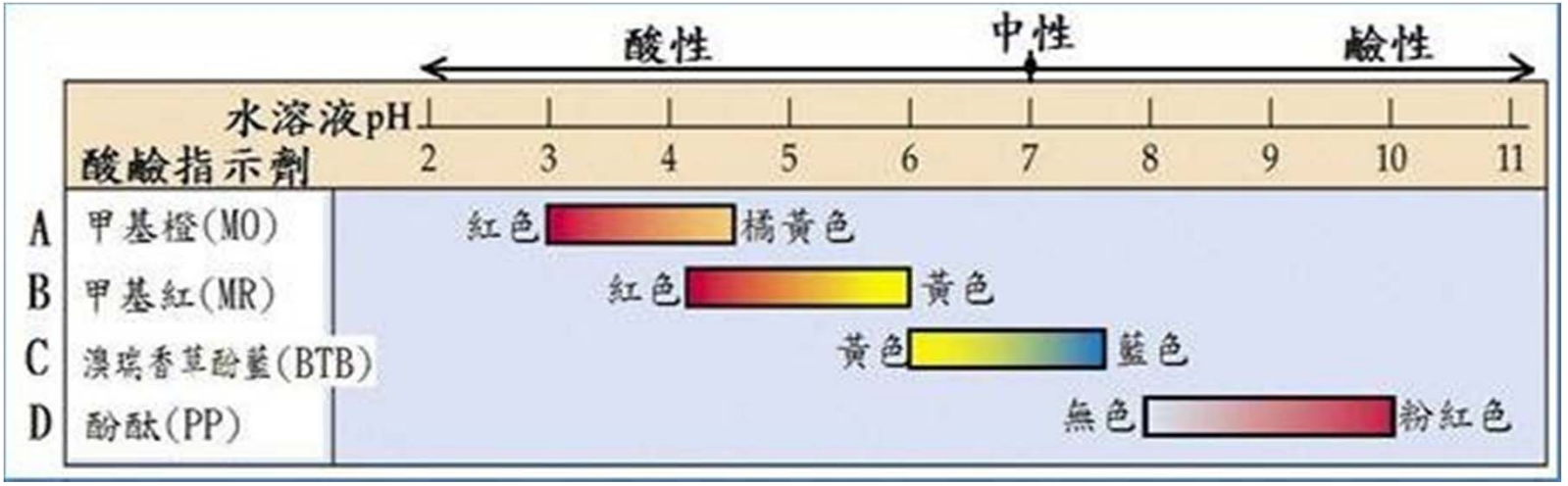

白醋


O
OH
HO
OH
O


O
OH
O
HO
OH
O
OH

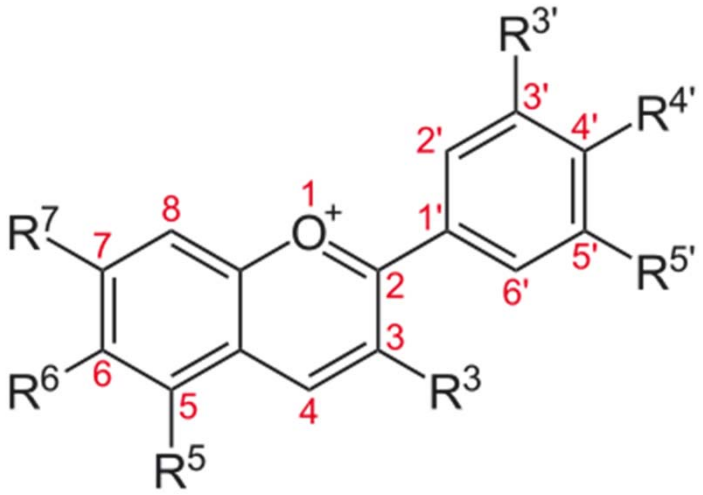

HO
H
O
HO
O
HO
OH

酸鹼指示劑



$pK_1 = 2.00$ $pK_2 = 8.00$

H_2In	HIn^-	In^{2-}
紅	黃	紅
$\lambda_{max} = 520nm$	$\lambda_{max} = 435nm$	$\lambda_{max} = 572nm$
$\varepsilon_{520} = 5.00 \times 10^4\ (cm^{-1}M^{-1})$	$\varepsilon_{520} = 2.00 \times 10^3$	$\varepsilon_{520} = 2.50 \times 10^4$
$\varepsilon_{435} = 1.50 \times 10^4$	$\varepsilon_{435} = 1.80 \times 10^4$	$\varepsilon_{435} = 1.20 \times 10^5$
$\varepsilon_{572} = 2.00 \times 10^4$	$\varepsilon_{572} = 2.00 \times 10^3$	$\varepsilon_{572} = 5.00 \times 10^4$



天然指示劑	紫甘藍	紅鳳菜	牽牛花	石蕊地衣
酸	紅	紅	紅	紅
鹼	黃	黃	藍	藍

當土壤偏酸性pH值5至5.5以下時，土壤中的金屬離子會與植物中的色素結合，使花萼呈現藍紫色；土壤酸鹼值為pH6至6.5時，則會降低鋁離子的有效性，花萼則為粉紅色或紅色。

沉澱反應

$$Ag^{+} + Cl^{-} \longrightarrow AgCl$$

$$Pb^{2+} + CrO_4^{2-} \longrightarrow PbCrO_4$$

$$Fe^{3+} + 3(OH)^{-} \longrightarrow Fe(OH)_3$$

$$3Ca^{2+} + 2PO_4^{3-} \longrightarrow Ca_3(PO_4)_2$$

Solubility product (K_{sp}): 溶解度越小，溶解度越差

沉澱的應用?
氨水為何可除鐵鏽?
銀針試毒的根據何在?

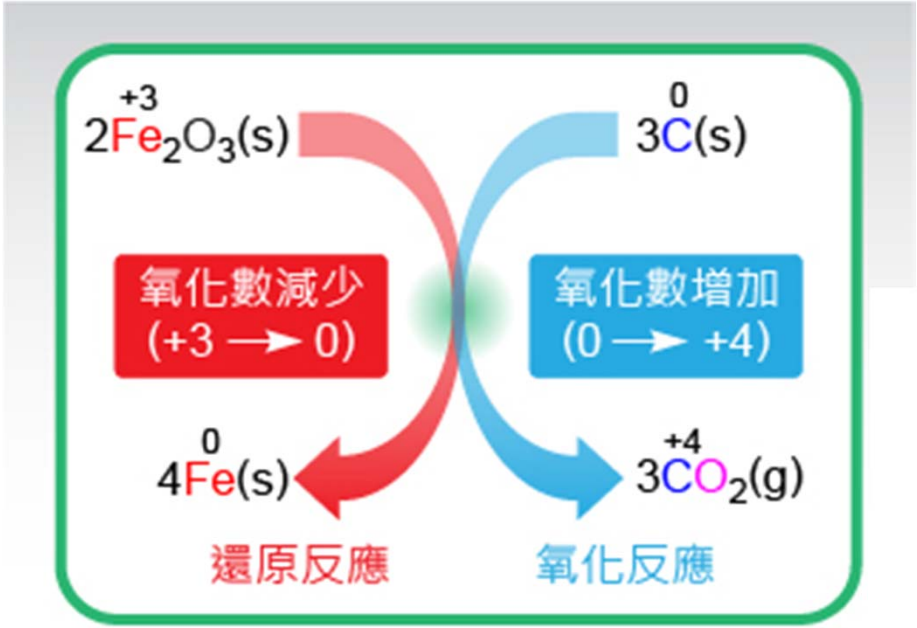
Ag_2S

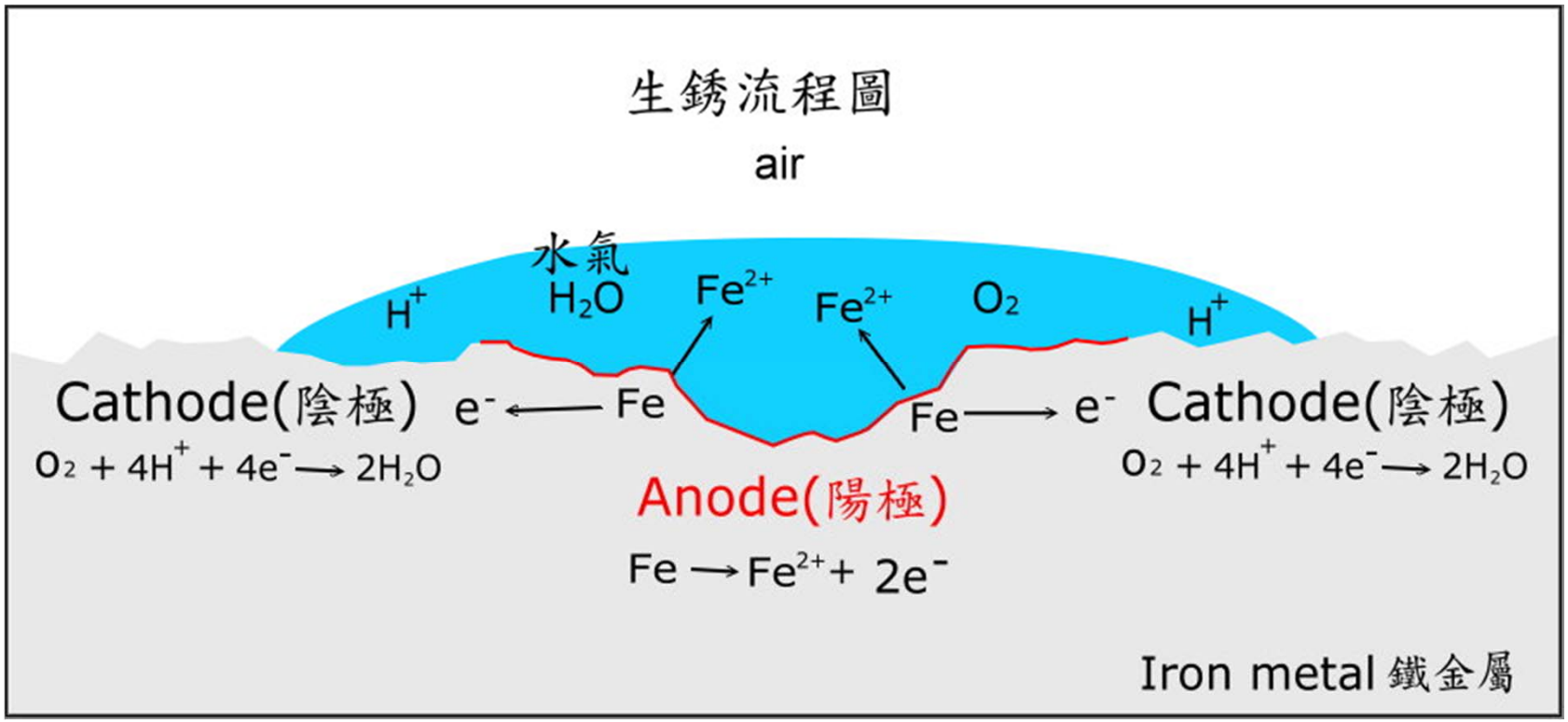
CdS

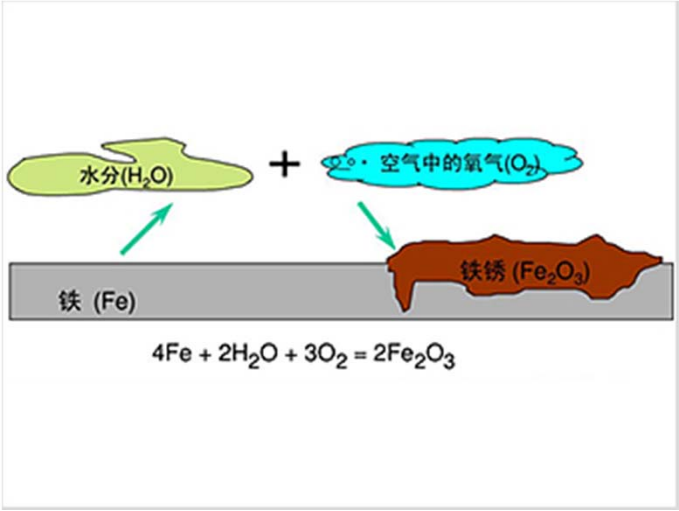
HgS

砒霜(白色霜狀粉末): 三氧化二砷，分子式 As_2O_3。古時砒霜不純，常含有硫化物。砒霜中會混有大量的硫或硫化物，呈現紅色，故又稱「鶴頂紅」

氧化反應: 失去電子的反應
還原反應: 獲得電子的反應




生銹流程圖
air
水氣
H_2O
H^+
Fe^{2+}
Fe^{2+}
O_2
H^+
Cathode(陰極)
e^-
Fe
Fe
e^-
Cathode(陰極)
$O_2 + 4H^+ + 4e^- \rightarrow 2H_2O$
$O_2 + 4H^+ + 4e^- \rightarrow 2H_2O$
Anode(陽極)
$Fe \rightarrow Fe^{2+} + 2e^-$
Iron metal 鐵金屬


水分(H_2O)
+
空气中的氧气(O_2)
铁锈 (Fe_2O_3)
铁 (Fe)
$4Fe + 2H_2O + 3O_2 = 2Fe_2O_3$

防止鐵生鏽?

隔絕空氣

避水

?

防止鐵製品生鏽

1. 在鐵製品表面覆蓋保護層如油漆等: 防鏽漆容易受外在環境影響剝落。

2. 表面覆蓋比鐵更容易氧化的物質(如鋅和鎂): 把鋼材表面直接「包膜」，裹上一層鋅，防鏽更持久。利用攝氏**400~500**度高溫把鋅溶成液態，把鋼材浸入，冷卻後就成了鍍鋅防鏽膜。鋅的氧化電位比鋼鐵高，碰到水汽、鹽分（氯離子），鋅會為鋼鐵「犧牲」，逐漸氧化消失不見，直到露出鋼材為止。因此，一般鍍鋅防鏽層的厚度約**85~100 μm**。

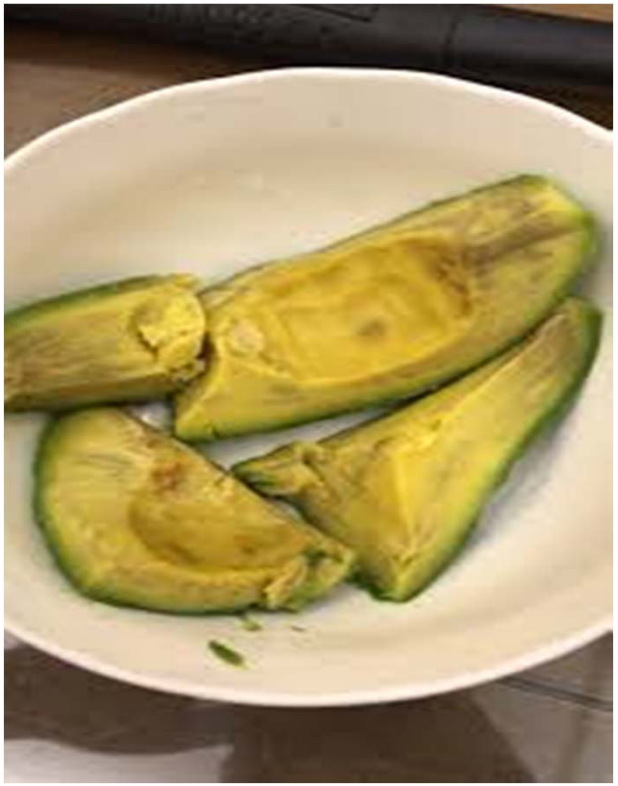
3. 合金

鋼（**Steels**): 鐵－碳合金，除了含有碳元素外，亦可進一步包含微量其它合金元素。

低碳鋼 **(C <0.25%)**、中碳鋼**(C <0.60%)** 、高碳鐵**(C <1.40%)**和不銹鋼。

不銹鋼: 具有良好的抗蝕性（生銹）。主要添加的合金元素是鉻，其濃度至少需11wt%鉻以上，藉著添加鎳、鉬或銅可強化抗蝕性


微信号: ludouec

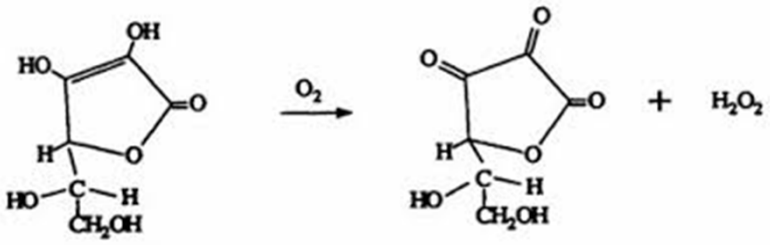


水果去皮後，果肉會直接接觸氧氣，在氧的作用下，水果中含有的「兒茶酚等酚類」物質，會和另一種物質「多酚氧化酶」，發生「酶促褐變反應」，形成「黑色素」，也就是我們常說的水果變色。

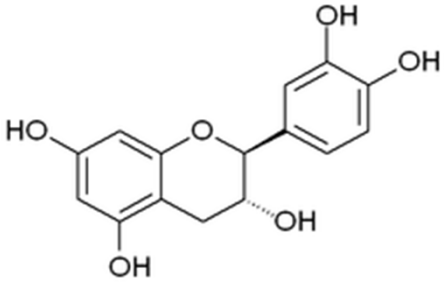
泡水或鹽水

水果包上保鮮膜

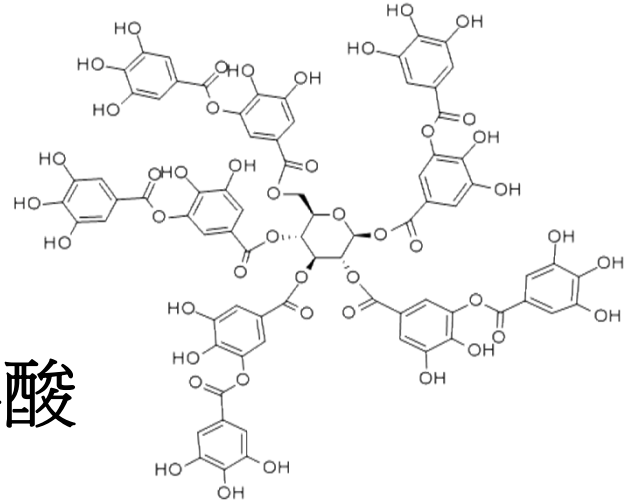
添加天然還原劑:滴幾滴富含檸檬酸和維他命C的果汁



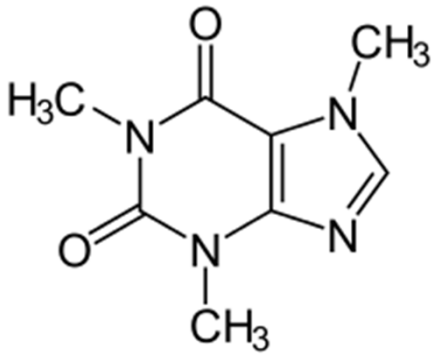
兒茶素成分具有抗氧化的效果



將茶持續泡在水裡，茶葉裡的單寧酸、咖啡因會一直釋出，使茶湯苦澀難入口，還有大量咖啡因，容易讓人心悸、胃不舒服。



單寧酸

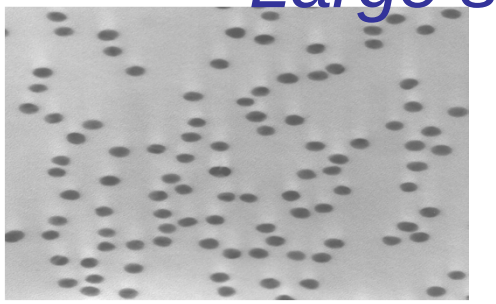


咖啡因

Nanomaterials-Gold and silver

Size effect

Large surface area

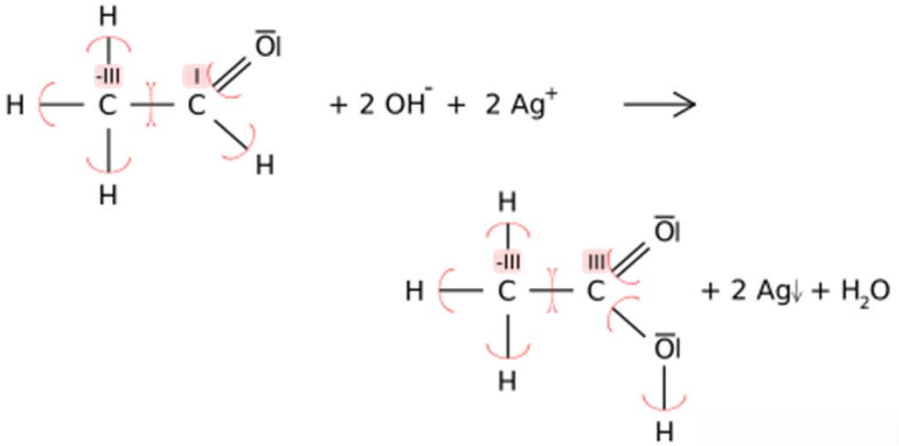


Unique optical, electric, and magnetic properties

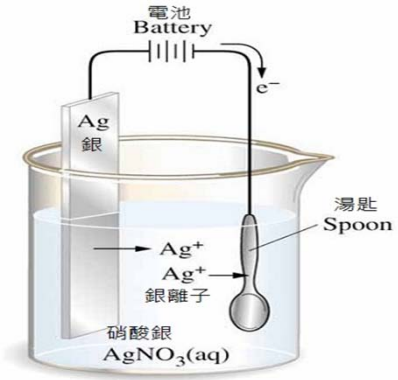
還原劑常用於合成金屬奈米粒子

鹼性條件下，糖還原銅離子形成銅奈米粒子
酸性條件下，檸檬酸還原金離子形成金奈米粒子

於氨水中，甲醛和銀離子的反應:



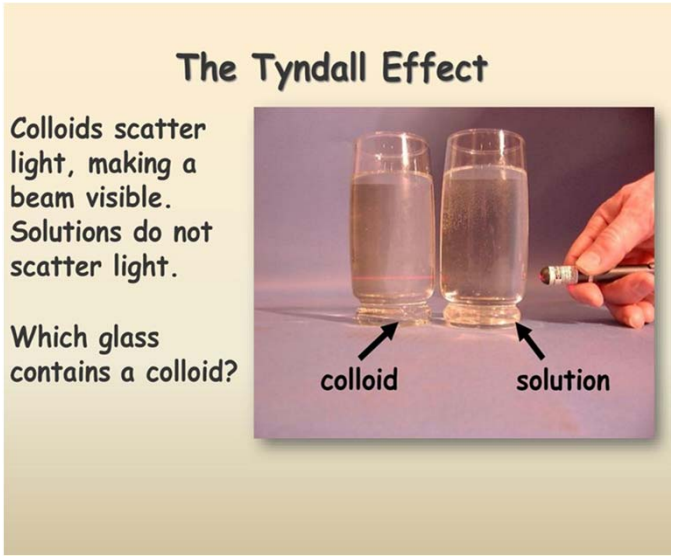
湯匙鍍銀，
為何需要氨水?

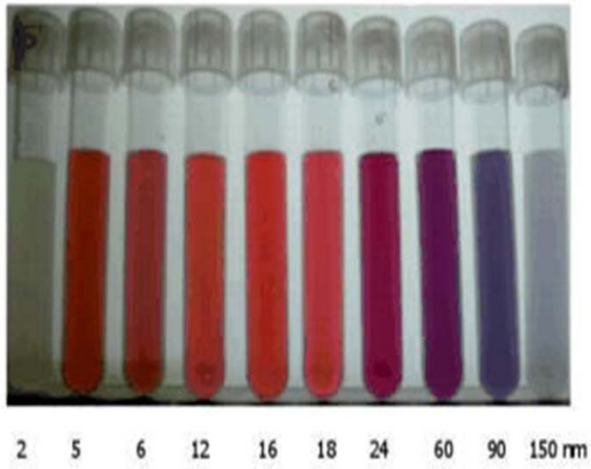


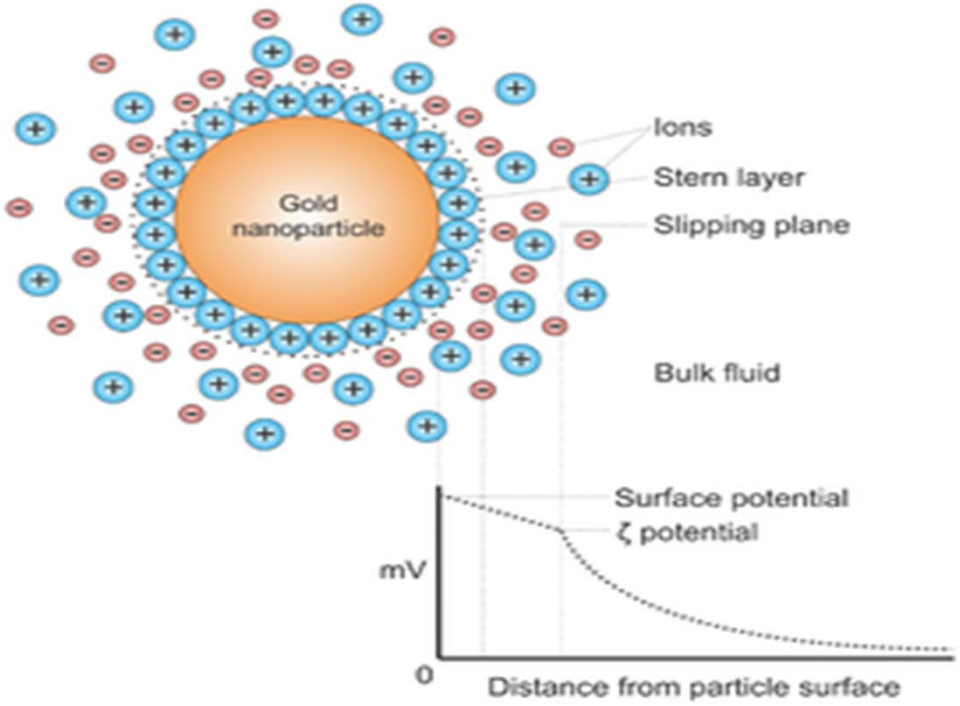
膠體 (colloid)和奈米粒子 (nanoparticles)

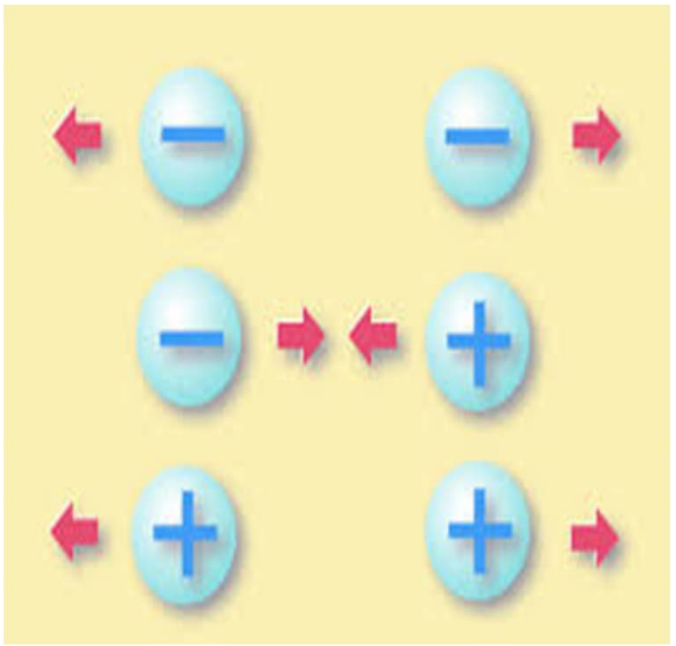
膠體 > 100 nm

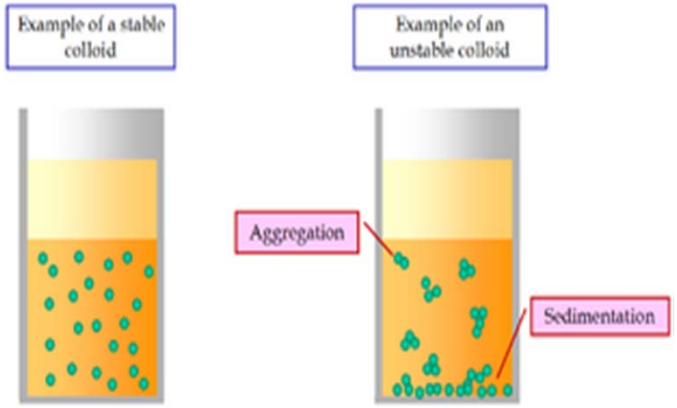
奈米粒子: 1-100 nm (10^{-9} m)






Gold nanoparticle
Ions
Stern layer
Slipping plane
Bulk fluid
Surface potential
ζ potential
mV
0
Distance from particle surface

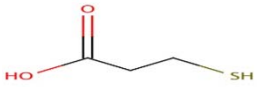


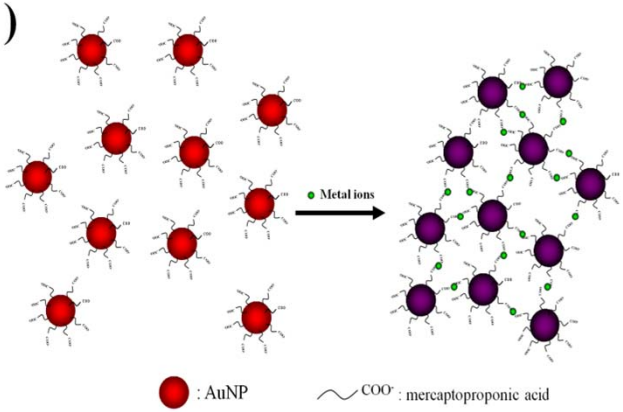

Example of a stable colloid
Example of an unstable colloid
Aggregation
Sedimentation

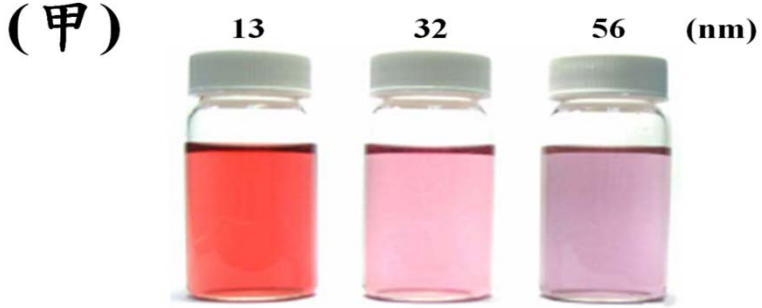
Sodium citrate

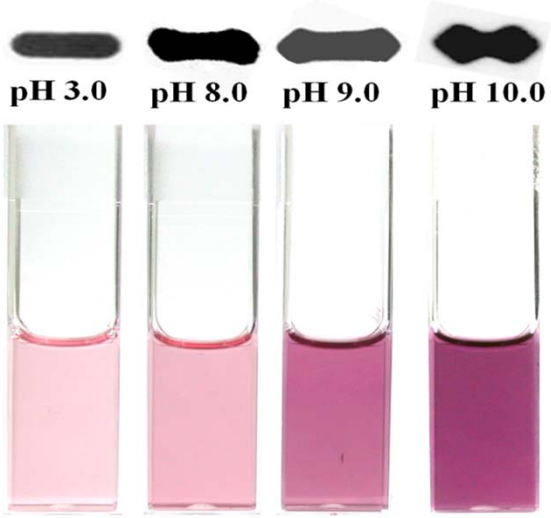
$HAuCl_4(aq) + Na_3C_6H_5O_7(aq)$ → Au NPs
$+ CO_2 + HCOOH + \ldots$

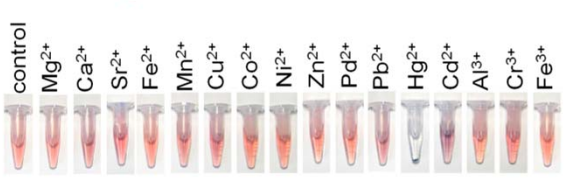
3-Mercaptopropionic acid

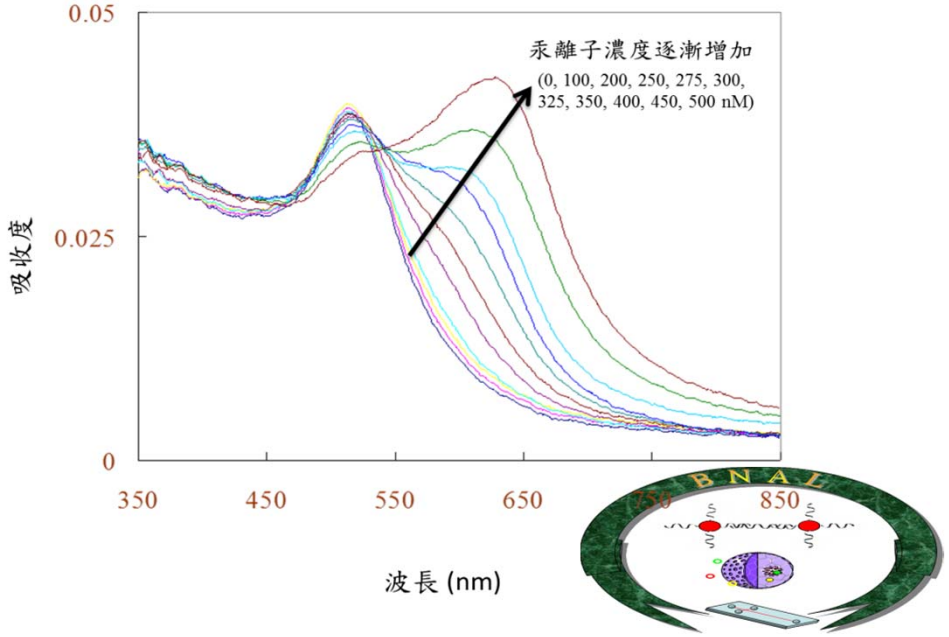








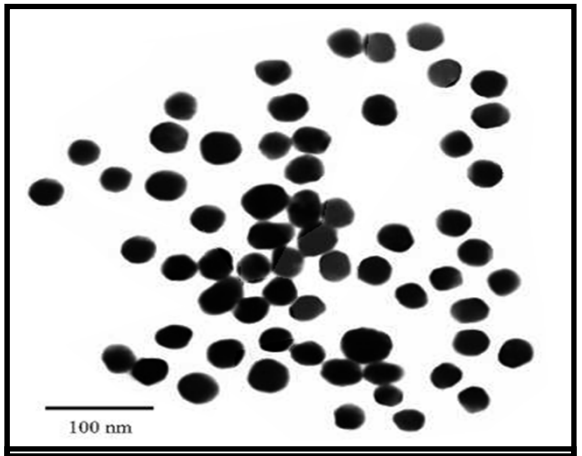


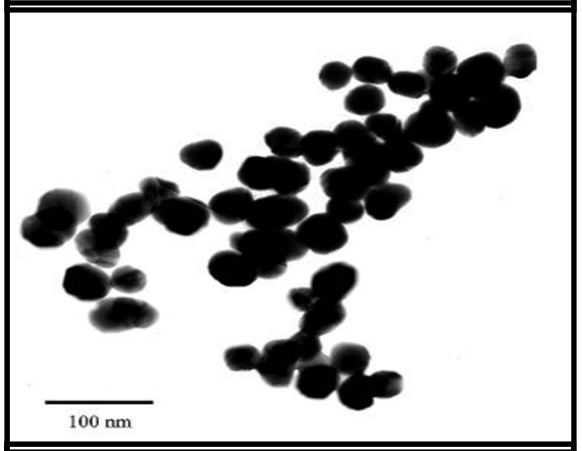


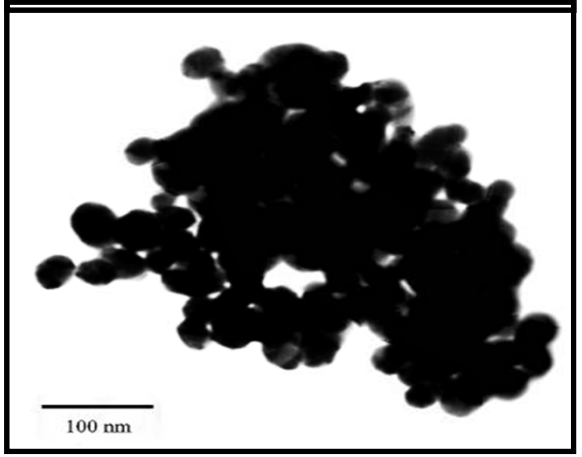
A. Negatively charged thiols

B. Neutral thiols

C. Positively charged thiols



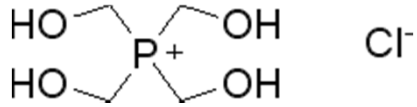




Preparation of 11-MUA-L_{AuND}

12 μL tetrakis(hydroxymethyl)phosphonium chloride (THPC) in 46 mL DI water

THPC



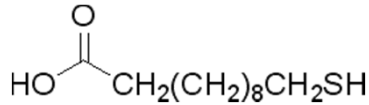
***Angew. Chem. Int. Ed.* 2007, *46*, 6824-6828.**

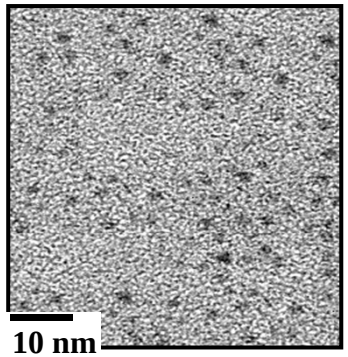
Add 0.5 N NaOH (1 mL)

1% hydrogen tetrachloroaurate(III) trihydrate ($HAuCl_4 \cdot 3H_2O$) 1.5 mL

Au NPs

11-MUA



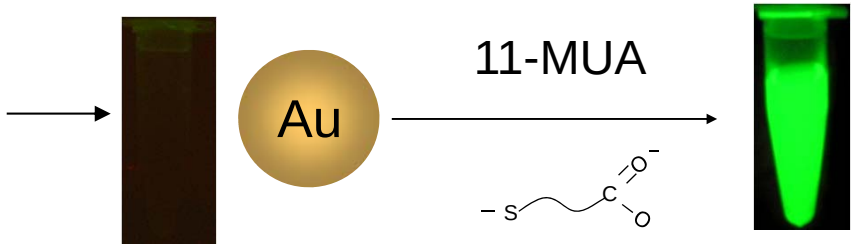


10 mM 11-mercaptoundecanoic acid (11-MUA)

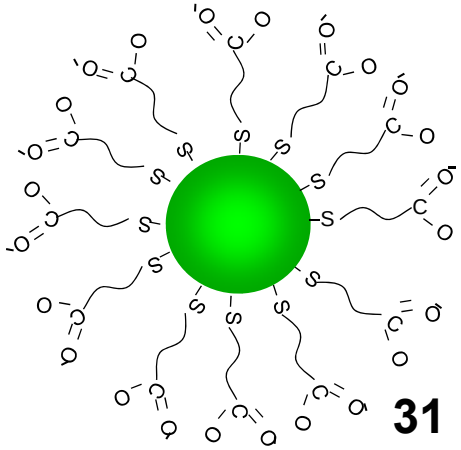
11-MUA-L_{AuND}

11-MUA-L_{AuND}

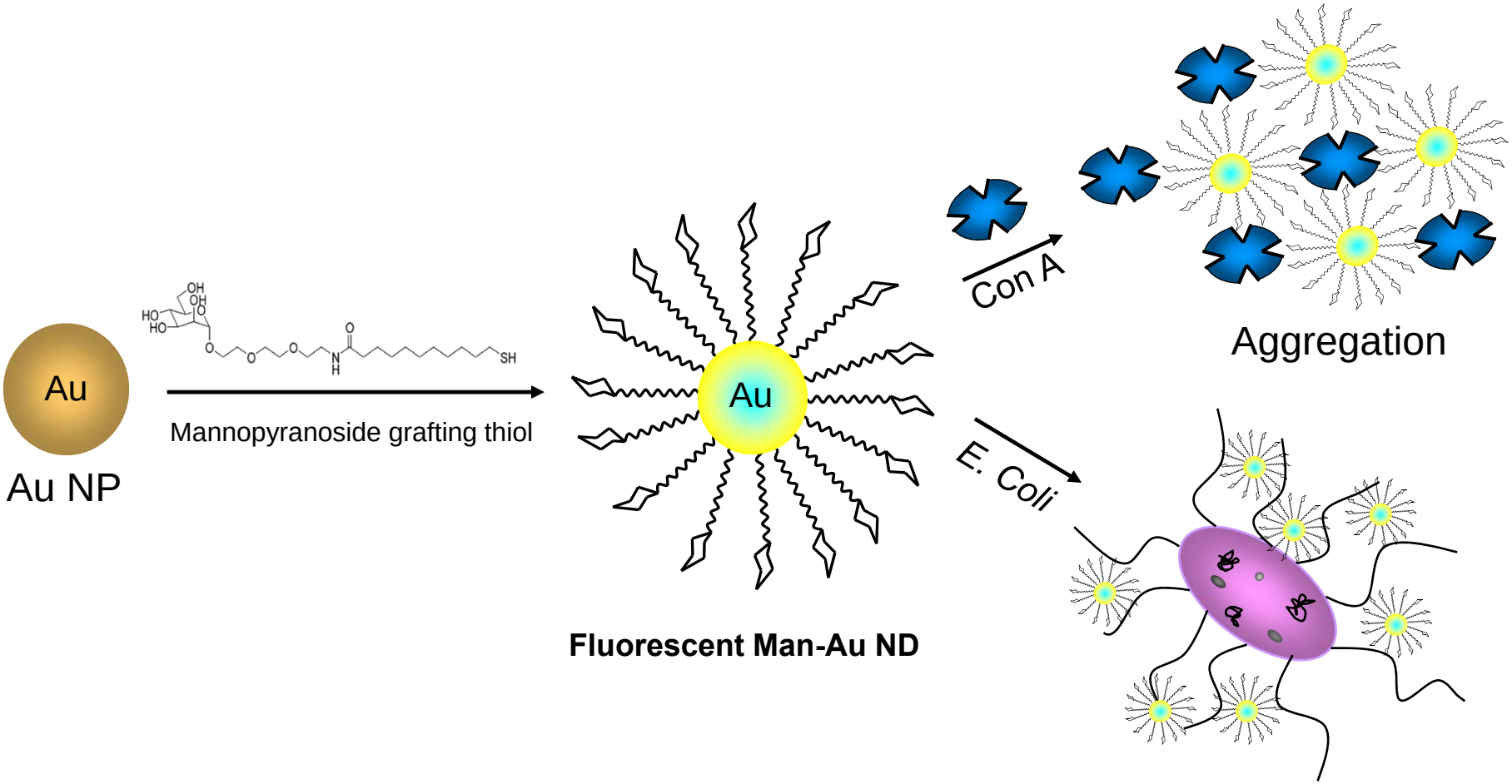
$P(CH_2OH)_4Cl$
(THPC, reducing agent)
+
$HAuCl_4$

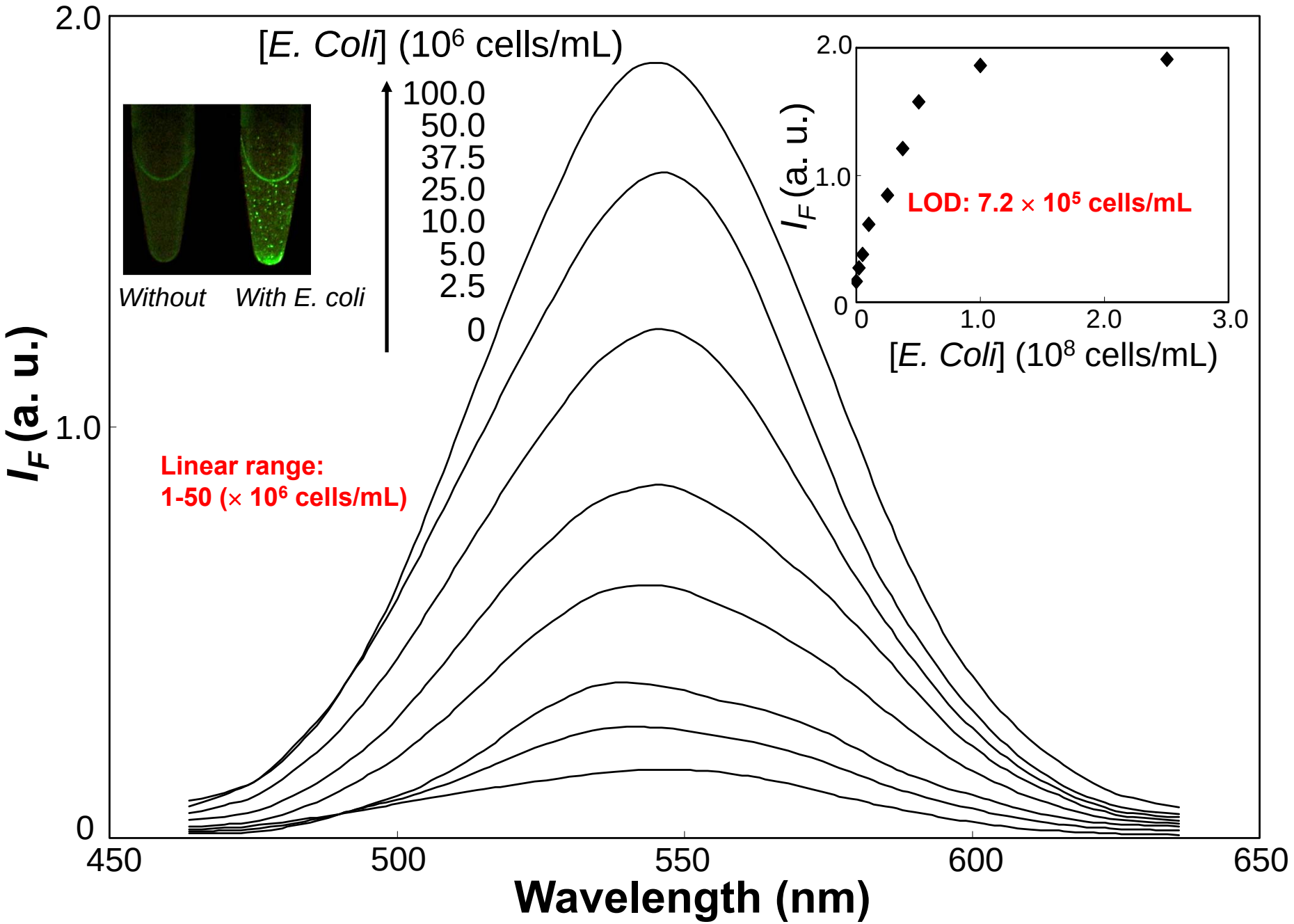


Au NP

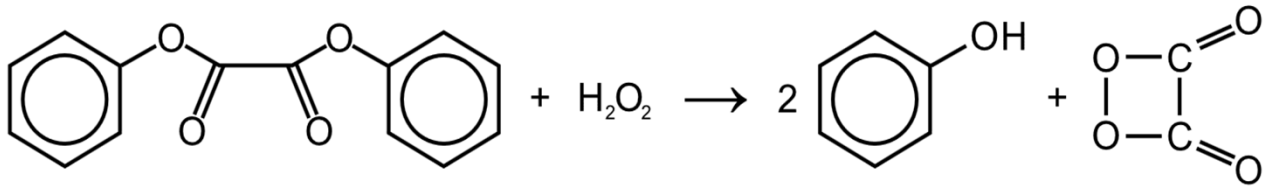


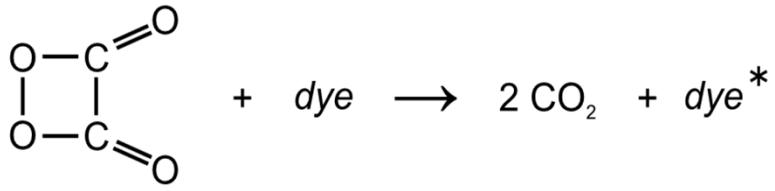
Synthesis of Fluorescent Carbohydrate-Protected Au Nanodots for Detection of Concanavalin A and *Escherichia coli*

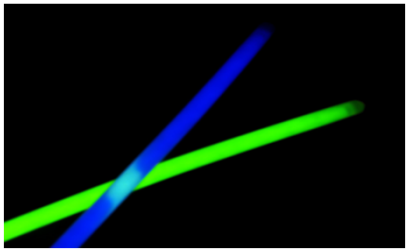



[E. Coli] (10^6 cells/mL)
100.0
50.0
37.5
25.0
10.0
5.0
2.5
0
Without
With E. coli
Linear range:
1-50 (× 10^6 cells/mL)
I_F (a. u.)
Wavelength (nm)
2.0
1.0
0
450
500
550
600
650
LOD: 7.2 × 10^5 cells/mL
[E. Coli] (10^8 cells/mL)
3.0

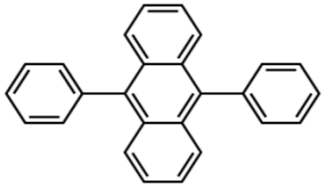
Glow stick contains two chemicals and a suitable dye (sensitizer, or fluorophor).



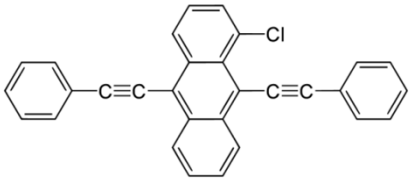




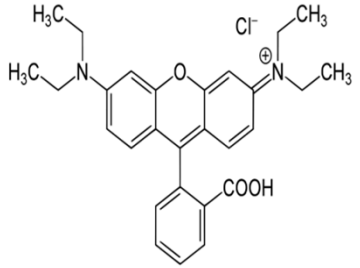
dye* ⟶ dye + hv



9,10-Diphenylanthracene (DPA) emits blue light



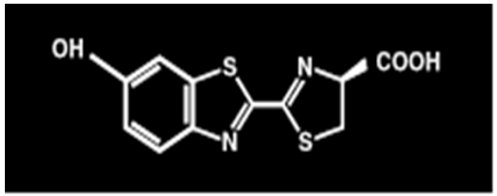
9,10-Bis(phenylethynyl)anthracene (BPEA) emits green light with maximum at 486 nm



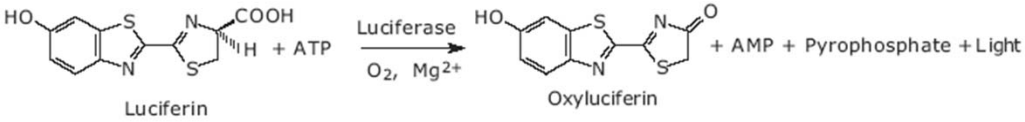
Rhodamine B emits red ligh

Bioluminescence

Firefly luciferin



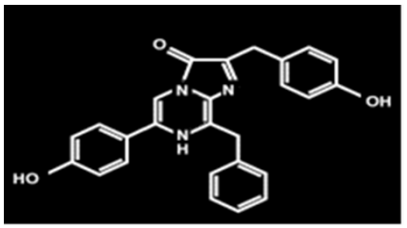
is used in a luciferin-luciferase system that requires ATP as a cofactor.



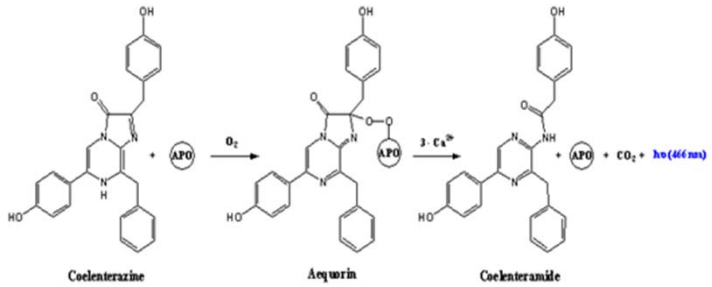
Photuris pennsylvanica was measured to be 552 nm (green-yellow)

0.6 picograms of adenosine triphosphate (ATP) or 0.1 femtograms of luciferase

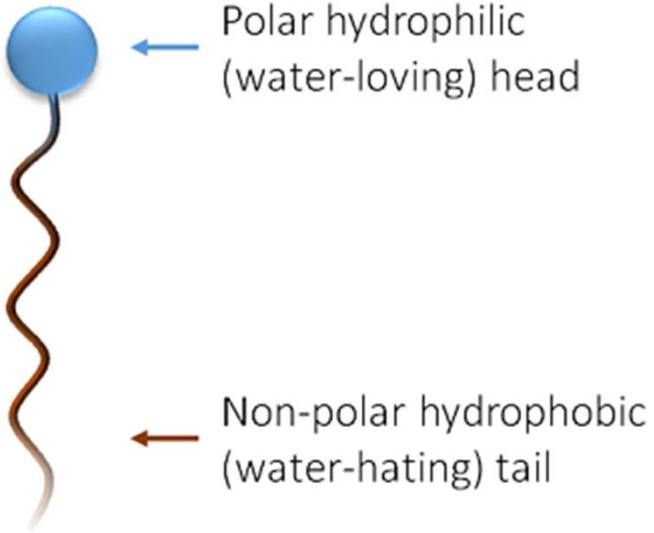
Coelenterazine

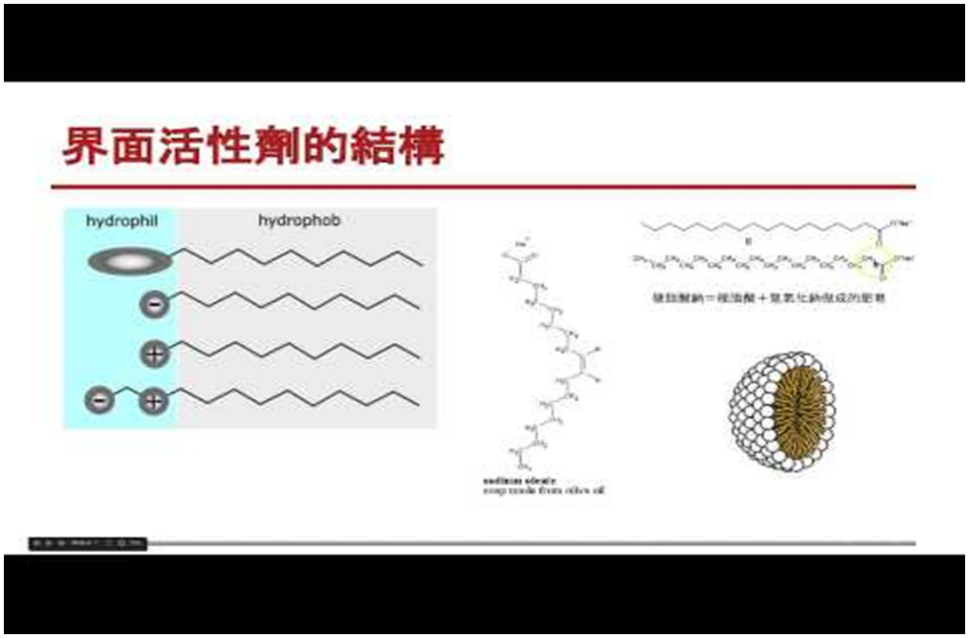


the most "popular" of the marine luciferins. This molecule can occur in luciferin-luciferase systems, and is famous for being the light emitter of the photoprotein "aequorin".

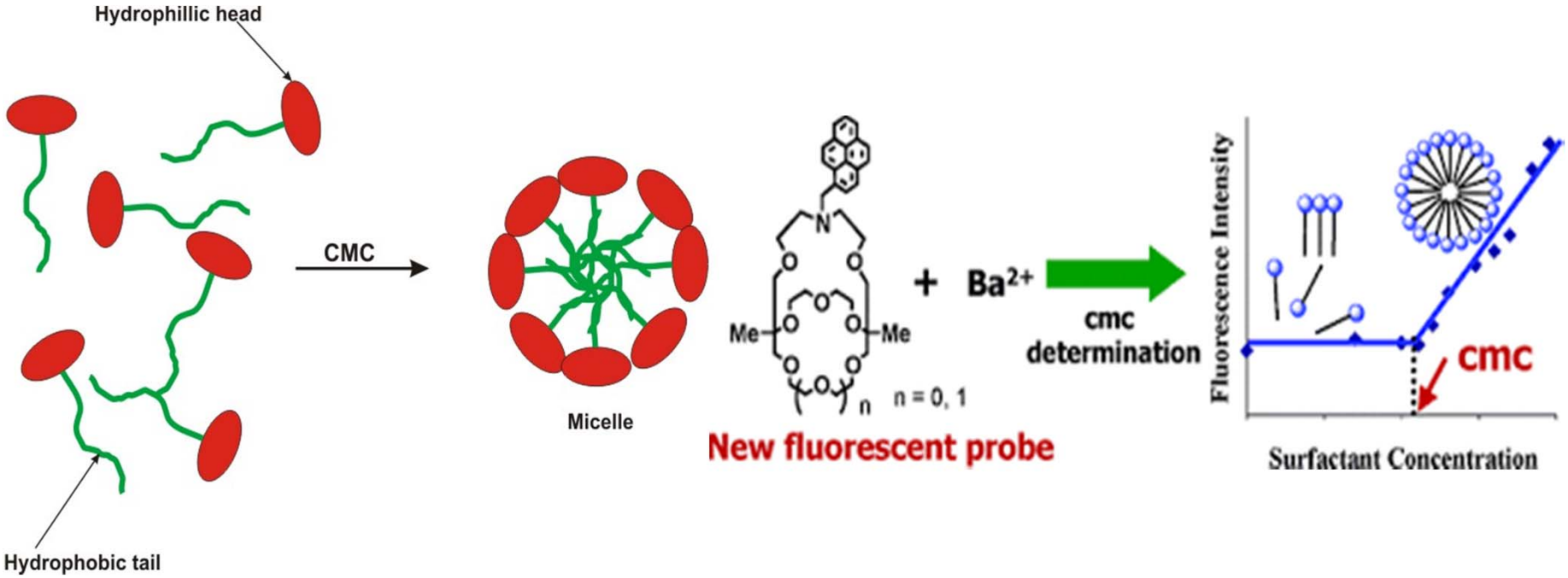


界面活性劑 (Surfactant):

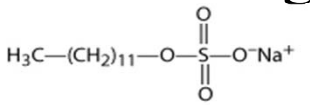




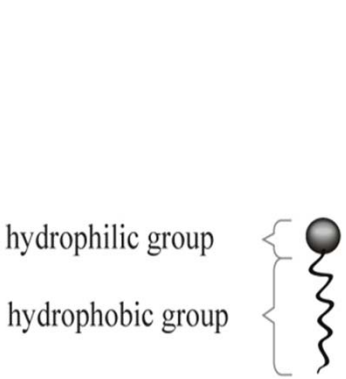
臨界微胞濃度（Critical micelle concentration；CMC），

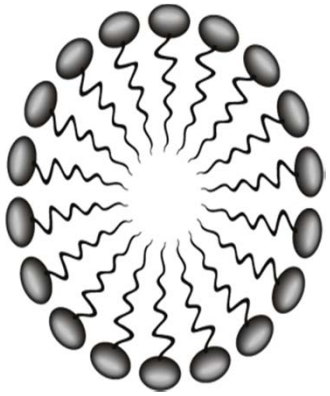


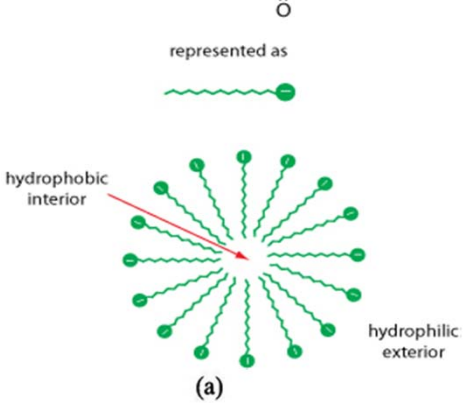
A **micelle** is an aggregate of surfactant molecules dispersed in a liquid colloid. In aqueous solution, aggregates are formed with the hydrophilic "head" regions in contact with surrounding solvent, sequestering the hydrophobic single-tail regions in the micelle center. This type of micelle is known as a normal-phase micelle (oil-in-water micelle) as shown in (a). Inverse micelles have the head groups at the center with the tails extending out (water-in-oil micelle) as shown in (b).

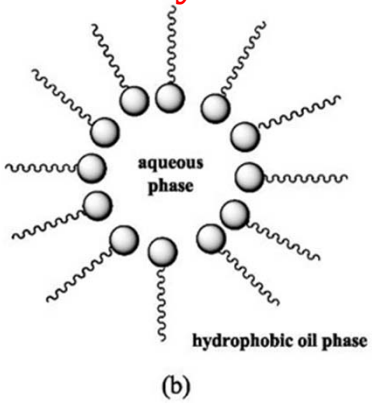


Sodium dodecyl sulfate (SDS)

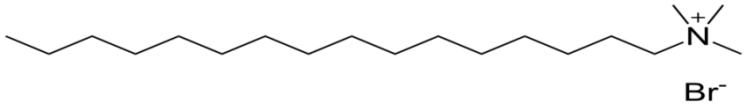


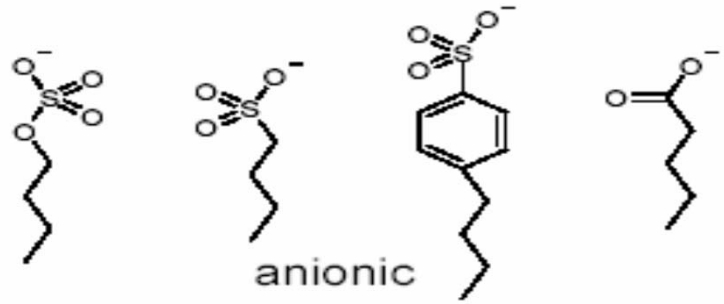


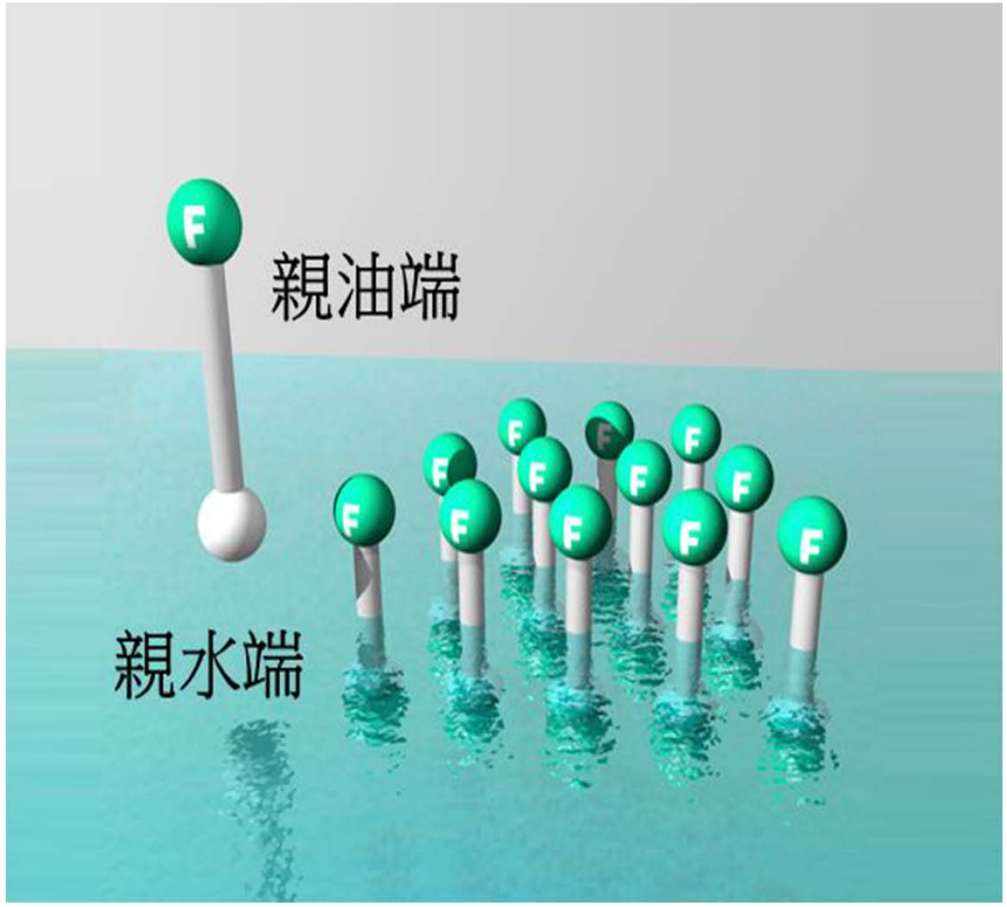


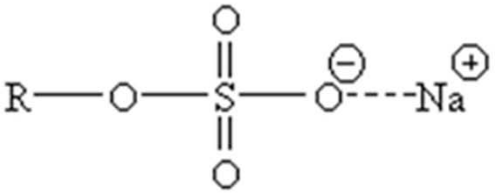


Cetyltrimethylammonium bromide (CTAB);
$(C_{16}H_{33})N(CH_3)_3Br$



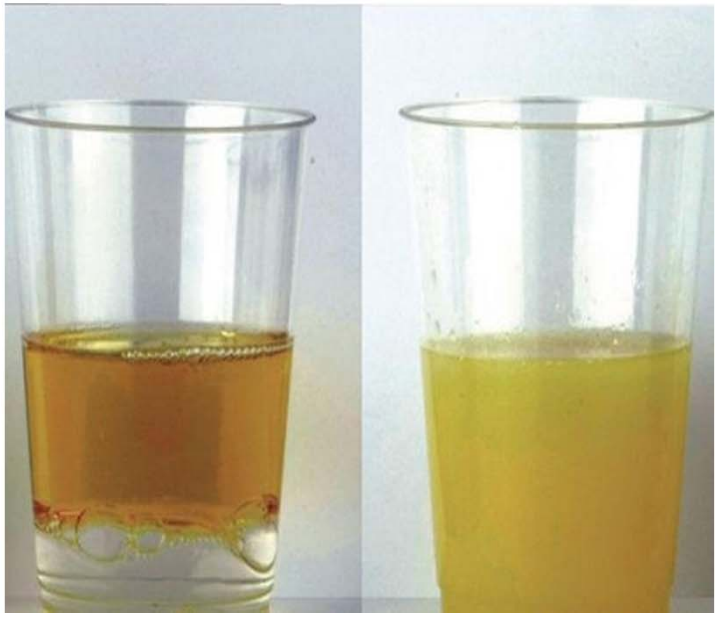






陰離子性界面活性劑
（烷基硫酸鈉）

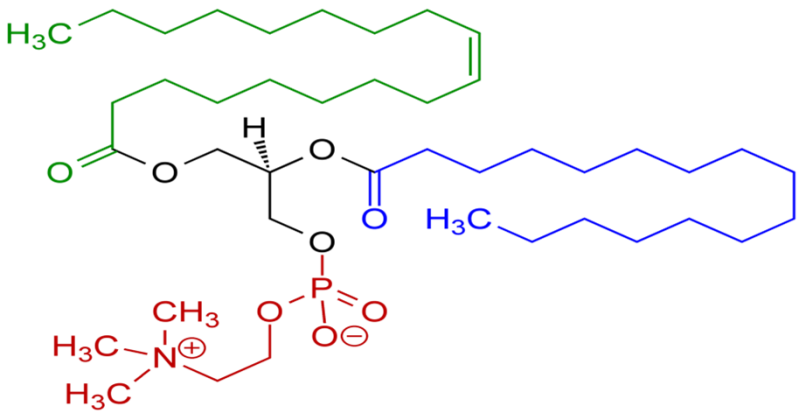
+ Surfactant



自製冰淇淋

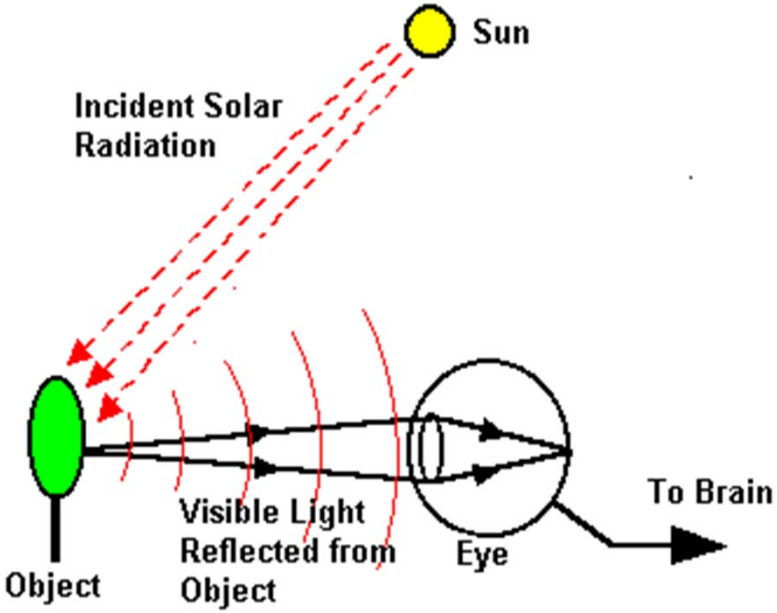
鮮奶油 和 芒果泥混合均勻，然後加入一顆蛋黃 (卵磷脂；乳化劑)

冰塊＋鹽水



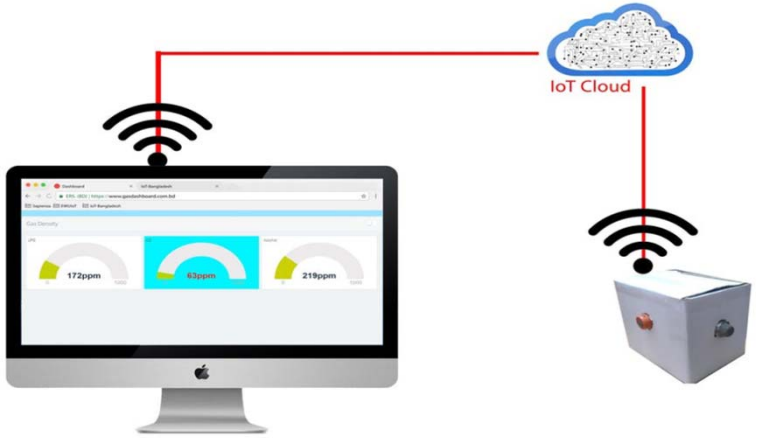
卵磷脂

感測器 (Sensor)

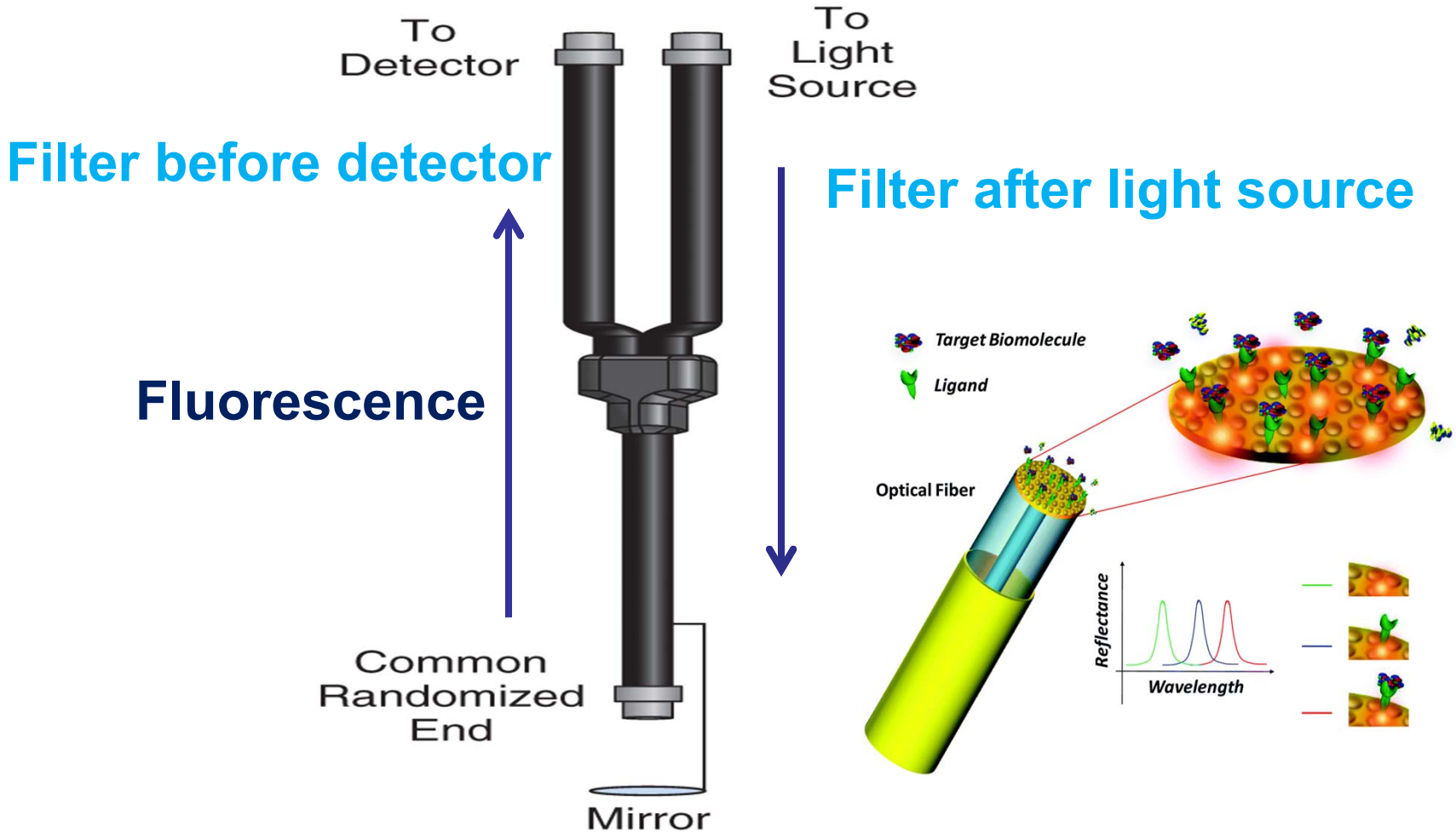


偵測器 — 訊號傳輸 — 感應端

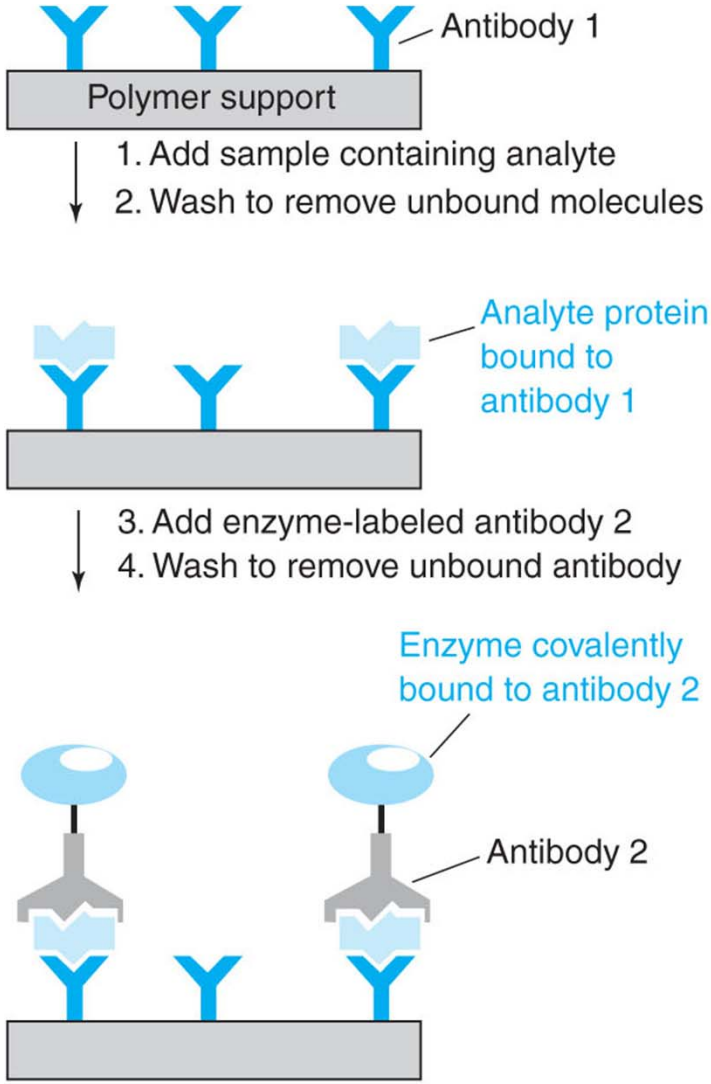
光、電、熱、壓力等



Fiber-optic sensors are good alternatives to electrodes, with no requirement for a reference electrode.

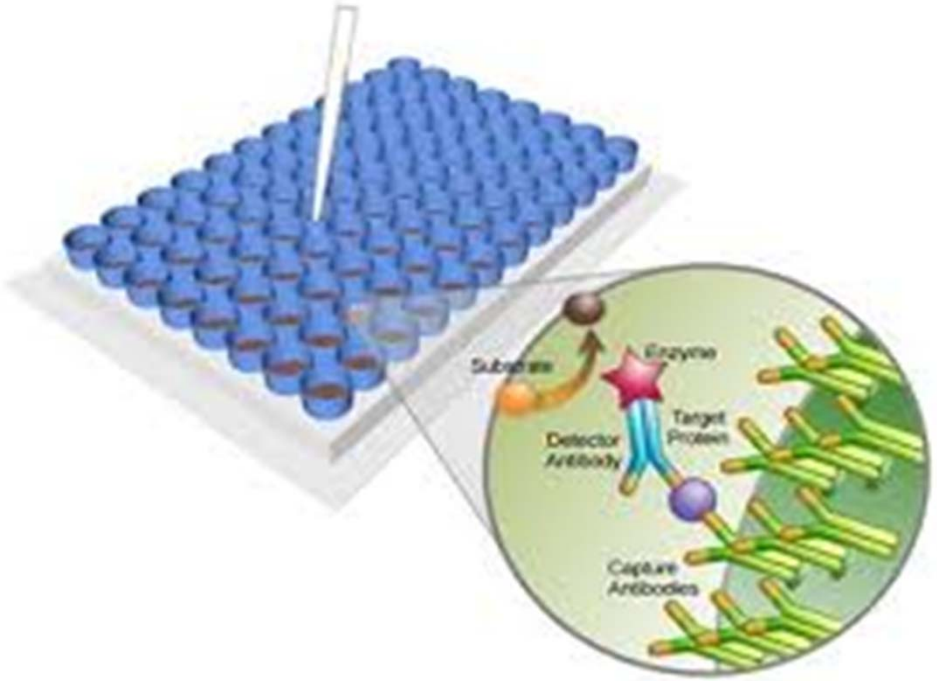


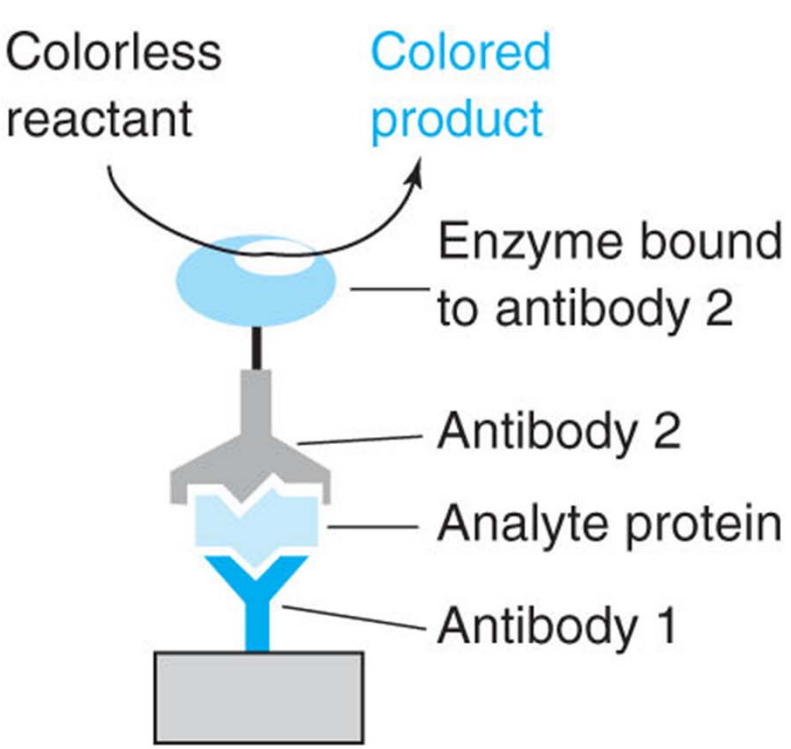
Bifurcated fiber-optic based spectrophotometric probe.

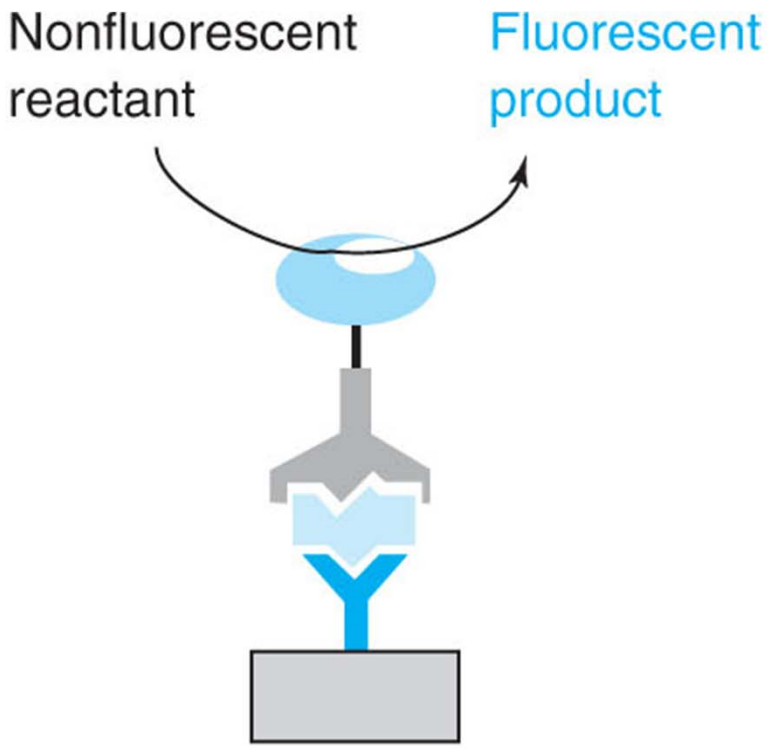


ELISA: enzyme-linked immunosorbent assay

酵素結合免疫吸附分析法







Enzyme bound to antibody 2 can catalyze reactions that produce colored or fluorescent products. Each molecule of analyte bound in the immunoassay leads to many molecules of colored or fluorescent product that are easily measured.

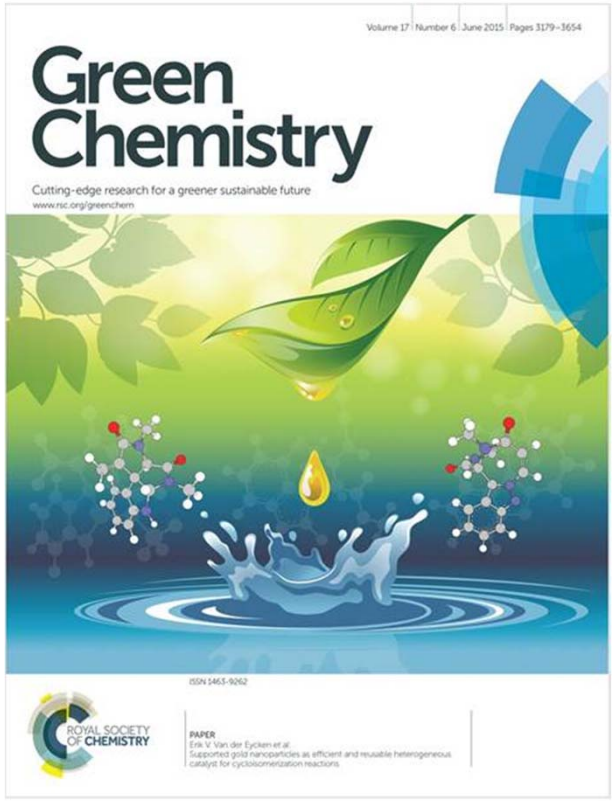
ELISA檢測癌症標記物:

攝護腺特異抗原 **(Prostate Specific Antigen; PSA):** 在攝護腺肥大的病人也可能昇高。

癌胚抗原 **(carcinoembryonic antigen，CEA; CEA):** 大腸直腸癌的病人才會增加，在乳癌、肺癌、胃癌等很多癌症都可能會增高，而且在肝硬化、肺病變、抽菸等情形也會增加。

胎兒球蛋白（**alpha-fetoprotein; AFP**）: 肝癌病人可能昇高。

綠色化學的基本精神



低毒 *低能*

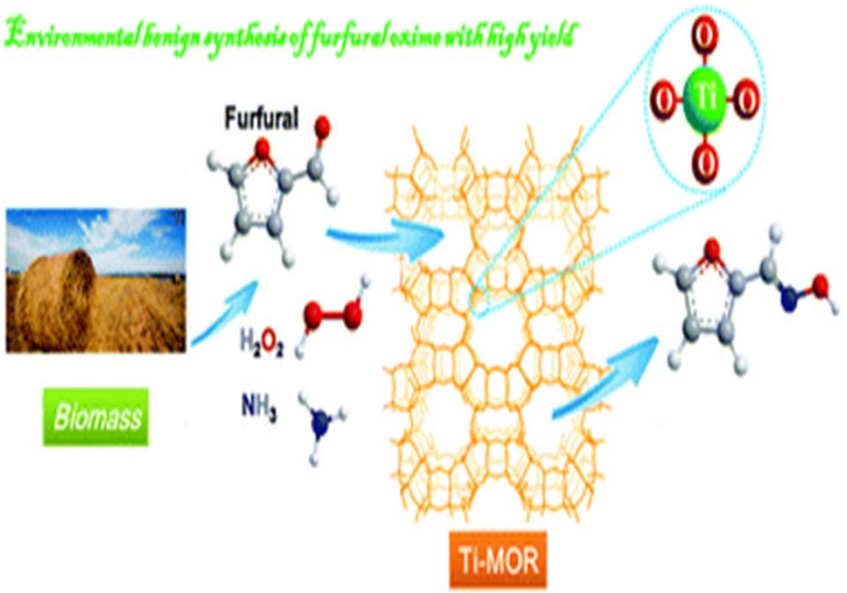
高效率 *再生*

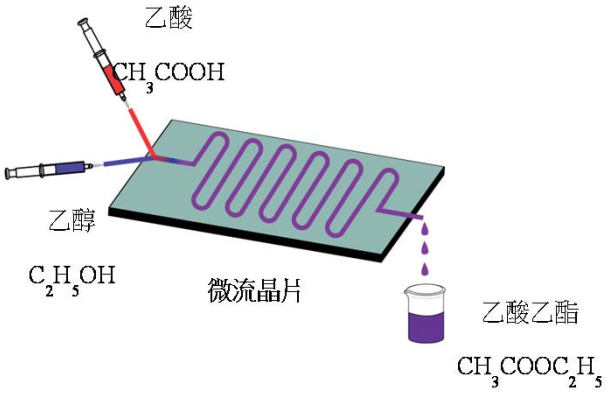
P T Anastas and J C Warner (1998): Green chemistry is the utilization of a set of principles that reduces or eliminates the use or generation of hazardous substances in the design, manufacture and application of chemical products.

Green Chemistry is at the frontiers of this interdisciplinary science that attempts to reduce the environmental impact of the chemical enterprise by developing a technology base that is inherently non-toxic to living things and the environment.

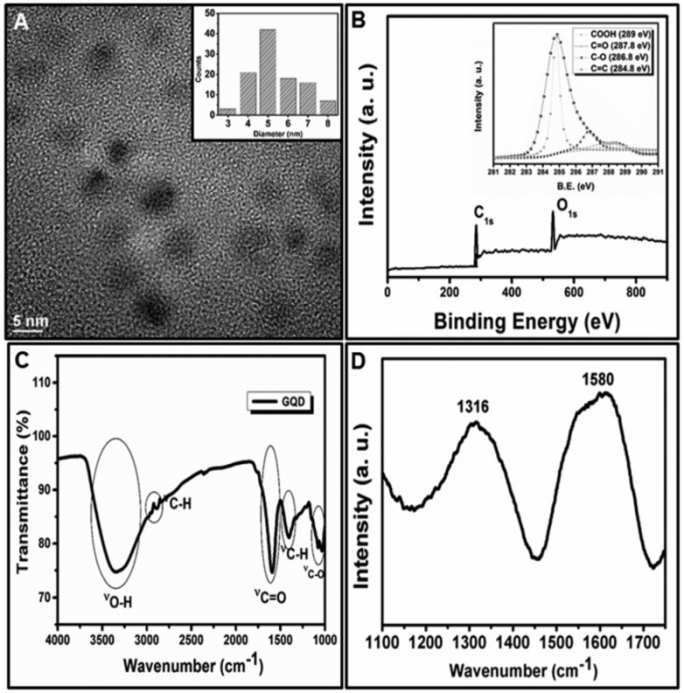
化學家可做的事?

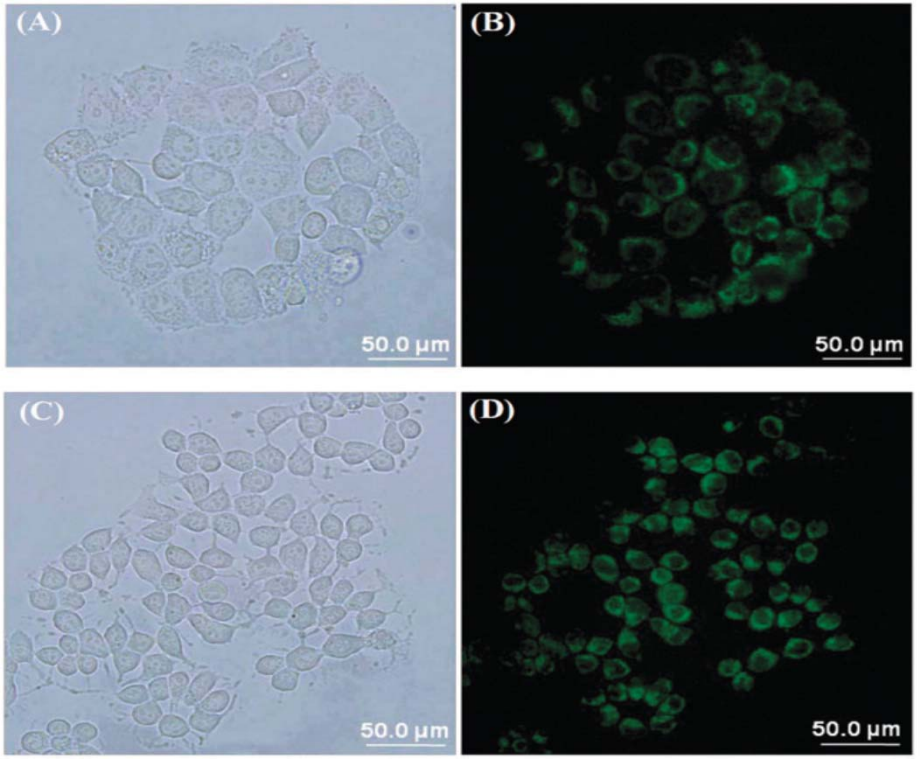
更有效的合成方法
奈米催化劑
晶片(微流管)合成系統
離子液體
超級吸附劑
等等





碳點





MCF-10A (A and B) and MCF-7 (C and D) cells treated with C-dots prepared from glycine.

合成:水熱法、電化學

特性:穩定、水中分散性佳、螢光、生物相容性

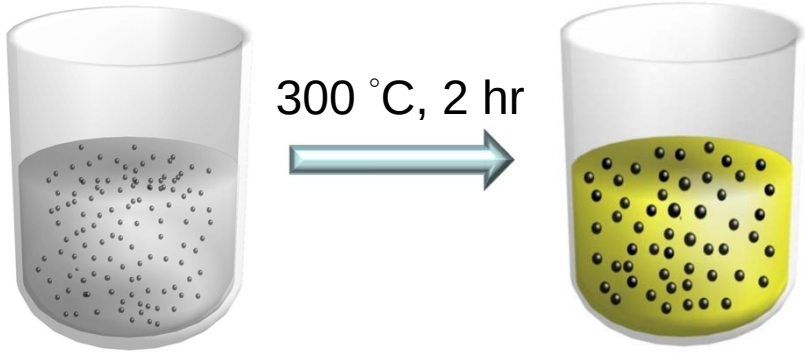
應用: 感測器、醫藥、工業（催化劑、LED）

Preparation of C-dots

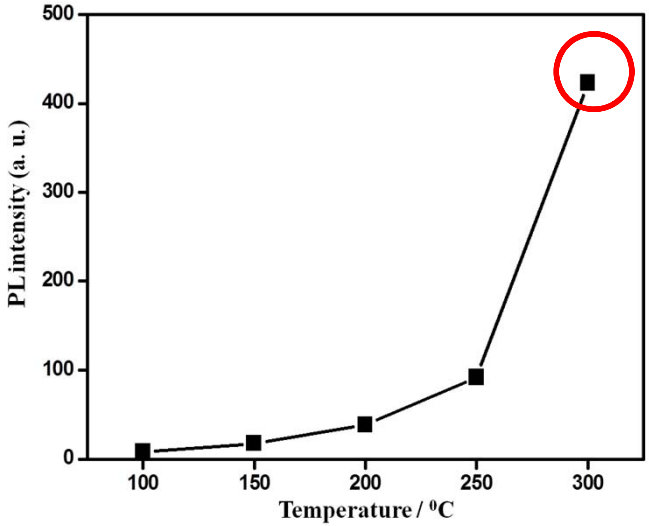
Hydrothermal Calcination

1. Wide varieties of resources
2. One-pot preparation
3. Fast (2 hr)
4. Green (no solvent & strong acid)
5. narrower size distribution

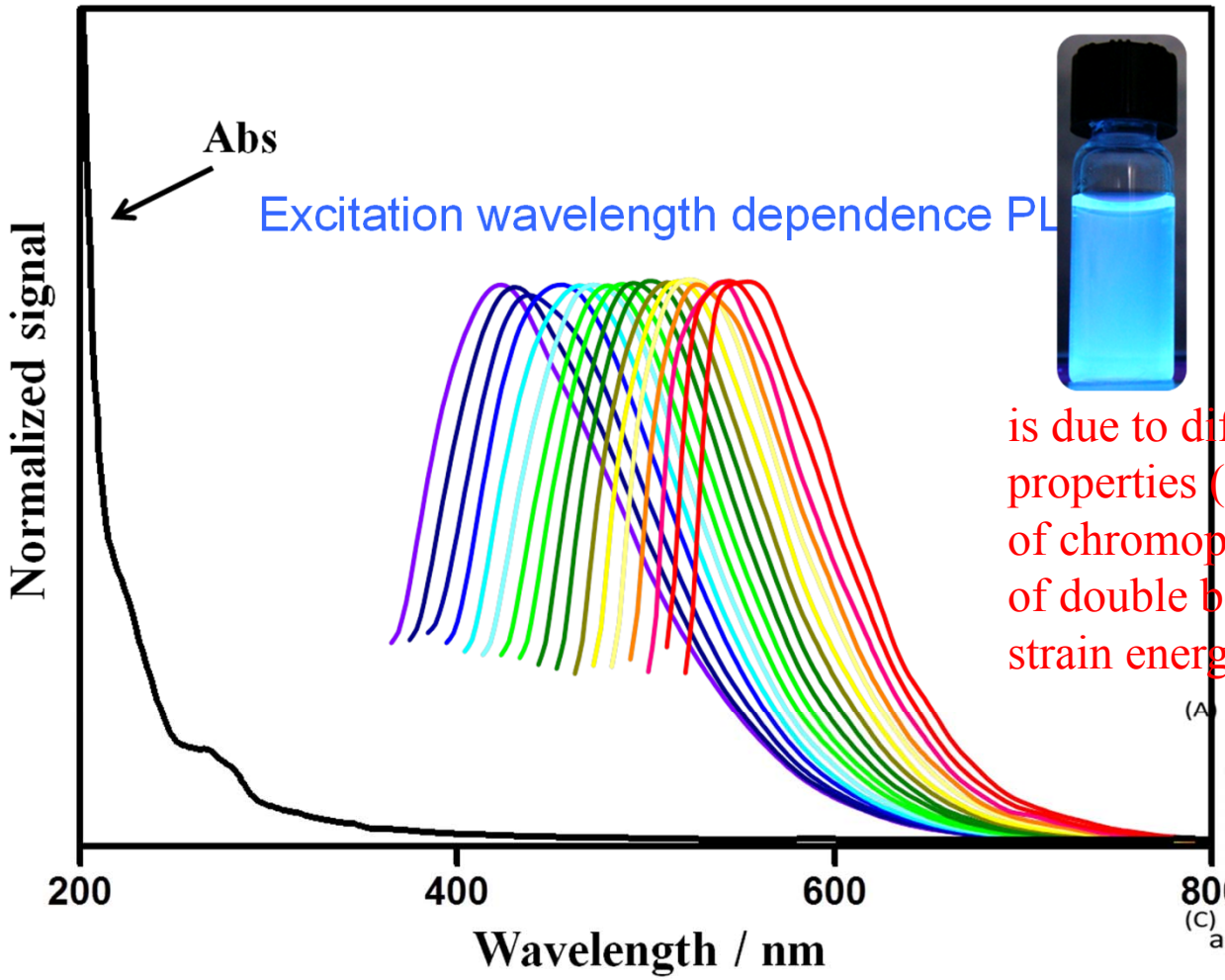
Heated in stainless steel



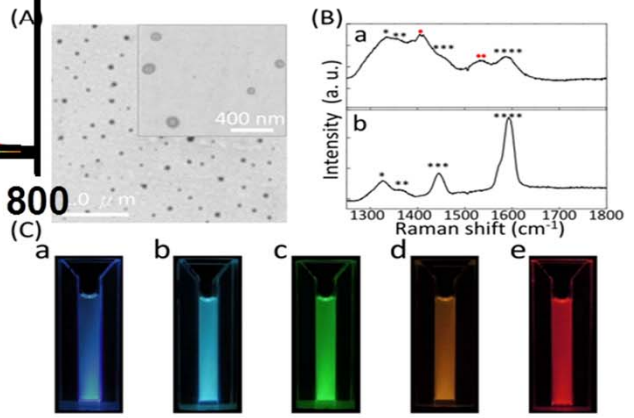
Temperature effect on the preparation of C-dots



Optical property of ground coffee C-dots



is due to different sizes and surface properties (the presence of various types of chromophores with different degrees of double bond conjugation and strain energies)

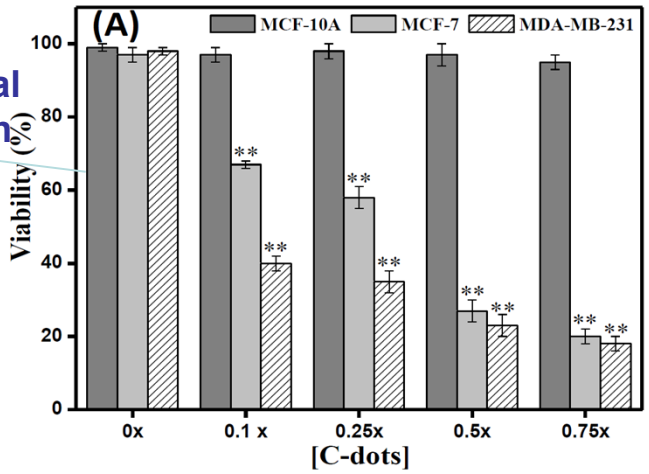


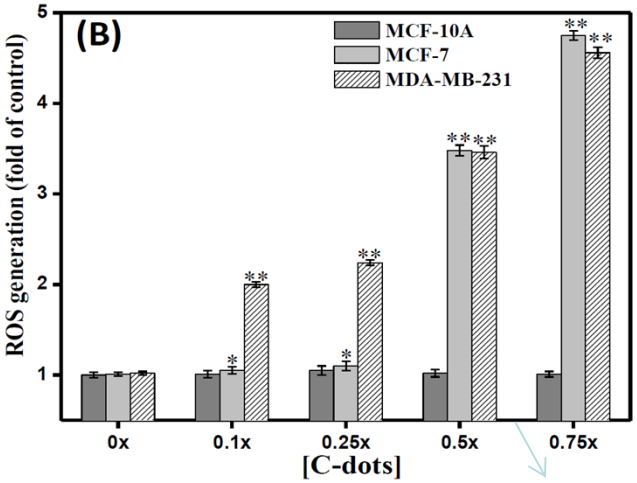
Absorption and PL emission spectra with increasing excitation wavelengths (in 15 nm increments starting from 350 nm) of C-dots. Inset: PL photograph of a C-dots solution under a hand-held UV lamp (365 nm).

Green Chem. **2012**, *14*, 917-920.

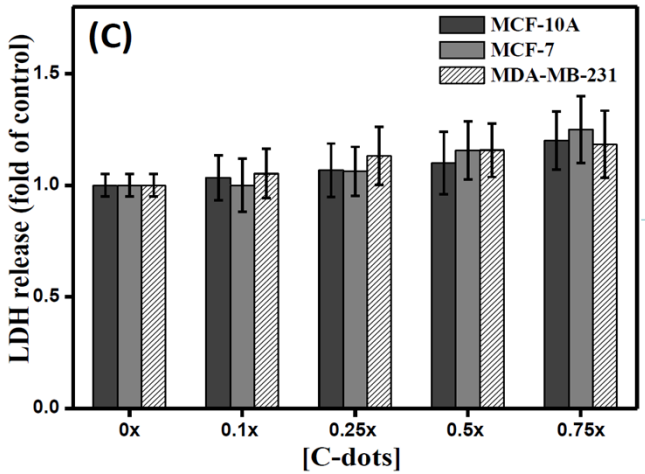
Biosafety to normal cells, but inhibition of cancer cells

Surface molecules such as catechins must play some roles





Reactive oxygen species (ROS) generated; an oxidative stress mechanism



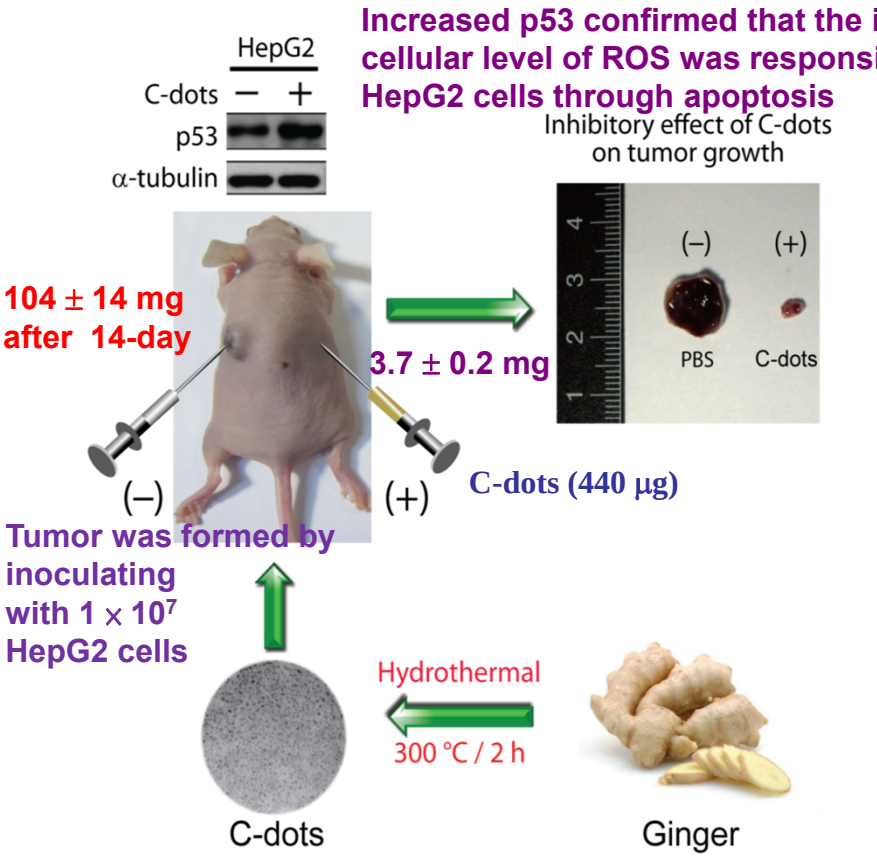
membrane binding without damage

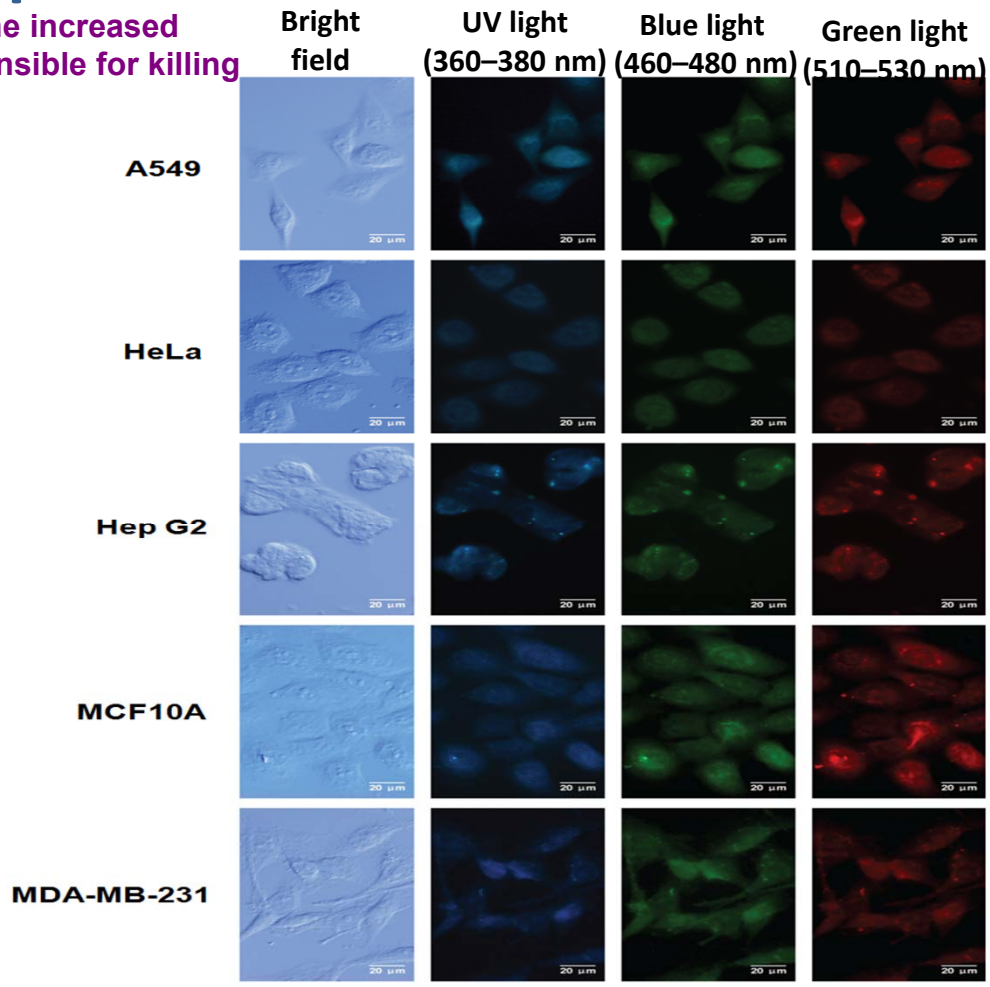
C-dots caused the inhibition of the cancer cells through apoptosis

J. Mater. Chem. B **2013**, *1*, 1774-1781.

C-dots induced (A) cytotoxicity, (B) oxidative stress, and (C) LDH release of MCF-10A, MCF-7 and MDA-MB-231 cells. 1× = 0.36 mg/mL. The percentages of cell viability, fold of ROS generation, and fold of LDH release are shown as a relative value to control (MCF-10A cells). The values represent (mean ± SD, n = 3, **p < 0.001, *p < 0.01).

Carbon dots prepared from ginger exhibit efficient inhibition of human hepatocellular carcinoma cells





Curcumin could trigger the pro-apoptotic factor to promote HepG2 cell apoptosis

C-dots induced the proliferation delay and the enhanced ROS production

C-dots were located in the cytoplasmic area of the cells, revealing that they easily penetrated into the cells via receptor-mediated and/or non-receptor-mediated endocytosis

J. Mater. Chem. B, 2014, 2, 4564–4571

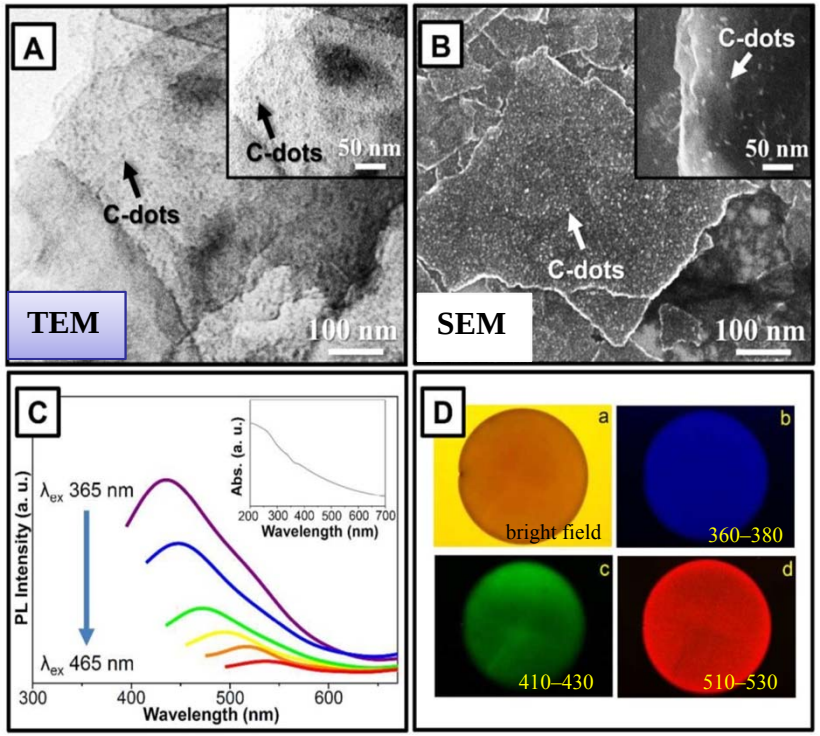
Photoluminescent C-dots@RGO Probe for the Detection of Acetylcholine

- Ach: neurotransmitter
- No electroactive, chromophore, or fluorophore group in ACh.
- [ACh] : 8.66 ± 1.02 nM

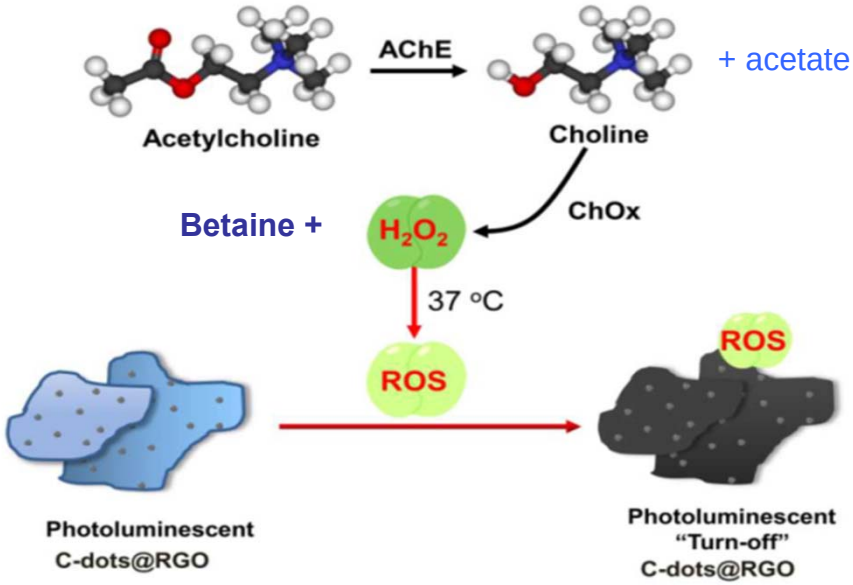
GO —(+)-catechin, Hydrothermal reduction 300℃/ 2h→ **C-dots@RGO**

λ_{ex} : 365 nm

λ_{em} : 445 nm



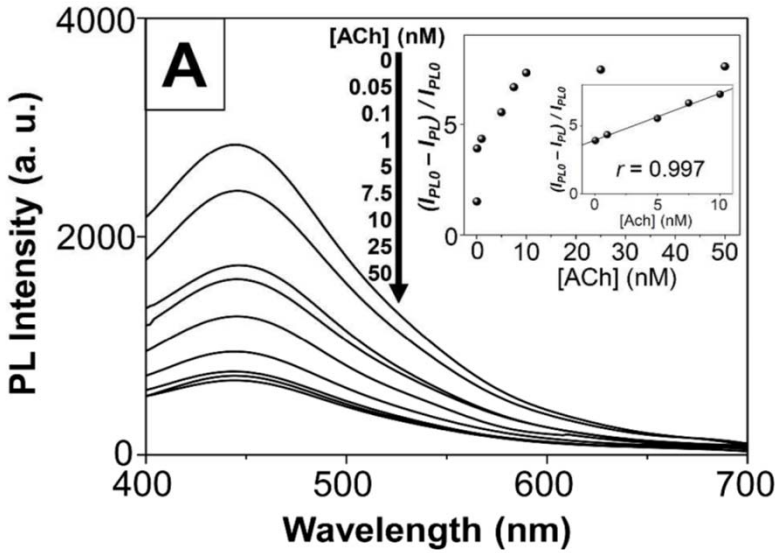
Excitation wavelength dependence of its PL properties



- **H_2O_2 (100 nM) in Tris-HCl buffer (25 mM, pH 9.0)**
- **I_{PL0} and I_{PL} are the PL intensities of the solutions before and after the PL quenching reaction, respectively.**

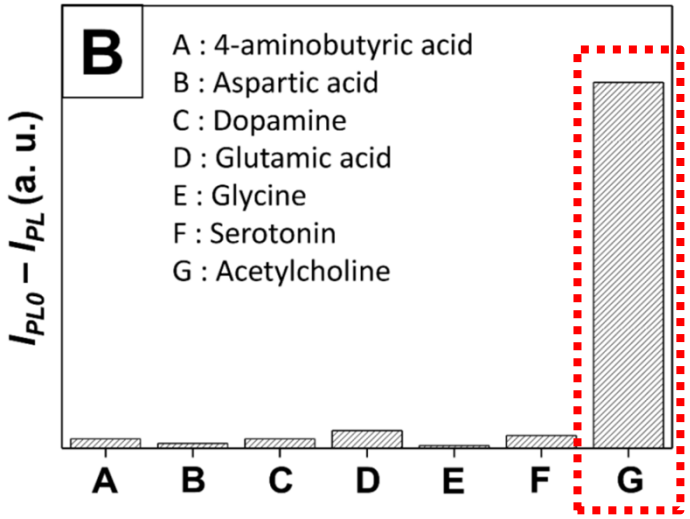
Anal. Chem. **2013**, *85*, 3263−3270

Detection of ACh Using C-dots@RGO

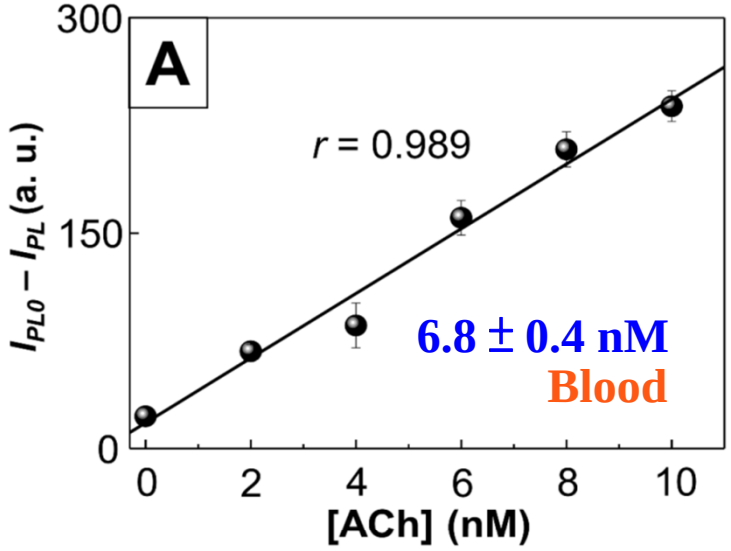


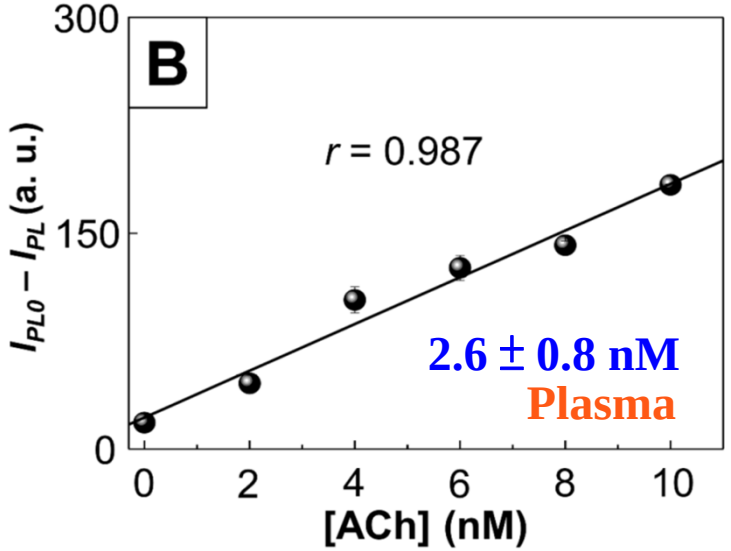
Linear range : 0.05–10 nM LOD : 30 pM

Selectivity



Detection of ACh in real samples

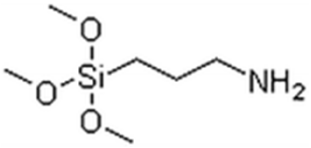


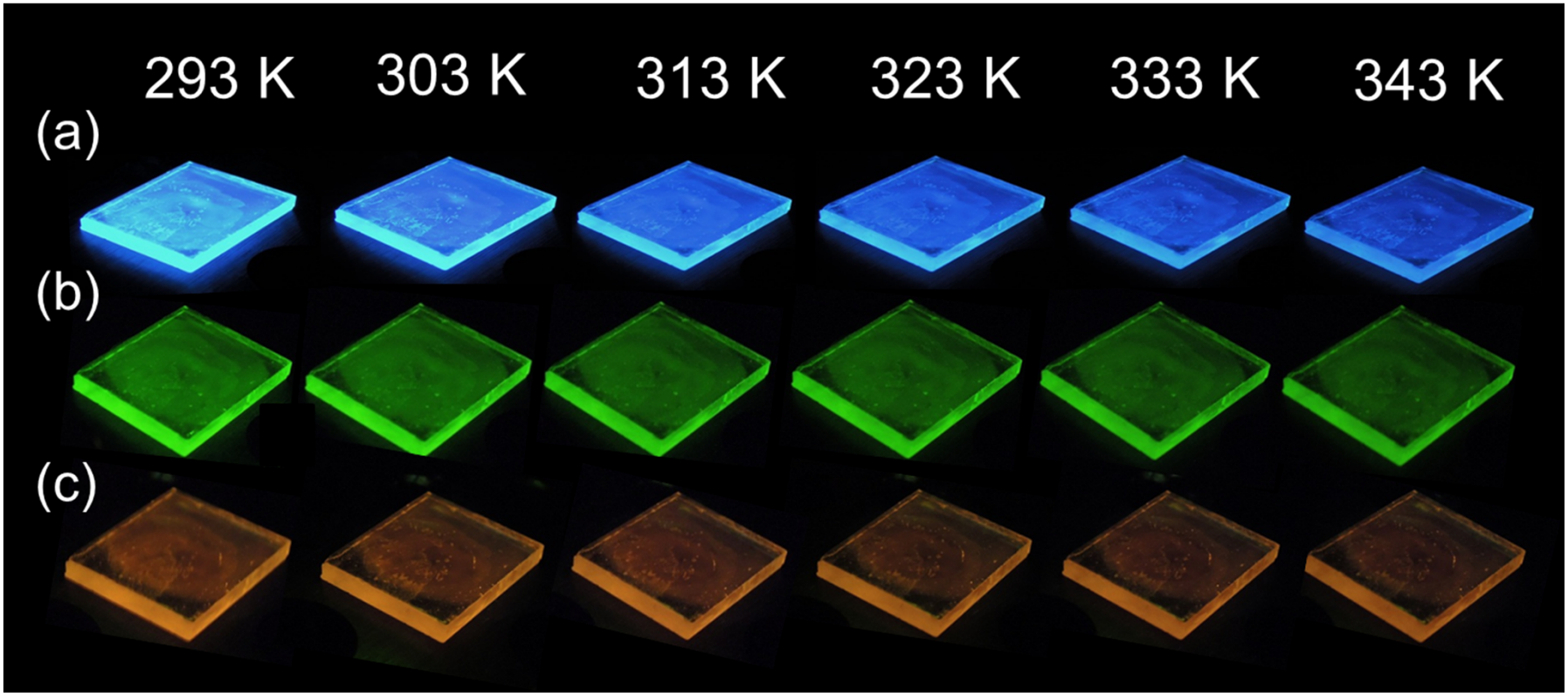


(A) PL spectra of [C-dots@RGO] : 0.4 mg mL^{-1}

(B) [ACh] : 10 nM, [other solutes] : 100 nM. [AChE/ChOx] : 0.5/0.1 U mL^{-1}. Reaction time for the enzyme and PL-quenched reactions at 37 ˚C is 2 h.

SiC-dots thin film temperature probe

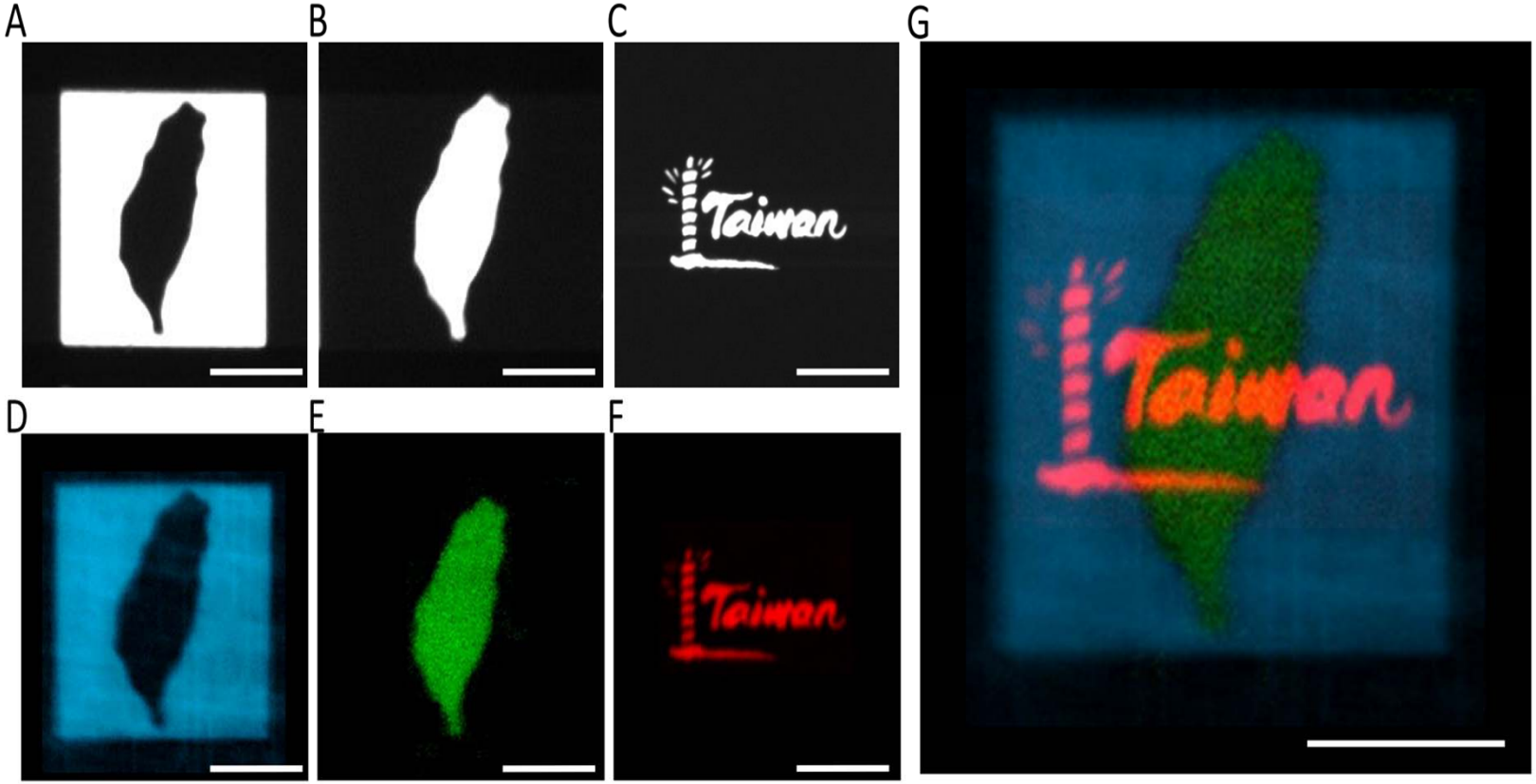




Temperature-sensitive photoluminescence of organosilane-functionalized carbon dot films. The SiC-dot films were stable for at least 10 cycles of water washing, mainly because of strong Si–O–Si interactions between the SiC-dots and the glass substrates.

Chem. Commun. **2013**, *49*, 1639-1641.

Photodeposition of C-dots

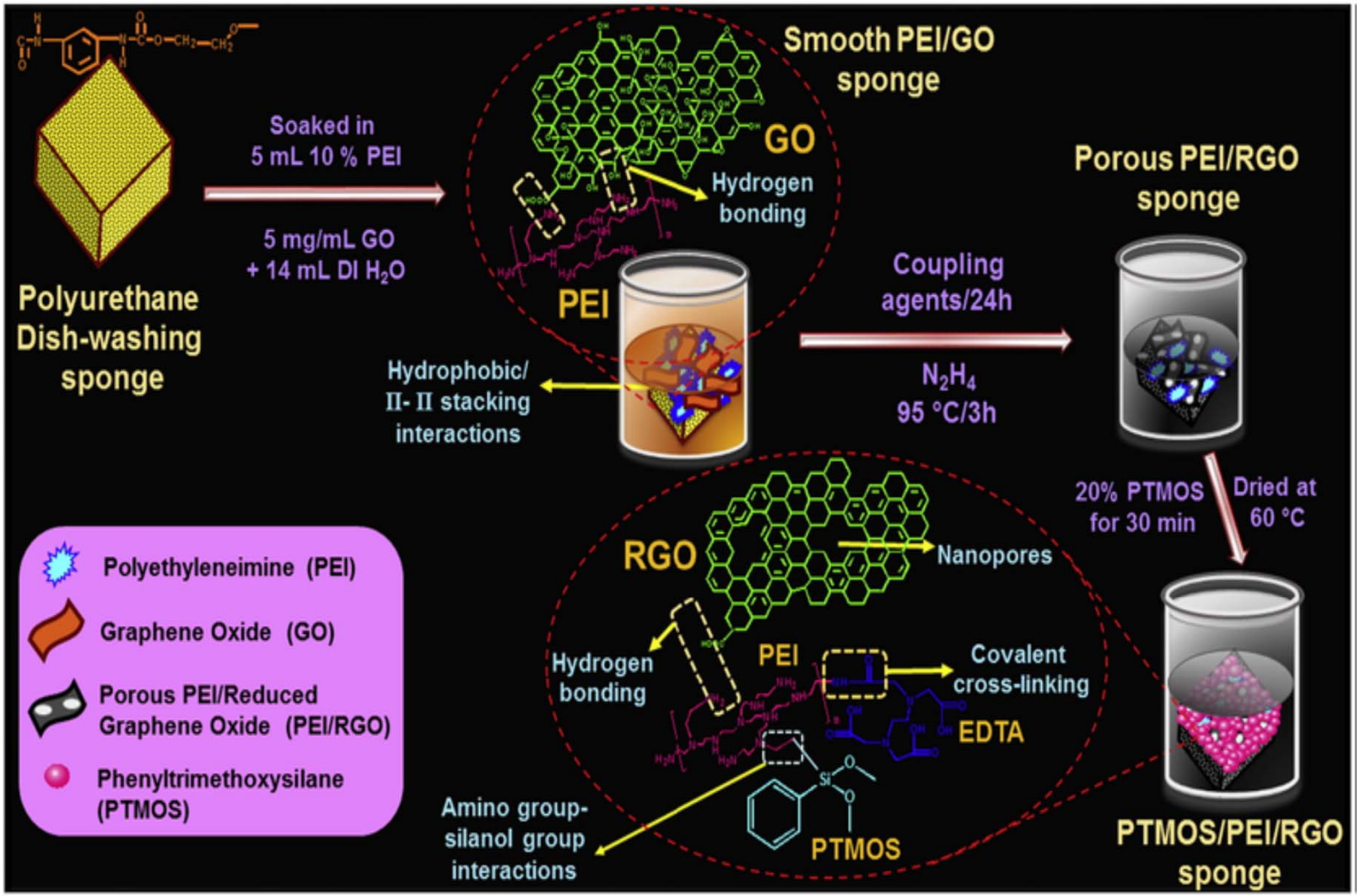


Excitation wavelength (nm):

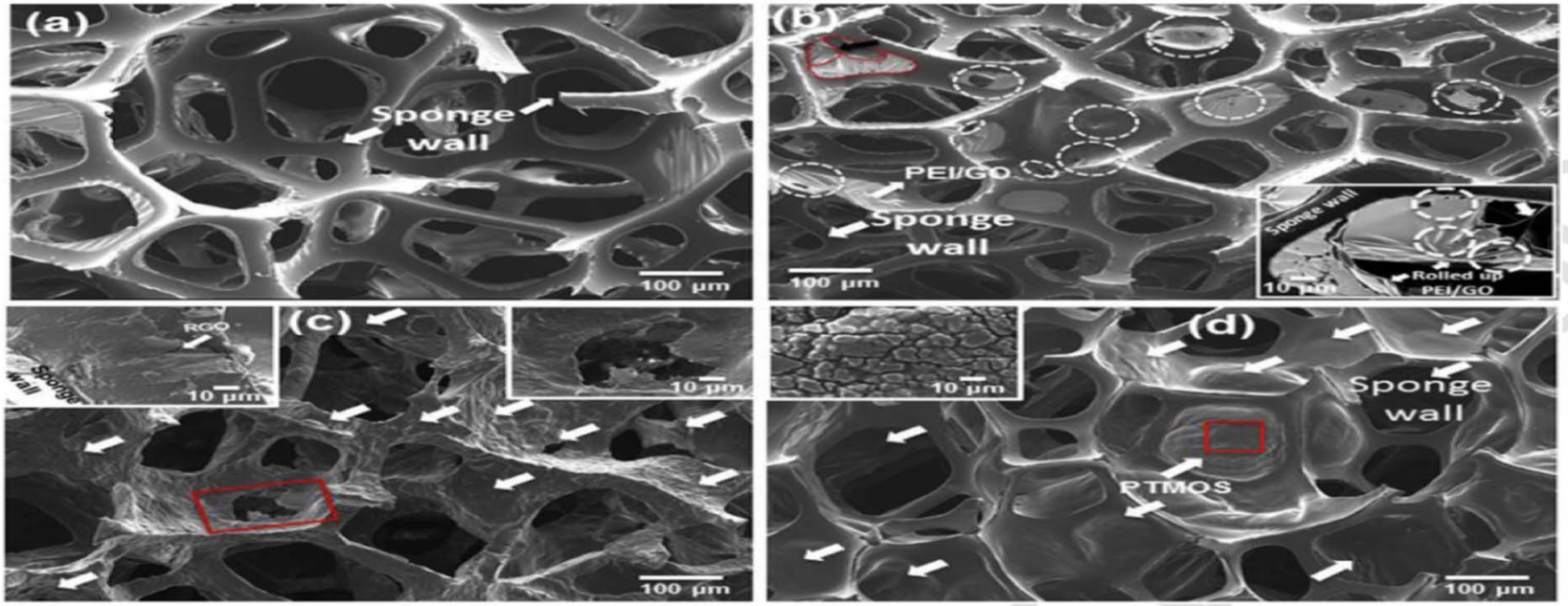
(D) 365 (E) 488 (F) 532

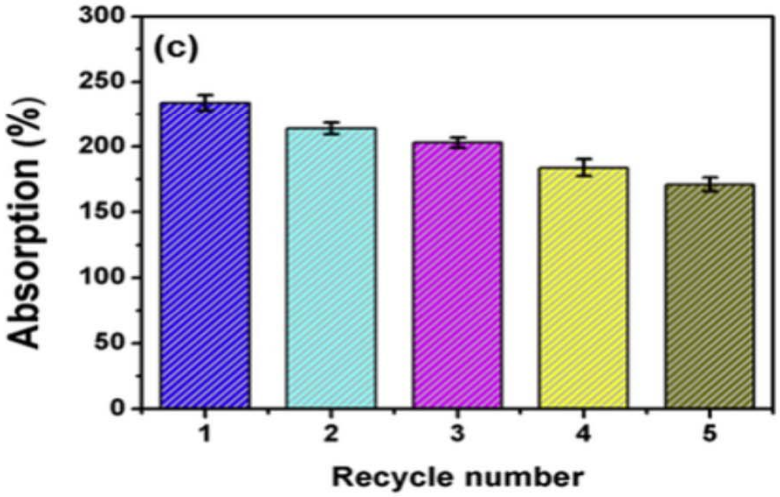
Scale bar: 200 μm

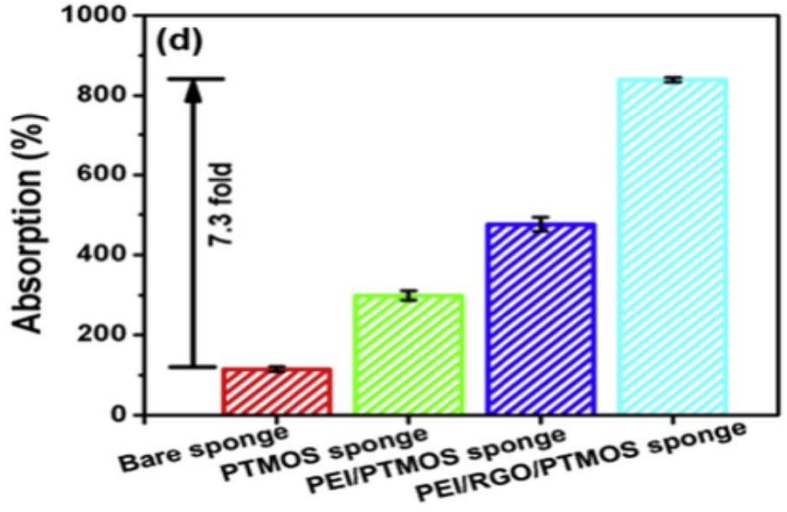
超級吸油海綿


Polyurethane Dish-washing sponge
Soaked in 5 mL 10 % PEI
5 mg/mL GO + 14 mL DI H_2O
Smooth PEI/GO sponge
GO
Hydrogen bonding
PEI
Hydrophobic/ Π- Π stacking interactions
Coupling agents/24h
N_2H_4 95 °C/3h
Porous PEI/RGO sponge
20% PTMOS for 30 min
Dried at 60 °C
RGO
Nanopores
Hydrogen bonding
PEI
Covalent cross-linking
EDTA
PTMOS
Amino group-silanol group interactions
PTMOS/PEI/RGO sponge
Polyethyleneimine (PEI)
Graphene Oxide (GO)
Porous PEI/Reduced Graphene Oxide (PEI/RGO)
Phenyltrimethoxysilane (PTMOS)

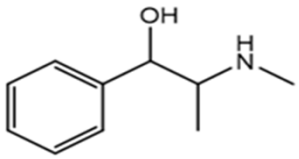
電子顯微鏡圖


(a)
Sponge wall
100 μm
(b)
PEI/GO
Sponge wall
100 μm
Sponge wall
Rolled up PEI/GO
(c)
RGO
Sponge wall
10 μm
10 μm
100 μm
(d)
10 μm
Sponge wall
PTMOS
100 μm

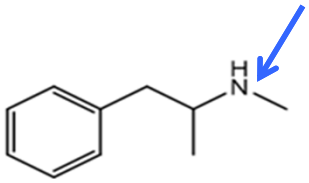

(c)
Absorption (%)
300
250
200
150
100
50
0
1
2
3
4
5
Recycle number


(d)
Absorption (%)
1000
800
600
400
200
0
7.3 fold
Bare sponge
PTMOS sponge
PEI/PTMOS sponge
PEI/RGO/PTMOS sponge

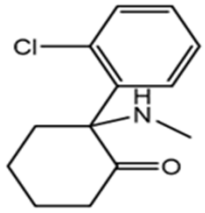
碳量子點於毒品檢測之應用



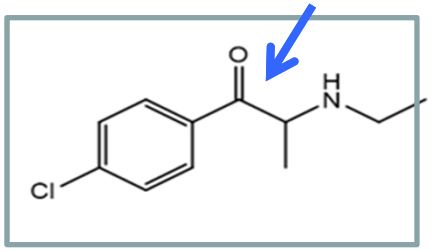
Ephedrine



Methamphetamine

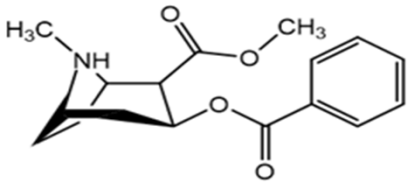


Ketamine

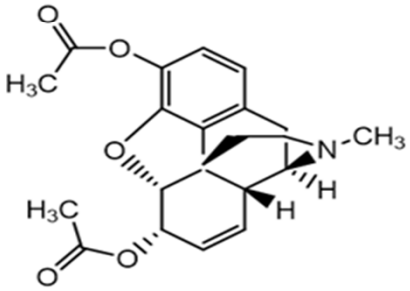


卡西酮

4-Chloroethcathinone



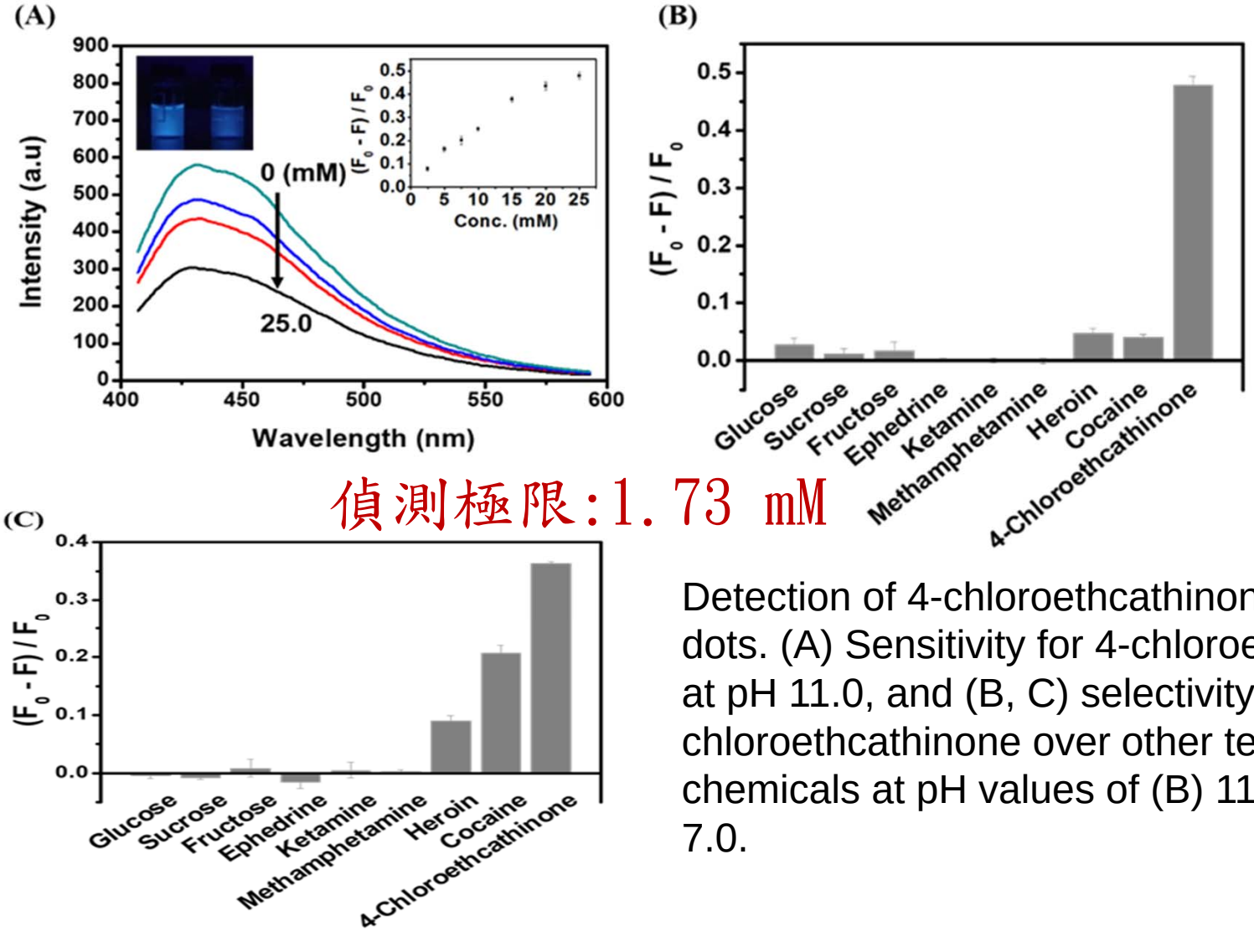
Cocaine 古柯鹼



Heroin 海洛因

亦稱為β- 酮基安非他命:新興精神作用物質常以浴鹽（bath salts）的名稱進行販賣。

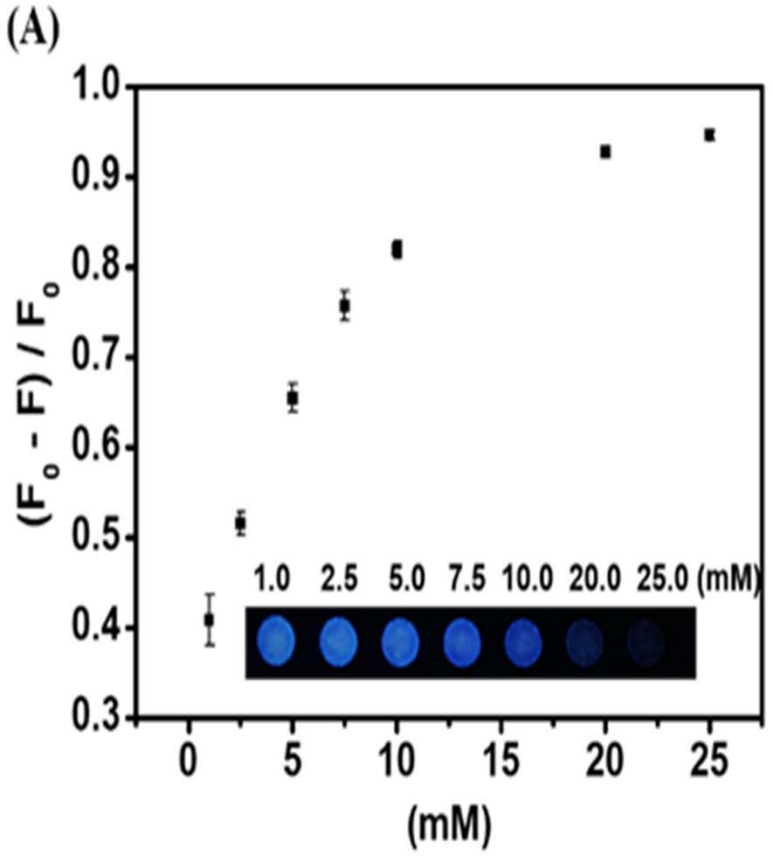
溶液相檢測

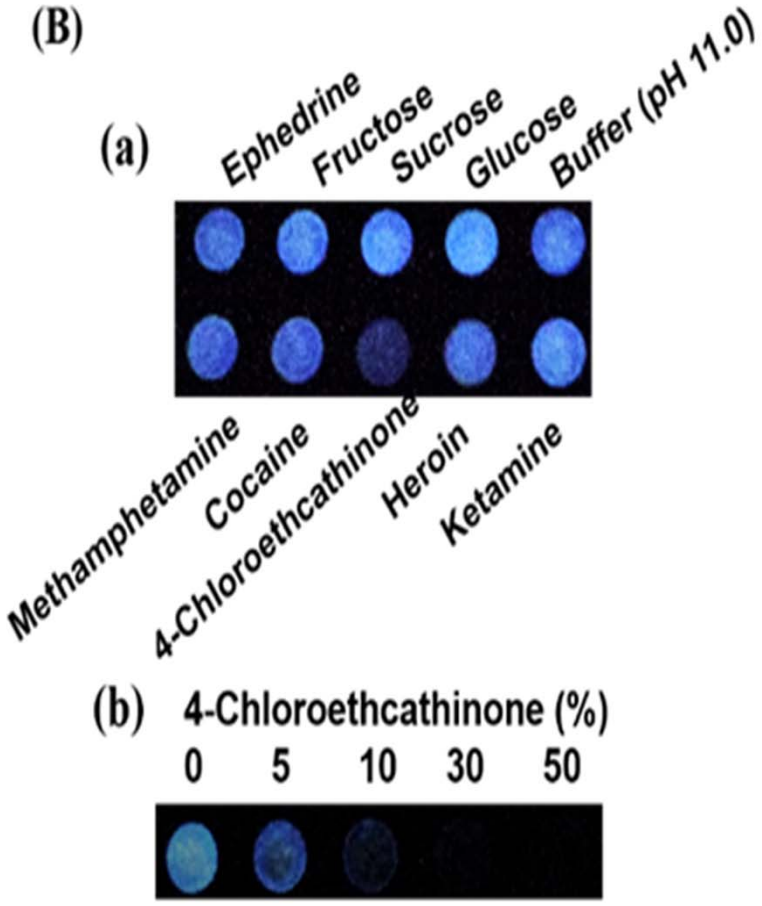


偵測極限:1.73 mM

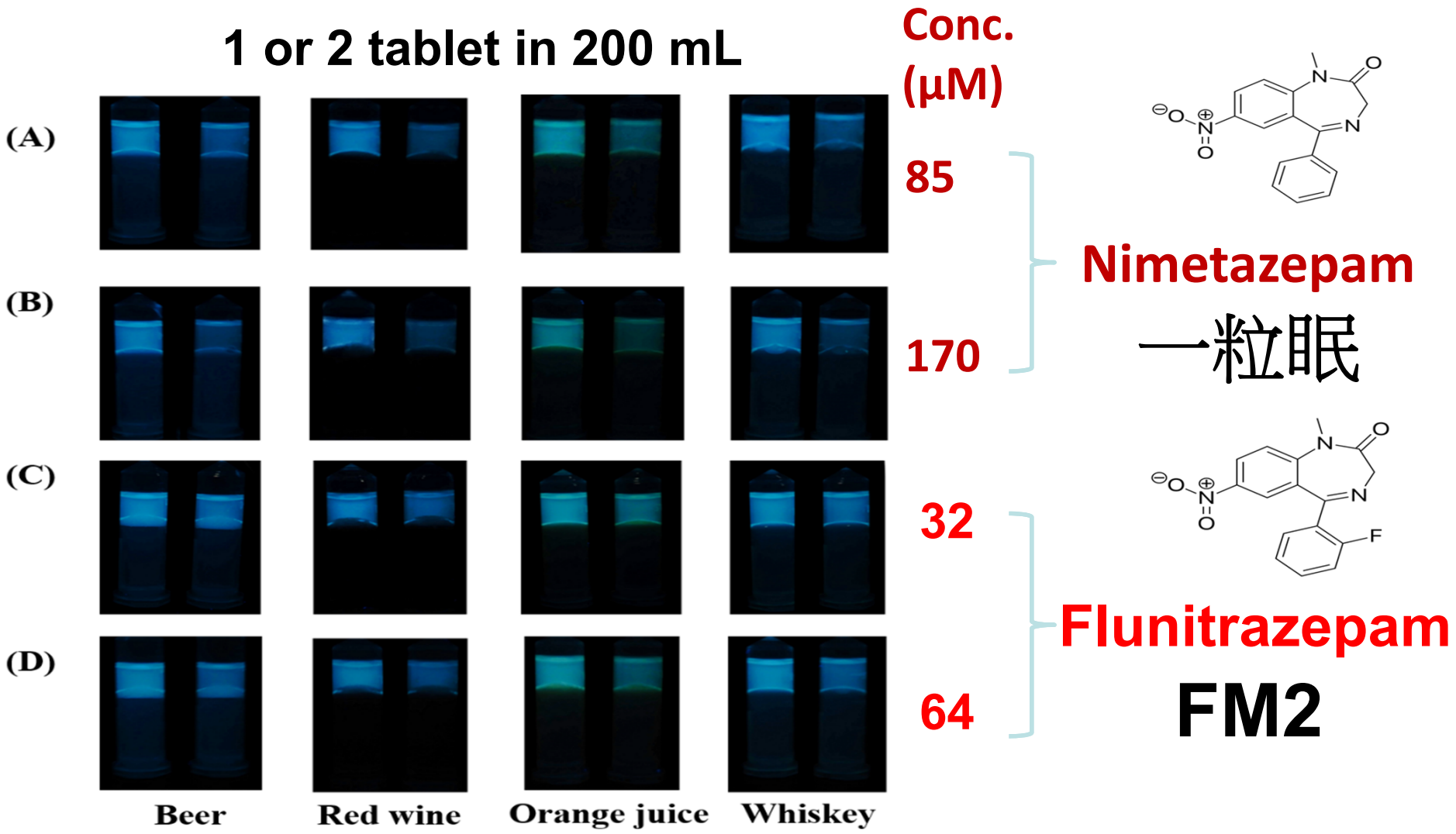
Detection of 4-chloroethcathinone using C-dots. (A) Sensitivity for 4-chloroethcathinone at pH 11.0, and (B, C) selectivity of 4-chloroethcathinone over other tested chemicals at pH values of (B) 11.0 and (C) 7.0.

試紙檢測





偵測極限: 0.82 mM



C dots in 0.5 mL of toluene; Sample: 1.5 mL

Excitation/Emission wavelengths: 365/427 nm

Conclusions:

1. 化學是很生活化的科學。
2. 化學不難且實用。
3. 強調低耗能和低毒性的綠色化學是一門值得推廣的科學。
4. 奈米感測器可檢測多種分析物；如碳點用於檢測毒品。

Thank you for your attention