Gold Nanoparticles for Biosensor Development

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ABSTRACT

Gold nanoparticles, are one of the most widely investigated nanoparticles (NP) and are normally synthesized by the reduction of metal salts in citrate solution. The reason for studying this nanostructured material from a technological standpoint is mainly the anticipated application in different areas based on optical properties explained with plasmon resonance. The main work of this study was to develop different sensing systems using gold nanoparticles. Three techniques have been utilized, being lateral flow immunoassay (LFIA), surface plasmon resonance (SPR), and surface-enhanced Raman scattering (SERS).

A one-step semi-quantitative LFIA strip test was developed using colloidal gold coated by a partially-purified polyclonal antibody (pAb) raised in sheep as a signal generator, and bovine serum albumin-Estriol-16-glucuronide (BSA-E3-16G) conjugates as the capture agent spotted onto a nitrocellulose membrane as the test line. In this system, gold nanoparticles were applied for visualising the response. The application of the strip sensor to urinary samples from pregnant woman proved successful.

A quantitative evaluation of low levels of E3-16G in liquid media was developed based on SPR, which used the same pAb-nanogold conjugates employed for the LFIA analysis. The assay can be carried out directly on any urine samples without sample pretreatment. In this system, gold nanoparticles were utilized as high mass label to improve the sensitivity of the assay.

A SERS probe was developed which comprised of Raman reporter molecules (RRM) and gold NPs. Results showed that the conducting polymer materials of 3’-[(E)-2-(4-R-phenyl)ethenyl]-2’2’:5’,2”-terthiophene (R-pe3T, where R is NO_2 or NH_2) showed significant enhancement. Moreover, high bio-activity groups included in the compounds make them potential candidates for the development of a SERS based sensing system.

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Chapter 3: Lateral flow immunoassay

Chapter 4: SPR Biosensor-based immunoassay

Chapter 5: Surface-enhanced Raman scattering

Abbreviations

E3-16G	**Estriol-16-glucuronide**
SPR	**Surface plasmon resonance**
SERS	**surface-enhanced Raman scattering**
LFIA	**Lateral flow immunoassay**
BSA	**bovine serum albumin**
RRM	**Raman reporter molecule**
R-pe3T	**3’-[(E)-2-(4-R-phenyl)ethenyl]-2’2’:5’,2”-terthiophene**
NP	**nanoparticle**
NR	**NanoRod**
MTP	**multiple twinned particles**
CTAB	**cetyltrimethylammonium bromide**
R	**aspect ratio**
GS	**growth solution**
LFA	**Lateral flow assay**
RU	**Reaction Unit or Resonance Unit**
DDC	**Direct Digital Control**
TEM	**transmission electron microscopy**
Ab	**antibody**

pAb	**polyclonal primary antibody**
Au-Ab	**nanogold-antibody**
2˚AS	**anti-sheep serum raised in rabbit**
E1-3G	**Estrone-3-glucuronide**
E3-3G	**Estriol-3-glucuronide**
E3-17G	**Estriol-17-glucuronide**
LOD	**low limit of detection**
TM	**Tris-maleate**
CV	**coefficient of variation**
RIA	**radio immunoassay**
HPLC	**high performance liquid chromatography**
LC	**liquid chromatography**
MS	**mass spectroscopy**
OVA	**ovalbumin**
OEG	**oligoethylene glycol**
FC	**flow cell**
FR	**flow rate**
EDC	**1-ethyl-3-(3-dimethylaminopropyl) carbodiimide**
NHS	**N-hydroxysuccinimide**

EAH	**ethanolamine-HCl**
RelResp	**relative response**
OD	**optical density**
PEG	**poly ethylene glycol**
PdG	**pregnanediol glucoronide**
PVP	**polyvinylpyrrolidone**
EDOT	**2,3-dihydrothieno[3,4-b]-1,4-dioxin**
PEDOT	**poly(2,3-dihydrothieno-1,4-dioxin)**
DCM	**dichloromethane**
ZnTXP	**5,10,15,20-Tetrakis(3',5'-dimethylphenyl)porphyrinato zinc(II)**
ZnTPP	**5,10,15,20-Tetraphenylporphyrinato zinc(II)**

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1. The first paper based on the SPR work discussed in Chapter Four has been published in Steroids.

   Jiang, X. Q., Waterland, M., Blackwell, L., Wu, Y. Q., Jayasundera, K. P., & Partridge, A. (2009). Sensitive determination of estriol-16-glucuronide using surface plasmon resonance sensing. *Steroids, 74*(10-11), 819-824.

2. The second paper based on the applications of Lateral flow immunoassay and SPR assay in human urinary samples (discussed in Chapter Three and Four) has been published in Analytical methods.

   Jiang, X. Q., Waterland, M., Blackwell, L., & Partridge, A. (2009). Determination of Estriol 16-glucuronide in human urine with surface plasmon resonance and lateral flow immunoassays. *Analytical Methods*, 2010, **2**, 368-374.

3. The third paper based on the surface enhanced Raman scattering (Chapter Five) has been finished and is going to be submitted to Small soon.

   Jiang, X. Q., Waterland, M., & Partridge, A. (2010).