FABRICATION OF GOLD NANOPARTICLES AS PAPER-BASED MICROFLUIDIC DEVICE FOR COLORIMETRIC ASSAY OF HUMAN CHORIONIC GONADOTROPIN

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AUTHOR DECLARATION

I hereby declare that the work in this thesis is my own except for quotations and summaries, which have been duly acknowledged.

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ABSTRAK

Pengesanan gonadotropin korionik manusia (HCG) adalah salah satu daripada banyak kaedah diagnostik yang terkenal dalam obstetrik, ginekologi dan onkologi. Dalam kajian ini, gabungan nanopartikel emas (AuNPs) yang difungsikan dengan glutathion disulfida (GSSG) dan peranti analisis mikrofluidik berasaskan kertas (μPAD) digunakan untuk mengesan dan menilai prestasinya terhadap pengesanan HCG dalam aspek kelurusan, kepekaan dan selektiviti. AuNPs yang digunakan dalam kajian ini berjaya disintesis dan dicirikan dengan rentang ukuran zarah dan hidrodinamik pada 4.89 - 34.40 nm dan 31.03 nm - 10.19 μm masing-masing dan dihadkan dengan ion sitrat. AuNP yang difungsikan dengan GSSG berjaya ditukar sebagai sensor berasaskan AuNP untuk HCG. Walau bagaimanapun, disebabkan kekurangan penglihatan pada perubahan warna, sensor tidak dapat digunakan pada μPAD dengan berkesan. Sementara itu, sensor berasaskan AuNP menunjukkan prestasi pengesanan yang baik kerana ia bertindak balas secara linear kepada perubahan kepekatan HCG dengan nilai R^2 bersamaan 0.9877, bersamaan dengan kepekaan yang rendah berbanding dengan kajian terdahulu dengan nilai pengesanan terendah 0.1577 ppm. Walaubagaimanapun, sensor yang dihasilkan tidak begitu selektif terhadap HCG kerana kajian gangguan sensor menunjukkan gangguan tinggi apabila dicampurkan dengan bendasing.

ABSTRACT

Detection of human chorionic gonadotropin (HCG) is one of many prominent diagnostics methods in obstetrics, gynaecology and oncology. In this study, the combination of gold nanoparticles (AuNPs) functionalized with glutathione disulfide (GSSG) and microfluidic paper-based analytical device (μPAD) was used to detect and assess its performance on detection of HCG in the aspect of linearity, sensitivity and selectivity. AuNPs used in this study was successfully synthesized and characterized with particle and hydrodynamic size ranges at 4.89 – 34.40 nm and 31.03 nm – 10.19 μm respectively and capped with citrate ion. GSSG-functionalized AuNPs was successfully derivatized as the AuNP-based sensor for HCG. However, due to lack of visibility on the colour changes, the sensor was unable to be applied on the μPAD effectively. Meanwhile the AuNP-based sensor shown a good sensory performance as it responded linearly to the changing concentration of HCG with R^2 value of 0.9877. The sensor also shown high sensitivity compared to previous studies with limit of detection value of 0.1577 ppm. Yet, the sensor produced was not highly selective to HCG as interference study shown high interference from the impurities added.

AL-MULAKHKHAS

يعد الكشف عن موجهة الغدد التناسلية المشيمية البشرية أحد طرق التشخيص البارزة في أمراض النساء والتوليد والأورام. في هذه الدراسة ، تم استخدام مزيج من جزيئات الذهب النانوية الوظيفية مع ثاني كبريتيد الجلوتاثيون وجهاز تحليلي مستند إلى ورق ميكروفلويديك للكشف عن وتقييم أدائها عند الكشف عن موجهة الغدد التناسلية المشيمية البشرية في الجانب الخطي والحساسية والانتقائية. تم تصنيع الجسيمات النانوية الذهبية المستخدمة في هذه الدراسة بنجاح وتميزت بحجم الجسيمات والهيدروديناميكية في 4.89 - 34.40 نانومتر و 31.03 نانومتر - 10.19 ميكرون على التوالي وتوجت مع أيون سترات. تم اشتقاق الجسيمات النانوية المصنوعة من ثاني كبريتيد الجلوتاثيون بنجاح كجهاز استشعار قائم على الجسيمات النانوية الذهبية لمكورات الغدد التناسلية المشيمية البشرية. ومع ذلك ، بسبب عدم وضوح رؤية تغيرات الألوان ، لم يكن المستشعر قابلاً للتطبيق على الجهاز التحليلي المستند إلى ورق ميكروفلويديك بشكل فعال. وفي الوقت نفسه ، أظهر المستشعر المستند إلى الجسيمات النانوية الذهبية أداءً حسيًا جيدًا حيث استجاب خطيًا للتركيز المتغير لمكورات الغدد التناسلية المشيمية البشرية بقيمة R^2 تبلغ 0.9877. كما أظهر المستشعر حساسية منخفضة مقارنة بالدراسات السابقة مع تحديد قيمة الكشف البالغة 0.1577 جزء في المليون. ومع ذلك ، فإن المستشعر المنتج لم يكن انتقائيًا للغاية لمكورات الغدد التناسلية المشيمية البشرية حيث أظهرت دراسة التداخل تدخلًا كبيرًا من الشوائب المضافة.

TABLE OF CONTENTS

AUTHOR DECLARATION i

ACKNOWLEDGEMENTS ii

ABSTRAK iii

ABSTRACT iv

AL-MULAKHKHAS v

LIST OF TABLES ix

LIST OF FIGURES x

LIST OF UNITS OF MEASUREMENTS xii

LIST OF ABBREVIATIONS xiii

CHAPTER 1: INTRODUCTION

1.1 Background of study 1

1.2 Problem statement 3

1.3 Objectives 4

CHAPTER 2: LITERATURE REVIEW

2.1 Gold nanoparticles (AuNPs) 5

2.1.1 Introduction 5

2.1.2 Synthesis of gold nanoparticle *via* trisodium citrate reduction 7

2.1.3 Characteristics of gold nanoparticles 8

2.1.4 AuNPs as chemical sensors 11

2.2 Microfluidic paper-based analytical device (µPAD) 15

2.2.1 Introduction 15

2.2.2 Applications of μPADs 16

2.3 Human chorionic gonadotropin 21

2.3.1 Introduction 21

2.3.2 Structure of HCG 22

2.3.3 Functions in medical field 23

CHAPTER 3: SYNTHESIS AND CHARACTERIZATION OF GOLD NANOPARTICLES AND ITS SENSORY DERIVATIVE

3.1 Experimental 26

3.1.1 Materials 26

3.1.2 Methods 26

3.2 Results and discussions 29

3.2.1 UV-Vis spectroscopy analysis of AuNP 29

3.2.2 FTIR spectroscopy analysis of AuNP 34

3.2.3 DLS measurement of AuNP 35

3.2.4 Formation of disulfide-linked AuNPs as AuNPs-based sensor 37

3.3 Conclusion 41

CHAPTER 4: FABRICATION OF MICROFLUIDIC PAPER-BASED ANALYTICAL DEVICE (μPAD)

4.1 Experimental 42

4.1.1 Materials 42

4.1.2 Fabrication of μPADs 42

4.1.3 Flow rate assessment of μPADs 43

4.2 Results and discussions 44

4.2.1 Flowrate from differing volumes of analyte 44

4.2.2 Flowrate from differing channel width 46

4.3 Conclusion 47

CHAPTER 5: CHARACTERIZATION OF DISULFIDE-LINKED GOLD NANOPARTICLES AS GOLD NANOPARTICLE-BASED SENSOR

5.1 Experimental 48

5.1.1 Materials 48

5.1.2 Linearity 48

5.1.3 Sensitivity 48

5.1.4 Selectivity 49

5.2 Results and discussions 49

5.2.1 Linearity and sensitivity 49

5.2.2 Selectivity 52

5.3 Conclusion 54

CHAPTER 6: CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion 55

6.2 Recommendations for future studies 56

REFERENCES 58

APPENDICES 63

List of presentations related to this study 63

List of publications related to this study 64

Example calculation particle size (Equation 1) 65

Example calculation interference percentage (Equation 17) 65

LIST OF TABLES

Tables		Page
Table 2.1:	Applications of μPADs in medical field (Shah et al. (2013))	16
Table 2.2:	Analysis results of transition metals present in welding fumes	18
Table 3.1:	Calculated number of gold atoms available in reaction solution	31
Table 3.2:	Molar ratio of gold chloride to sodium citrate	32
Table 3.3:	Peak assignment of each IR spectrum of sodium citrate and AuNPs from Figure 3.3	35
Table 3.4:	Average hydrodynamic size of synthesized AuNPs along with its respective polydispersity index	37
Table 5.1:	List of recently developed AuNPs-based HCG sensor along with its R2 and LOD value	53
Table 5.2:	Percentage of interference from the introduced interferent with respect to its added volume into 100 μl of 0.1 ppm HCG solution.	54

LIST OF FIGURES

Figures		Page
Figure 2.1:	UV-Vis spectrum of gold nanoparticle with SPR band ranged in 500-550 nm (Honary et al. (2012))	5
Figure 2.2:	FTIR spectra of citrate ion on AuNP and AgNP, compared to trisodium citrate (P. Wulandari et al.., 2015)	9
Figure 2.3:	Schematics of carboxylate stretching bands on AuNP under plasmon effect (P. Wulandari et al.., 2015)	9
Figure 2.4:	Simplified schematics of detection of AFU via AuNP and carbon dots (Mintz et al.., 2018)	11
Figure 2.5:	Schematics of modification of AuNP for cholera toxin sensing assay (Khan et al.., 2015)	12
Figure 2.6:	Regions in a microfluidic paper-based analytical device	14
Figure 2.7:	Jaffé reaction of creatinine and picric acid in alkaline medium (Randviir et al. (2013))	19
Figure 2.8:	Representation of structures of HCG with its related subunits and metabolites in the placenta, blood, and urine (Cole, 1997)	22
Figure 3.1:	Flow process of synthesizing AuNPs	27
Figure 3.2:	UV-Vis spectra of synthesized AuNP using different synthesis parameters: (a) reaction temperature; (b) gold chloride concentration; (c) sodium citrate concentration.	30
Figure 3.3:	Calculated particle size of synthesized AuNPs using formula by Haiss et al. (2007) from the UV-Vis spectra.	30
Figure 3.4:	IR spectra of the synthesized AuNPs compared to sodium citrate solution in distilled water	35
Figure 3.5:	Intensity-weighted size distributions of synthesized AuNP using different synthesis parameters: (a) reaction temperature, (b) sodium citrate concentration, (c) gold chloride concentration	36
Figure 3.6:	Synthesis of AuNP-GSSG using 3,3-DTDPA, EDC HCl and NHS to replace Lomant’s reagent	39

Figure 3.7: UV-Vis spectra of the synthesized AuNPs and the functionalized AuNPs with GSSG 40
Figure 4.1: Fabricated μPADs with different channel widths ((a) 5.0 mm, (b) 3.0 mm, (c) 1.0 mm) after wax treatment and drying. 44
Figure 4.2: Effect of varying volumes of liquid onto the flowrate on μPAD in relation to the contact angle of liquid 45
Figure 4.3: Effect of channel width on flowrate of liquid on μPAD in relation to the pressure difference between input and output region 47
Figure 5.1: UV-Vis spectra of AuNP-GSSG as AuNPs-based sensor along with the optical response upon introducing HCG into sensor solution 51
Figure 5.2: Linear plot of absorbance of AuNP-GSSG response to HCG versus the concentration of HCG 52
Figure 6.1: Excitation fluorescence spectra of AuNPs and its GSSG derivative 57

LIST OF UNITS OF MEASUREMENTS

Temperature	°C
Volume of liquid	ml
Concentration of solution	mM
	%
	ppm
	mIU/ml
Wavenumber	cm^{-1}
Wavelength	nm
Particle size	nm
Hydrodynamic size	nm
Mass	mg
	g
Amount of mole	mole
Channel width	mm
Flowrate of fluid	$\mu l\ s^{-1}$
Pressure difference	Pa

LIST OF ABBREVIATIONS

HCG	Human chorionic gonadotropin
POCT	Point-of-care testing
AuNPs	Gold nanoparticles
µPADs	Microfluidic paper-based analytical devices
SPR	Surface plasmon resonance
FRET	Förster resonance energy transfer
AgNPs	Silver nanoparticles
FTIR	Fourier transform infrared
DLS	Dynamic light scattering
EDC HCl	N-(3-dimethylaminopropyl)-N’-ethylcarbodiimide hydrochloride
NHS	N-hydroxysuccinimide
GSSG	Glutathione disulfide
PdI	Polydispersity index
LOD	Limit of detection
LOQ	Limit of quantification