Korespondensi_Artikel_Abd Hakim. S

Terlebih dahulu diikutkan prereview di di edit fage dengan Histori sebagai berikut

Histori Prereview

1. Hasil Prereview_1 Tanggal 18 Oktober 2022
2. Hasil Prereview_2 Tanggal 09 November 2022
3. Hasil Prereview_3 Tanggal 17 November 2022
4. Hasil Prereview_4 Tanggal 18 November 2022

Histori Publikasi

1. Pembuatan Akun di jurnal : 23 November 2022
2. Submit ke Jurnal : 25 November 2022
3. Artikel diterima : 27 November 2022
4. Koreksi yang dibuat ditinjau dan disetujui oleh editor produksi jurnal, Pertanyaan dan jawaban : 30 November 2022.
5. Artikel open akses : 5 Desember 2022

Marta-Usu

Pembuatan dan Karakterisasi Elektrode indikator dari bahan PPy+H_2SO_4 dan PPy+Asam sulfonat sebagai sensor urea dengan teknik immobilisasi Enzim urease pada PVA.

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Abstraks

Telah dilakukan penelitian tentang elektroda indikator (1) PVA-Enzim/PVC-KTpClPB, sensitivitas 19.069 mV/decade, rentang deteksi 1.10^{-5} -5.10^{-4} M limit deteksi 1.10^{-5} M. Lebar puncak absorbansi Uv-vis sempit (2) PVA-Enzim/GA-2.9%/PVC-KTpClPB lebar puncak absorbansi UV-vis besar tetapi puncak absorbansi menurun, (3) PVA-Enzim/GA-2.9%/PVC-KTpClPB-o-NPOE analisis XRD pola spektrum amorf muncul (4) PVA-Enzim/GA-2.9%/PPy+H_2SO_4/PVC-KTpClPB-o-NPOE (5) PVA-Enzim/GA-2.9%/PPy+Asam Sulfonat/PVC-KTpClPB-o-NPOE, pola spektrum amorf pada (4) dan (5) sangat berkurang untuk variasi enzim 0.6 g dalam 0.5 mL (50% air + 50% akohol). GA berperan menambah rentang deteksi, o-NPOE membentuk amorf, variasi enzim meningkatkan intensitas pola spektrum XRD. Metode pengembangan modifikasi membran elektroda indikator secara bertahap dengan ikatan silang GA, o-NPOE, polimer konduktif. Hasil terbaik diperoleh pada elektroda indikator PVA-Enzim/GA-2.9%/PPy+Asam Sulfonat/PVC-KTpClPB-o-NPOE. Analisis kurva linear sampel As-1 sensitivitas 41.56 mV/dekacde, rentang deteksi 10^{-4} - 10^{-1} M serta limit deteksi 10^{-4} M, R^2 = 97.51 %. Elektrode indikator terbaik adalah EI_5.

Key word : PVA-Enzim/GA-2.9%/PPy+H_2SO_4 atau Asam Sulfonat/PVC-KTpClPB-o-NPOE, Potensiometri biosensor, Immobilisasi enzim urease

Introduction

Modifikasi lapisan membran elektroda indikator dimulai dari (1) PVA-Enzim/PVC-KTpClPB **[Dana Vlascici 2008],** (2) PVA-Enzim/GA-2.9%/PVC-KTpClPB **[Aparicio-Collado, 2021; Dana Vlascici 2008]**, (3) PVA-Enzim/GA-2.9%/PVC-KTpClPB-o-NPOE, (4) PVA-Enzim/GA-2.9%/PPy+ H_2SO_4 /PVC - KTpClPB-o-NPOE, PVA-Enzim/GA-2.9%/PPy+Asam Sulfonat/PVC-KTpClPB-o-NPOE.

Masing masing elektroda indikator diberi notasi EI_1, EI_2, EI_3, EI_4 dan EI_5. EI_1 pola spektrum absorbansi sempit menghasilkan rentang deteksi kecil dimodifikasi menjadi EI_2. EI_2 dimodifikasi dengan menambahkan lapisan GA pada variasi 2.6%, 2.9% dan 3.0% di PVA-Enzim dari EI_1. Larutan GA dianalisis dengan UV-Vis pola spektrum absorbansi meningkatkan lebar puncak absrbansi yang berpengaruh pada rntang deteksi (lihat gambar 1a). Modifikasi EI_2 dilanjutkan lagi dengan menambahkan larutan o-NPOE pada variasi 61% dan 66% di larutan PVC-KTpCLPB. Laritan PVC-KTpCLPB-o-NPOE dianalisis dengan UV-Vis mengasilkan pola spektrum absorbansi terlihat gambar 1b. Analisis EI_2 dengan XRD

menghasilkan pola difraksi spektrum amorf di sekitar sudut 2theta 20 – 25 derajat disertai turunnya intensitas energi lihat gambar 2a. Terbentuknya pola spektrum amorf dan menurunya intensitas.

Atas dasar gambar 1 dan 2, peneliti lanjutkan modifikasi membran elektroda indikator dengan bahan polimer konduktor yaitu PPy. PPy ini hanya bisa larut di H_2SO_4 dan Asam sulfonat. H_2SO_4 larut pada konsentrasi 8 M sedangkan asam sulfonat larut pada konsentrasi 1 M. Modifikasi membran elektroda secara berurutan (1) PVA-Enzim/GA-2.9%/PPy+H_2SO_4/PVC-KTpClPB-o-NPOE, dinotasi EI_4-1(2) PVA-Enzim/GA-2.9%/PPy+Asam Sulfonat/PVC-KTpClPB-o-NPOE dinotasi EI_5-1. Prosedur modifikasi EI_4-1 dan EI_5-1, variasi jumlah tetes enzim urease yaitu satu tetes dan tiga tets, hasil analisis dapat dilihat gambar 2b, 2c dan tabel 1. Lapisan membran elektroda terdiri dari empat lapisan, lapisan pertama PVA-Enzim, lapisan kedua GA 2.9%, lapisan ketiga PPy+H_2SO_4 atau PPy+Asam Sulfonat, lapisan keempat PVC-KTpClPB-o-NPOE 61%. Dipilihnya o-NPOE 61% dari analisis UV-Vis gambar 1. Dihubungkan dengan gambar 2b, 2c dan tabel 1, analisis pola spektrum difraksi XRD menunjukkan bekurang sangat banyak pola spektrum amorf diikuti juga meningkatnya pola spektru kristal.

Terseleksinya sampel elektroda indikator ini untuk memilih elektroda terbaik menurut modifikasi lapisan yang telah dianalisis pola spektrum absorbansi dari lapisan satu immobilisasi PVA-enzim; lapisan dua ikatan silang GA; lapisan tiga polimer konduksi PPy; dan lapisan empat plastesisier o-NPOE pada PVC-KTpClPB [**El-Naby, E.H., 2019**]. Setelah analisis XRD dari sampel EI_5-1, EI_5-3, EI_4-1, EI_4-3 dipilih sampel terbaik yaitu EI_5-1 dan EI_4-1. kedua sampel dianalisis dengan FTIR, respon waktu sel potensiometer dan analisis kurva linear menentukan sensitivitas, rentang deteksi, limit deteksi dan $R^{2.}$

Methods

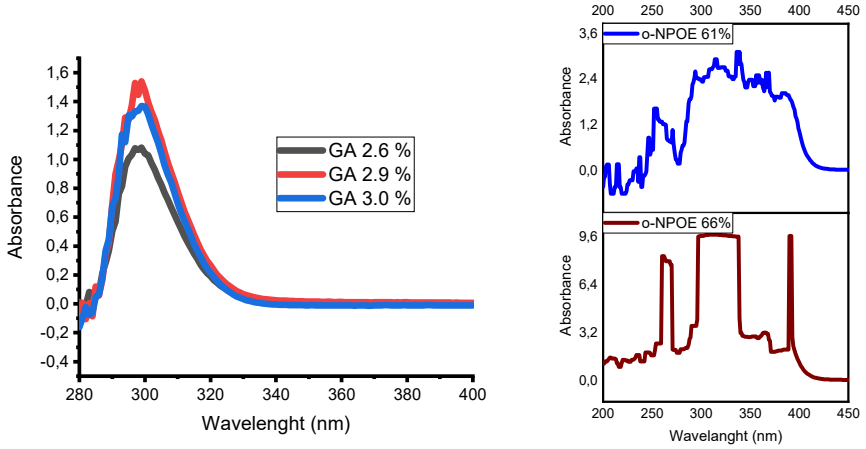
Metode dalam penelitian ini adalah metode potensiometri biosensor [**Thakur dan Ragavan, 2013**]; **Amal M. Al-Mohaimeed, at. All 2021; Linda Bertel 2021]** teknik immobilisasi [**Nimse, 2014**] enzim urease yang analit urea, dengan menggunakan sel potensimetri menentukan kelayakan sensor urea berdasarkan (1) respon waktu sampel EI_5-1 dan EI_4-1, (2) melalui analisis kurva linear. Bahan terdiri dari tungsten diameter 1,0 mm 267 562 99,99%, PVA [-CH_2CHOH-]n, enzim EC 3.5.1.5 (Urease) U4002, *Glutaraldehyde* (GA), PPy, H_2SO_4, asam sulfonat, PVC (CH_2CHCl)n, potassium tetrakis 4-chlorophenyl borate $(ClC_6H_4)_4BK$, tetrahydrofuran C_4H_8O, o-NPOE, KCl. Potensiometer (Keithley 199 DMM, USA), elektroda indikator tungsten (W), Ag/AgCl MF-2052 Elektroda referensi RE-5B dalam sel elektrokimia yang dirakit dengan mikrokomputer (instrumen Powerlab ADI, Australia), pengaduk magnet serta injeksi aliran (FIA).

Result and Discussion

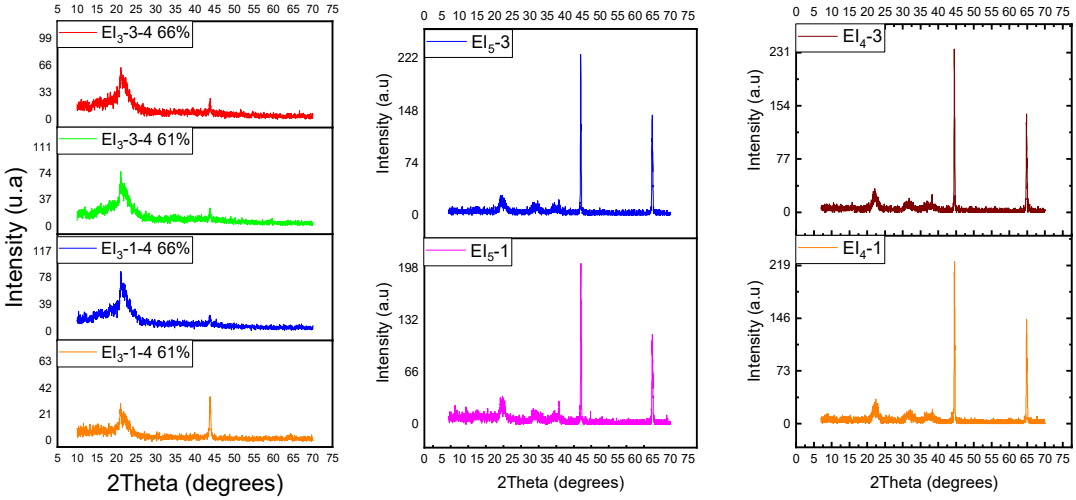
Gambar 1, menunjukkan analisis elektroda indikator dengan UV-Vis [**Rezayi dkk, 2012;Singh dkk, 2013; Sharma dkk, 2016; Alarfaj, N.A. and El-Tohamy, M. F., 2020**] terhadap larutan GA **[Aparicio-Collado, 2021]** dan larutan o-NPOE dalam PVC-KTpClPB (PVC-KTpClPB-o-NPOE) **[Dana Vlascici 2008, Ulianas, Heng and Ahmad, 2011; Huang, 2014; Mir, Lugo, Tahirbegi and Josep Samitier, 2014, Kaur, Chhibber and Mittal, 2017; Elbehery, 2019; Alarfaj, N.A. and El-Tohamy, M. F., 2020**; **Amr, 2021]**. Pola spektrum absorbansi terhadap bilangan gelombang keduanya menunjukkan pelebaran pola spektrum absorbansi baik untuk GA maupun PVC-KTpClPB-o-NPOE. Analisis gambar 1a dan 1b

terilih GA 2.9 % terbaik dan PVC-KTpClPB-o-NPOE (o-NPOE 61). atas dasar elektroda indikator dilapisi untuk lapisan kedua dan keempat.

Gambar 2, menunjukkan analisis pola spktrum difraksi XRD [**Shawky, 2021**] untuk elektroda indikator (a) EI_3-1-4 61%, EI_3-1-4 66%, EI_3-3-4 61% dan EI_3-3-4 66%, (b) EI_5-1, EI_5-3, (c) EI_4-1, EI_4-3. Pada gambar 2a pola spktrum difraksi XRD dari EI_3-1-4 61%, EI_3-1-4 66%, EI_3-3-4 61%, terbentuknya pola spektrum amorf dan kristal yang rendah intensitasnya. Berbeda dengan gambar 2b EI_5-1 dan EI_5-3, 2c EI_4-1 dan EI_4-3 [**Hakim et al, 2021**], terbentuk pola spektrum amorf yang rendah dan kristal yang tinggi intensitasnya. Jadi sudah jelas pola lapisan elektroda indikator EI_5-1, EI_5-3 dan EI_4-1, EI_4-3, masing-masing dalam variasi jumlah tetes enzim urease satu tetes dan tiga tetes. Tinggi puncak intensitas energi terhadap sudut difraksi 2theta dapat dilihat tabel 1 (a) EI_5-1 tinggi intensitas 204 (a.u) pada sudut difraksi 44.54 derajat, (b) EI_5-3 tinggi intensitas 228 (a.u) pada sudut difraksi 44.5 derajat, (c) EI_4-1 tinggi intensitas 224 (a.u) pada sudut difraksi 44.54 derajat, (d) EI_4-3 tinggi intensitas 236 (a.u) pada sudut difraksi 44.48 derajat.



Gambar 1. Analisis UV-Vis larutan (a) GA 2.6%, 2.9% dan 3.0%, (b) PVC-KTpClPB-o-NPOE 61%, 66%.



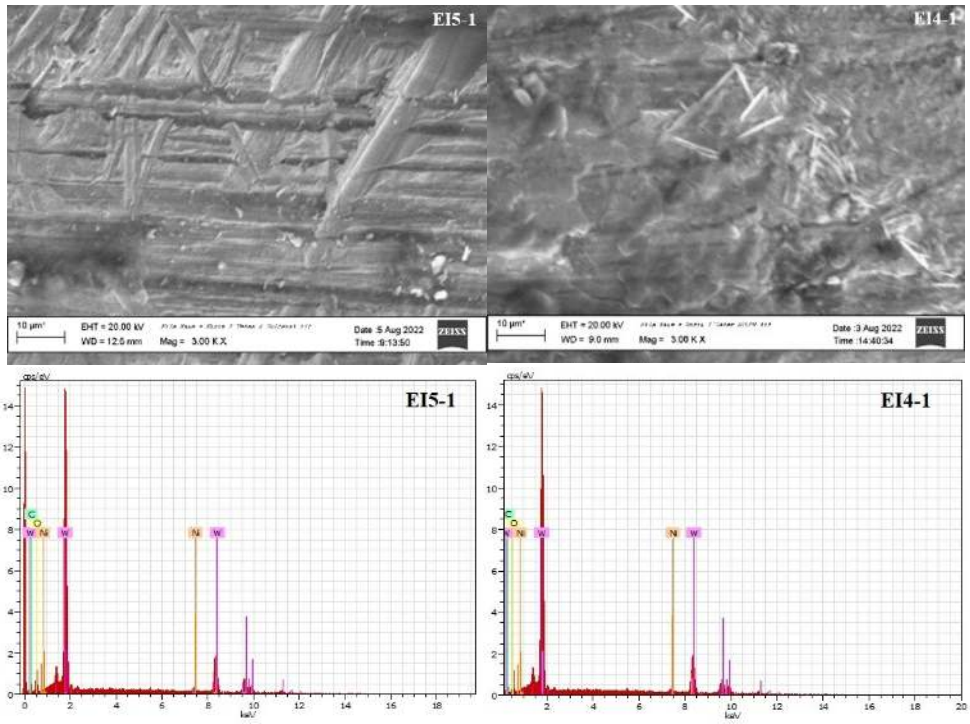
Gambar 2. Analisis pola spektrum difraksi XRD elektroda indikator (a) EI_3-1-4 61%, EI_3-1-4 66%, EI_3-3-4 61% dan EI_3-3-4 66%, (b) EI_5-1, EI_5-3, (c) EI_4-1, EI_4-3

Table 1. Analisis pola spektrum EDX elektroda indikator (a) EI_5-1, (b) EI_5-3, (c) EI_4-1, (d) EI_4-3

2Theta	EI_5-1	EI_5-3	EI_4-1	EI_4-3

44.48	140	220	166	236
44.5	164	228	210	216
44.54	204	176	224	172

Peneliti masih melanjutkan analisis dengan SEM-EDX dan FTIR [**Alharthi, S.S., Fallatah, A.M. and Al-Saidi, H.M., 2021**] untuk kepastian yang jelas dari material yang digunakan pada elektroda indikator (a) EI_5-1, (b) EI_5-3, (c) EI_4-1, (d) EI_4-3 sebagai satu sampel terbaik. Analisis morpologi SEM dengan perbesaran 3 Kx pada 10 µm tegangan 20 Kv menghasilkan perbedaan intensitas energi 13.5 cps/keV 1M sampel EI_5-1 dan intensitas energi 14.7 cps/keV, 8 M sampel EI_4-1. Atas dasar tabel 1 diperoleh peningkatan intensitas analisis XRD, tabel 2 diperoleh ketidak sesuaian data lebih besar persen berat EI_4-1 dari pada persen berat EI_5-1. Sedangkan analisis FTIR gambar 4 dan tabel 3 transmitansi meningkat untuk elektroda indikator EI_5-1 dan EI_5-3, sebaliknya transmitansi menurun untuk elektroda indikator EI_4-1 dan EI_4-3. Analisis XRD, FTIR dan SEM-EDX **[Amal M. Al-Mohaimeed, at. All 2021; Linda Bertel , 2021; Wei Chen 2022]** maka terpilih sampel terbaik adalah EI_5-1 dan EI_4-1.



Gambar 3. SEM morphology and Spectrum pattern of intensity to EDX energy from indicator electrode (a) EI_5-1, (b) EI_4-1

Tabel 2. Persen berat elektroda indikator dari pola spektrum EDX sampel EI_5-1 dan EI_4-1

Elektroda Indikator	Material	unn. C [wt.%]	norm. C [wt.%]	Atom. C [at.%]	Error (1 Sigma) [wt.%]
EI_5-1	W 74 L-series	69.07	76.86	29.23	2.28
EI_4-1	W 74 L-series	81.95	83.86	32.85	2.65

Table 3. Table of transmittance ranges for sample wave numbers (a) EI_4-1, (b) EI_5-1

Wavenumber (cm^{-1})	Transmittance (%)			
	EI_4-1	EI_4-3	EI_5-1	EI_5-3

600	60.8895	75.5583	75.9339	48.5782
4000	97.9351	100.9955	102.5625	100.8259

Setelah terpilih dua sampel elektroda indikaor EI_5-1 dan EI_4-1, sesuai dengan metode poenstiometri biosensor digunakan sel potensiometer untuk uji kelayakan respon waktu elektroda indikator (gambar 5). Analisa respon waktu **[Linda Bertel 2021]** gambar 5a dan 5b terbaik diperoleh pada sampel EI_5-1 juga didukung oleh data pada tabel 4 bahwa elektroda indikator EI_5-1 memiliki sensitivitas 41.56 mV/dekade, rentang deteksi 10^{-4} - 10^{-1} M, limit deteksi 10^{-4} M dan R^2 = 97.51% **[Rahman, 2008; Hakim, 2019**; **Amal M. Al-Mohaimeed, at. All 2021]**. Lebih besar rentang deteksi EI_5-1 daripada EI_4-1 rentang deteksi 10^{-3} - 10^{-1} M, limit deteksi 10^{-3} M sedangkan R^2 = 98.83% [**Ibupato dkk, 2012; Huang dkk, 2014; Elhag dkk, 2014**].

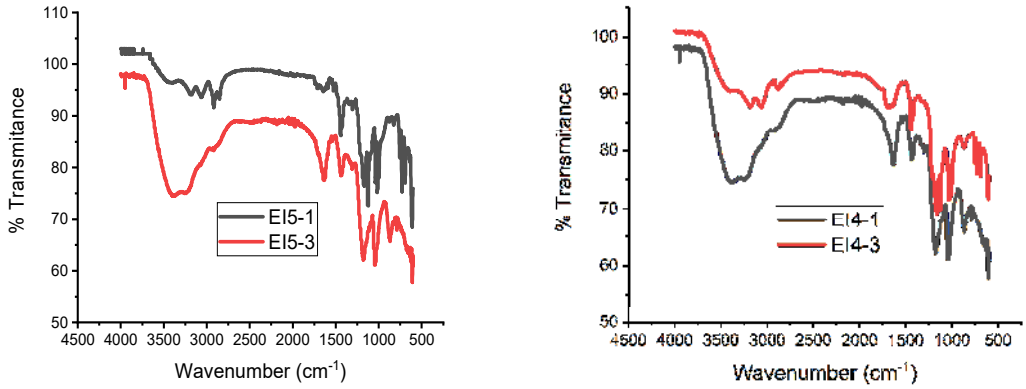
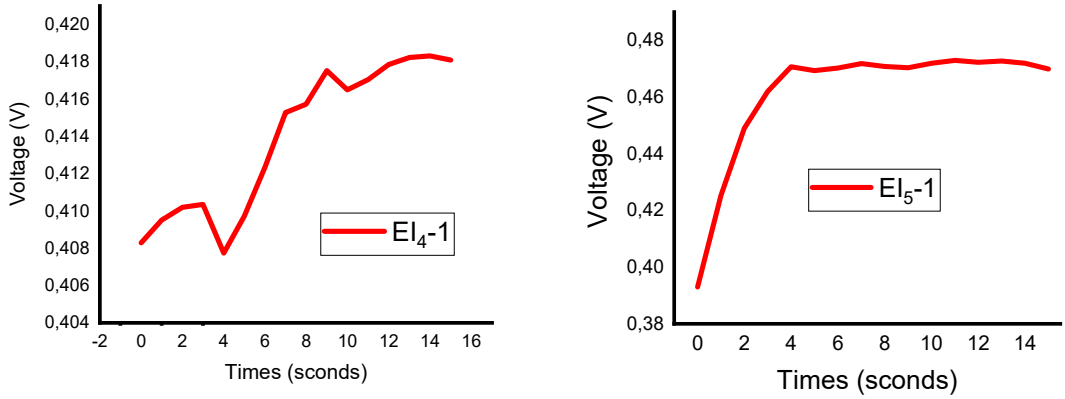


Figure 4. The pattern of the transmittance spectrum against the wavenumber of the indicator electrodes (a) EI_5-1, EI_5-3, (b) EI_4-1, EI_4-3



Gambar 5. Respon waktu (a) EI_4-1, (b) EI_5-1

Tabel 4. Kurva linear elektroda indikator EI_4-1 dan EI_5-1

Lapisan membran elektroda indikator	Sensitivitas mV/dekade	Rentang deteksi (M)	Limit deteksi (M)	R-square (R^2) (%)
EI_4-1	43.79	10^{-3} - 10^{-1}	10^{-3}	98.83
EI_5-1	41.56	10^{-4} - 10^{-1}	10^{-4}	97.51

Dalam deteksi elektrokimia, sinyal terkait dengan interaksi analit di ukur melalui elektroda. Pengukuran dapat dilakukan dengan cara (a) menghubungkan arus dan tegangan, yaitu biosensor voltametri dan metrik konduktor; (b) arus atau tegangan terhadap waktu, yaitu, amperometrik atau potensiometri; (c) imajiner versus bagian nyata dari impedansi, yaitu, impedometrik; (d) mengalirkan arus versus tegangan saluran dalam biosensor FET **[Linda Bertel , 2021],** kesepakatan dengan analisis yang dilaporkan sebelumnya (yaitu, FTIR, XRD, dan SEM) **[Wei Chen, 2022]** dan mengkonfirmasi interaksi dengan pengubah organik yang ditambahkan.

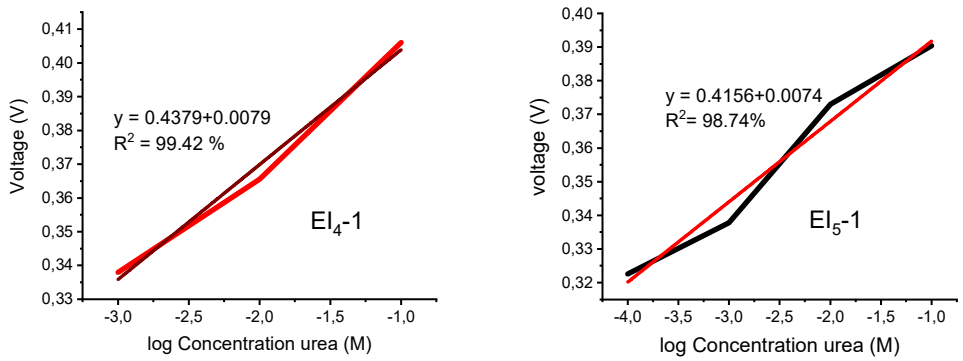


Figure 7. Analisis kurva linear (1) EI_5-1, (b) EI_4-1

Prosedur penelitian ini mengikuti (a) Analisis transmitansi, edx, xrd **[Bibi, Aamna 2022],** edx, xrd, kurva linear, sensitivitas dan rentang deteksi **[Mashuni, Mashuni, 2022],** transmitansi, consentrasi, sensitivitas **[Er-Yuan Chuang, 2021; Hui-Tzung Luh, 2022; Sriwichai, Saengrawee 2022];** (b) Sistem biosensor [**Thakur dan Ragavan, 2013**] yaitu (1) selektivitas, (2) sensitivitas, (3) respons linearitas yaitu rentang konsentrasi dari analit target yang akan diukur, (4) reproduksibilitas respons sinyal, sampel yang memiliki konsentrasi yang sama dianalisis beberapa kali harus memberikan respons yang sama, (5) waktu respons cepat dan waktu pemulihan untuk dapat digunakan kembalinya sistem biosensor, (6) Stabilitas dan masa operasi; (c) Teknik imobilisasi [Nimse dikembangkan didasarkan pada tiga mekanisme penting yaitu (1) adsorpsi fisik, (2) imobilisasi kovalen, (3) imobilisasi streptavidin-biotin. Pencapaian sensitivitas tinggi dan selektivitas membutuhkan minimalisasi adsorpsi nonspesifik dan stabilitas.

Conclusion

Sebagai kesimpulan dari analisis XRD, SEM-EDX dan FTIR, respon waktu serta analisis kurva linear diperoleh sampel terbaik adalah elektroda indikator EI_5-1dengan modifikasi empat lapisan yaitu PVA-Enzim/GA-2.9%/PPy+Asam Sulfonat/PVC-KTpClPB-o-NPOE.

Acknowledgement

Saya ucapkan terimakasih kepada Universitas Negeri Medan atas saya peroleh Penelitian Terapan tahun 2022, serta kerjasama analisis data dengan Universitas Sumatera Utara.

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Marta-Usu

Manufacture and characterization of indicator electrodes from PPy+H_2SO_4 and PPy+Sulfonic acid as a urea sensor using urease enzyme immobilization technique in PVA.

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Abstraks

Research has been carried out on indicator electrodes (1) PVA-Enzyme/PVC-KTpClPB, sensitivity 19,069 mV/decade, detection range 1.10^{-5} -5.10^{-4} M, detection limit 1.10-5 M. The width of the peak UV-vis absorbance is narrow (2) PVA-Enzyme/GA-2.9%/PVC-KTpClPB wide UV-vis absorbance peak but the absorbance peak decreased, (3) PVA-Enzyme/GA-2.9%/PVC-KTpClPB-o-NPOE XRD analysis amorphous spectral pattern appeared (4) PVA-Enzyme/GA-2.9%/PPy+H_2SO_4/PVC-KTpClPB-o-NPOE (5) PVA-Enzyme/GA-2.9%/PPy+Sulfonic Acid/PVC-KTpClPB-o-NPOE, amorphous spectrum pattern in (4) and (5) were greatly reduced for the enzyme variation of 0.6 g in 0.5 mL (50% water + 50% alcohol). GA plays a role in increasing the detection range, o-NPOE forms amorphous, enzyme variations increase the intensity of the XRD spectrum pattern. The method of developing a gradual modification of the indicator electrode membrane by cross-linking GA, o-NPOE, conductive polymer. The best results were obtained at the indicator electrode PVA-Enzyme/GA-2.9%/PPy+Sulfonic Acid/PVC-KTpClPB-o-NPOE. Analysis of the linear curve of the sample EI_5-1 with a sensitivity of 41.56 mV/decade, a detection range of 10^{-4} - 10^{-1} M and a detection limit of 10^{-4} M, R^2 = 97.51%. The best indicator electrode is EI_5-1.

Key words : PVA-Enzyme/GA-2.9%/PPy+H2SO4 or Sulphonic Acid/PVC-KTpClPB-o-NPOE, Biosensor potentiometry, Immobilization of urease enzyme

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Introduction

Modification of the indicator electrode membrane layer started from (1) PVA-Enzyme/PVC-KTpClPB [Dana Vlascici 2008], (2) PVA-Enzyme/GA-2.9%/PVC-KTpClPB [Aparicio-Collado, 2021; Dana Vlascici 2008], (3) PVA-Enzyme/GA-2.9%/PVC-KTpClPB-o-NPOE, (4) PVA-Enzyme/GA-2.9%/PPy+ H_2SO_4 /PVC - KTpClPB-o-NPOE, PVA- Enzyme/GA-2.9%/PPy+Sulfonic Acid/PVC-KTpClPB-o-NPOE.

Each indicator electrode is given the notation EI_1, EI_2, EI_3, EI_4 and EI_5. EI_1 narrow absorbance spectrum pattern resulting in a small detection range modified to EI_2. EI_2 was modified by adding a GA layer at variations of 2.6%, 2.9% and 3.0% in PVA-Enzyme from EI1. The GA solution was analyzed by UV-vis. The absorbance spectrum pattern increases the width of the absorption peak which affects the detection range (see Figure 1a). EI_2 modification was continued by adding o-NPOE solution at variations of 61% and 66% in PVC-KTpClPB solution. The PVC-KTpClPB-o-NPOE solution was analyzed by UV-vis to

produce the absorbance spectrum pattern seen in Figure 1b. EI_2 analysis with XRD produces an amorphous spectral diffraction pattern around the 2theta angle of 20-25 degrees accompanied by a decrease in energy intensity, see Figure 2a. The formation of an amorphous spectrum pattern and a decrease in intensity.

Based on Figures 1 and 2, the researchers continued to modify the indicator electrode membrane with a conducting polymer material, namely PPy. This PPy can only dissolve in H2SO4 and Sulphonic Acid. H_2SO_4 is soluble at a concentration of 8 M while sulfonic acid is soluble at a concentration of 1 M. Modification of the electrode membrane in sequence (1) PVA-Enzyme/GA-2.9%/PPy+H_2SO_4/PVC-KTpClPB-o-NPOE, denoted EI_4-1 (2) PVA-Enzyme/GA-2.9%/PPy+Sulfonic Acid/PVC-KTpClPB-o-NPOE denoted EI_5-1. Modification procedures EI_4-1 and EI_5-1, variations in the number of drops of urease enzyme are one drop and three drops, the results of the analysis can be seen in Figures 2b, 2c and table 1. The electrode membrane layer consists of four layers, the first layer is PVA-Enzyme, the second layer GA 2.9%, third layer PPy+H_2SO_4 or PPy+Sulfonic Acid, fourth layer PVC-KTpClPB-o-NPOE 61%. Selected o-NPOE 61% from the UV-Vis analysis of Figure 1. Compared to Figures 2b, 2c and table 1, the XRD diffraction spectrum pattern analysis showed a very large decrease in the amorphous spectrum pattern followed by an increase in the crystal spectral pattern.

This indicator electrode sample was selected to select the best electrode according to the layer modification which had analyzed the absorbance spectrum pattern of the PVA-enzyme immobilized layer; layer two GA crosslinks; PPy conduction polymer triple layer; and a layer of four o-NPOE plasticizers on PVC-KTpClPB [El-Naby, E.H., 2019]. After XRD analysis of samples EI5-1, EI5-3, EI4-1, EI4-3, the best samples were EI5-1 and EI4-1. Both samples were analyzed by FTIR, cell response potentiometer and linear curve analysis determining sensitivity, detection range, detection limit and R^2.

Methods

The method in this study is the biosensor potentiometric method [Thakur and Ragavan, 2013]; Amal M. Al-Mohaimeed, at. All 2021; Linda Bertel 2021] immobilization technique [Nimse, 2014] urease enzyme which analytes urea, using potentimetric cells to determine the feasibility of urea sensors based on (1) response time of samples EI_5-1 and EI_4-1, (2) through linear curve analysis. Materials consist of 1.0 mm diameter tungsten 267 562 99.99%, PVA [-CH_2CHOH-]n, enzyme EC 3.5.1.5 (Urease) U4002, Glutaraldehyde (GA), PPy, H_2SO_4, Sulphonic acid, PVC (CH_2CHCl) n, potassium tetrakis 4-chlorophenyl borate $(ClC_6H_4)_4BK$, tetrahydrofuran C_4H_8O, o-NPOE, KCl. Potentiometer (Keithley 199 DMM, USA), tungsten indicator electrode (W), Ag/AgCl MF-2052 RE-5B reference electrode in a microcomputer assembled electrochemical cell (ADI Powerlab instruments, Australia), magnetic stirrer and flow injection (FIA)

Result and Discussion

Figure 1, shows the analysis of the indicator electrode with UV-Vis [Rezayi et al, 2012; Singh et al, 2013; Sharma et al, 2016; Alarfaj, N.A. and El-Tohamy, M. F., 2020] on GA solution [Aparicio-Collado, 2021] and o-NPOE solution in PVC-KTpClPB (PVC-KTpClPB-o-NPOE) [Dana Vlascici 2008, Ulianas, Heng and Ahmad, 2011; Huang, 2014; Mir, Lugo, Tahirbegi and Josep Samitier, 2014, Kaur, Chhibber and Mittal, 2017; Elbehery, 2019; Alarfaj, N.A. and El-Tohamy, M. F., 2020; Amr, 2021]. he absorbance spectrum pattern with

respect to the wavenumber of both shows a widening of the absorbance spectrum pattern for both GA and PVC-KTpClPB-o-NPOE. Analysis of Figures 1a and 1b selected the best 2.9% GA and PVC-KTpClPB-o-NPOE (o-NPOE 61%). on the basis of coated indicator electrodes for the second and fourth layers.

Figure 2, shows the analysis of the XRD diffraction spectrum pattern [Shawky, 2021] for the indicator electrodes (a) EI_3-1-4 61%, EI_3-1-4 66%, EI_3-3-4 61% and EI_3-3-4 66 %, (b) EI_5-1, EI_5-3, (c) EI_4-1, EI_4-3. In Figure 2a the XRD diffraction spectrum pattern from EI_3-1-4 61%, EI_3-1-4 66%, EI_3-3-4 61%, amorphous and crystalline spectrum patterns are formed with low intensity. In contrast to Figures 2b EI_5-1 and EI_5-3, 2c EI_4-1 and EI_4-3 [Hakim et al, 2021], a low amorphous spectrum pattern and high intensity crystals are formed. So it is clear that the pattern of the indicator electrode layers EI_5-1, EI_5-3 and EI_4-1, EI_4-3, varies in the number of drops of urease enzyme, one drop and three drops, respectively. The peak height of energy intensity with respect to the diffraction angle of 2theta can be seen in table 1 (a) EI_5-1 high intensity 204 (a.u) at a diffraction angle of 44.54 degrees, (b) EI_5-3 high intensity 228 (a.u) at a diffraction angle of 44.5 degrees, (c) EI_4-1 high intensity 224 (a.u) at a diffraction angle of 44.54 degrees, (d) EI_4-3 high intensity 236 (a.u) at a diffraction angle of 44.48 degrees.

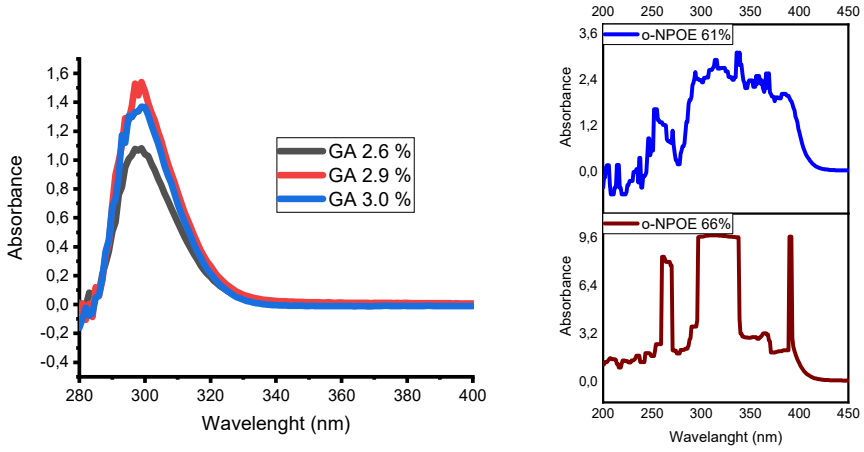

Figure 1. UV-Vis analysis of solutions (a) GA 2.6%, 2.9% and 3.0%, (b) PVC-KTpClPB-o-NPOE 61%, 66%.

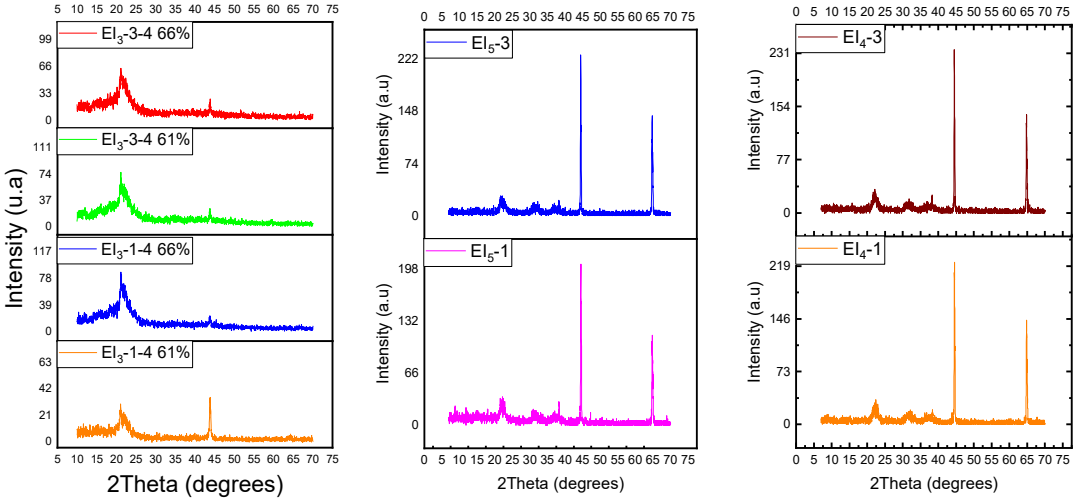

Figure 2. Analysis of the XRD diffraction spectrum pattern of the indicator electrode (a) EI_3-1-4 61%, EI_3-1-4 66%, EI_3-3-4 61% and EI_3-3-4 66%, (b) EI5-1 and EI_5-3, (c)EI_4-1and EI_4-3.

Table 1. Analysis of the EDX spectrum pattern of the indicator electrode (a) EI5-1, (b) EI5-3, (c) EI4-1, (d) EI4-3

2Theta	EI_5-1	EI_5-3	EI_4-1	EI_4-3
44.48	140	220	166	236
44.5	164	228	210	216
44.54	204	176	224	172

Researchers are still continuing the analysis with SEM-EDX and FTIR [Alharthi, S.S., Fallatah, A.M. and Al-Saidi, H.M., 2021] for clear assurance of the material used in the indicator electrodes (a) EI_5-1, (b) EI_5-3, (c) EI_4-1, (d) EI_4-3 as one sample best.
SEM morphology analysis with 3 Kx magnification at a voltage of 10 m 20 Kv resulted in a difference in energy intensity of 13.5 cps/keV 1M sample EI_5-1 and energy intensity 14.7 cps/keV 8 M sample EI_4-1. Based on table 1, it was obtained that the intensity of XRD analysis increased, table 2 obtained that the data discrepancy was greater in weight percent EI_4-1 than weight percent EI_5-1. While the FTIR analysis in Figure 4 and Table 3 increases the transmittance for the indicator electrodes EI_5-1 and EI_5-3, on the contrary, the transmittance decreases for the indicator electrodes EI_4-1 and EI_4-3. XRD, FTIR and SEM-EDX analysis [Amal M. Al-Mohaimeed, at. All 2021; Linda Bertel, 2021; Wei Chen 2022] then the best samples are EI_5-1 and EI_4-1.

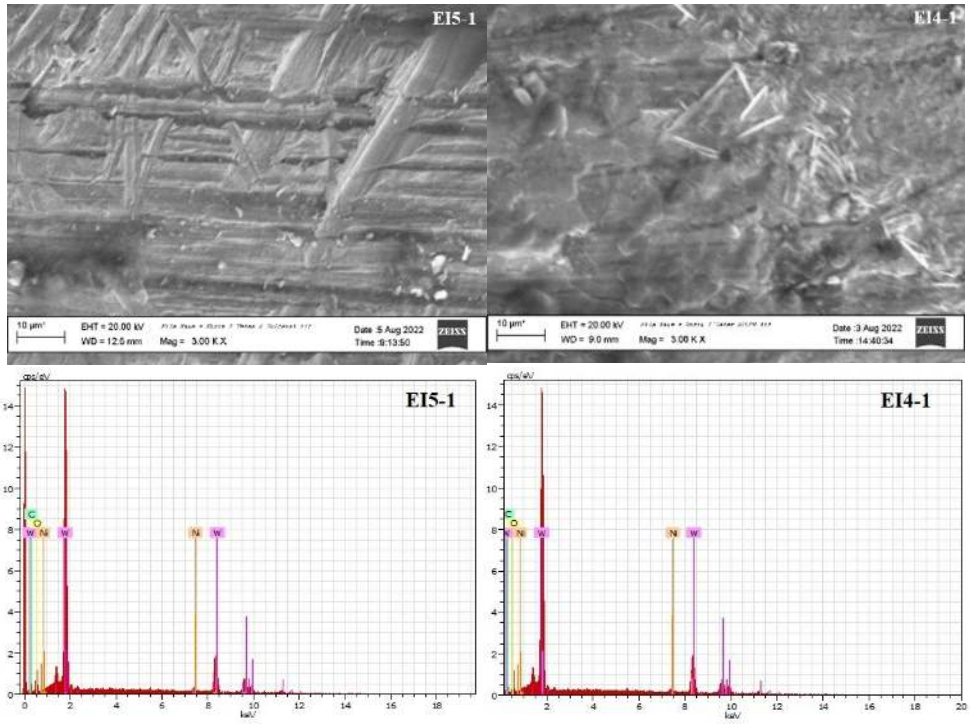

Figure 3. SEM morphology and Spectrum pattern of intensity to EDX energy from indicator electrode (a) EI_5-1, (b) EI_4-1

Table 2. Weight percentage of indicator electrodes from the EDX spectrum pattern of samples EI_5-1 and EI_4-1

Indicator Electrodes	Material	unn. C	norm. C	Atom. C	Error (1 Sigma)
		[wt.%]	[wt.%]	[at.%]	[wt.%]

EI_5-1	W 74 L-series	69.07	76.86	29.23	2.28
EI_4-1	W 74 L-series	81.95	83.86	32.85	2.65

Table 3. Table of transmittance ranges for sample wave numbers (a) EI4-1, (b) EI5-1

Wavenumber (cm^{-1})	Transmittance (%)			
	EI_4-1	EI_4-3	EI_5-1	EI_5-3
600	60.8895	75.5583	75.9339	48.5782
4000	97.9351	100.9955	102.5625	100.8259

After selecting two samples of indicator electrodes EI_5-1 and EI_4-1, according to the biosensor poenstiometry method, a potentiometer cell was used to test the feasibility of the indicator electrode response time (figure 5). The best response time analysis [Linda Bertel 2021] Figures 5a and 5b were obtained on the EI_5-1 sample also supported by the data in table 4 that the EI_5-1 indicator electrode has a sensitivity of 41.56 mV/decade, a detection range of 10^{-4} - 10^{-1} M, detection limit is 10^{-4} M and R^2 = 97.51% [Rahman, 2008; Judge, 2019; Amal M. Al-Mohaimeed, at. All 2021]. The detection range of EI_5-1 is greater than that of EI_4-1, the detection range is 10^{-3} - 10^{-1} M, the detection limit is 10^{-3} M, while R2 = 98.83% [Ibupato et al, 2012; Huang et al, 2014; Elhag et al, 2014].

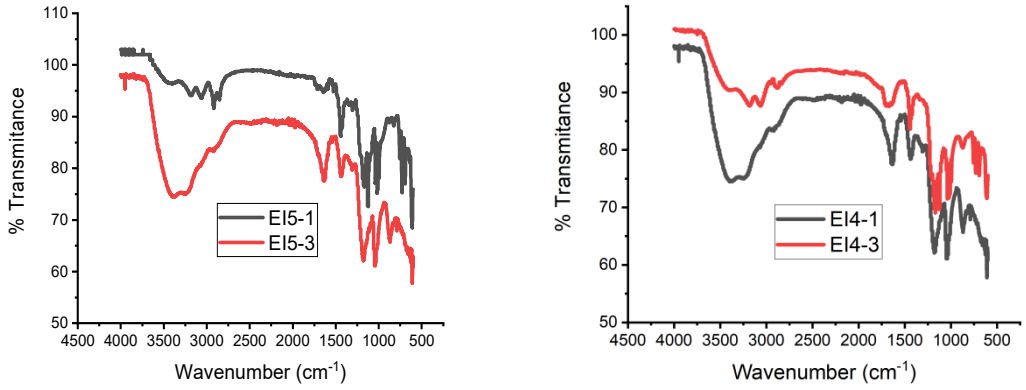

Figure 4. The pattern of the transmittance spectrum against the wavenumber of the indicator electrodes (a) EI_5-1, EI_5-3, (b) EI_4-1, EI_4-3

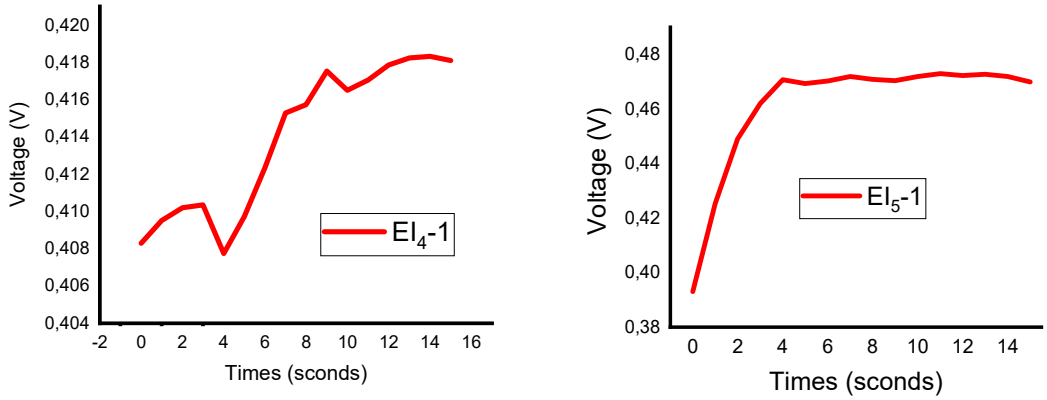

Figure 5. Response time (a) EI4-1, (b) EI5-1

Table 4. Linear curve of indicator electrodes EI_4-1 and EI_5-1

Indicator electrode membrane layer	Sensitivity mV/decade	Detection range (M)	Detection limit (M)	R-square (R^2) (%)
EI_4-1	43.79	10^{-3} - 10^{-1}	10^{-3}	98.83
EI_5-1	41.56	10^{-4} - 10^{-1}	10^{-4}	97.51

In electrochemical detection, the signal associated with the interaction of the analyte is measured through the electrode. Measurements can be made by (a) connecting current and voltage, namely voltammetric and conductor metric biosensors; (b) current or voltage with respect to time, ie, amperometric or potentiometric; (c) the imaginary versus the real part of the impedance, ie, impedometric; (d) drain current versus line voltage in a FET biosensor [Linda Bertel, 2021], agreement with previously reported analyzes (i.e., FTIR, XRD, and SEM) [Wei Chen, 2022] and confirming interactions with added organic modifiers.

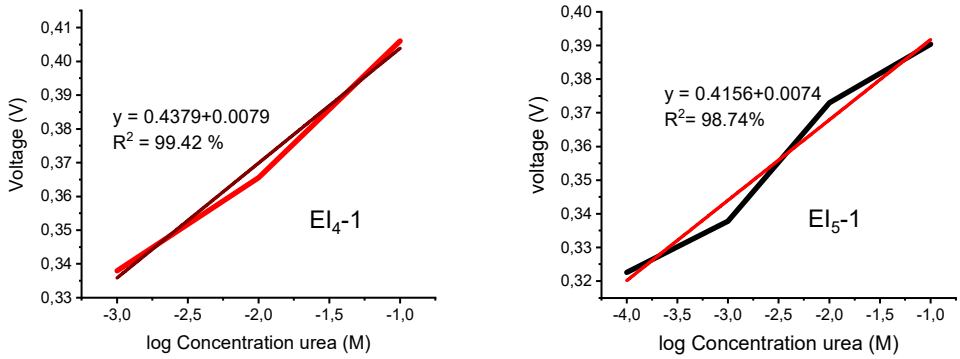

Figure 7. Analisis kurva linear (1) EI_5-1, (b) EI_4-1

The procedure of this study followed (a) Analysis of transmittance, edx, xrd [Bibi, Aamna 2022], edx, xrd, linear curve, sensitivity and detection range [Mashuni, Mashuni, 2022], transmittance, concentration, sensitivity [Er-Yuan Chuang, 2021; Hui-Tzung Luh, 2022; Sriwichai, Saengrawee 2022]; (b) The biosensor system [Thakur and Ragavan, 2013], namely (1) selectivity, (2) sensitivity, (3) linearity response, namely the concentration range of the target analyte to be measured, (4) reproducibility of signal response, samples having a different concentration. the same analyzed several times should give the same response, (5) fast response time and recovery time for reusability of the biosensor system, (6) stability and operating life; (c) The [Nimse 2014] immobilization technique was developed based on three important mechanisms, namely (1) physical adsorption, (2) covalent immobilization, (3) streptavidin-biotin immobilization. Achieving high sensitivity and selectivity requires minimization of nonspecific adsorption and stability.

Conclusion

As a conclusion from XRD, SEM-EDX and FTIR analysis, response time and linear curve analysis, the best sample is the EI_5-1 indicator electrode with four layer modifications, namely PVA-Enzyme/GA-2.9%/PPy+Sulfonic Acid/PVC-KTpClPB-o -NPOE.

Acknowledgement

I would like to thank Medan State University for obtaining Applied Research in 2022, as well as data analysis collaboration with the University of North Sumatra.

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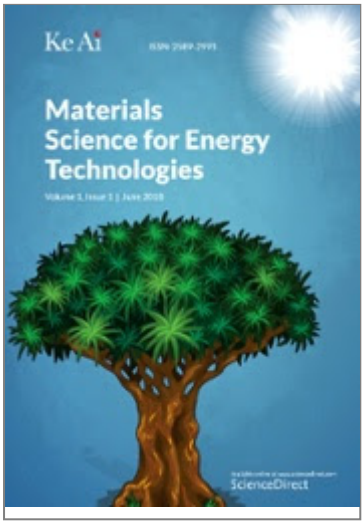

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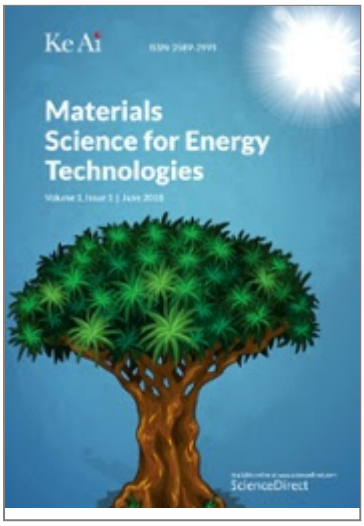

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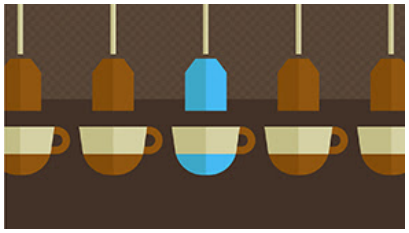

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*Corresponding author.

Abstract

Research has been carried out on indicator electrodes (1) PVA-Enzyme/PVC-KTpClPB, sensitivity 19,069 mV/decade, detection range 1.10^{-5}–5.10^{-4} M, detection limit 1.10–5 M. The width of the peak UV–vis absorbance is narrow (2) PVA-Enzyme/GA-2.9 %/PVC-KTpClPB wide UV–vis absorbance peak but the absorbance peak decreased, (3) PVA-Enzyme/GA-2.9 %/PVC-KTpClPB-o-NPOE XRD analysis amorphous spectral pattern appeared (4) PVA-Enzyme/GA-2.9 %/PPy + H_2SO_4/PVC-KTpClPB-o-NPOE (5) PVA-Enzyme/GA-2.9 %/PPy + Sulfonic Acid/PVC-KTpClPB-o-NPOE, amorphous spectrum pattern in (4) and (5) were greatly reduced for the enzyme variation of 0.6 g in 0.5 mL (50 % water + 50 % alcohol). GA plays a role in increasing the detection range, o-NPOE forms amorphous, enzyme variations increase the intensity of the XRD spectrum pattern. The method of developing a gradual modification of the indicator electrode membrane by cross-linking GA, o-NPOE, conductive polymer. The best results were obtained at the indicator electrode PVA-Enzyme/GA-2.9 %/PPy + Sulfonic Acid/PVC-KTpClPB-o-NPOE. Analysis of the linear curve of the sample EI_5-1 with a sensitivity of 41.56 mV/decade, a detection range of 10^{-4}–10^{-1} M and a detection limit of 10^{-4} M, R^2 = 97.51 %. The best indicator electrode is EI_5-1.

Keywords:

PVA-enzyme/GA-2.9%/PPy+H2SO4 or sulphonic acid/PVC-KTpClPB-o-NPOE, Biosensor potentiometry, Immobilization of urease enzyme

Abbreviations

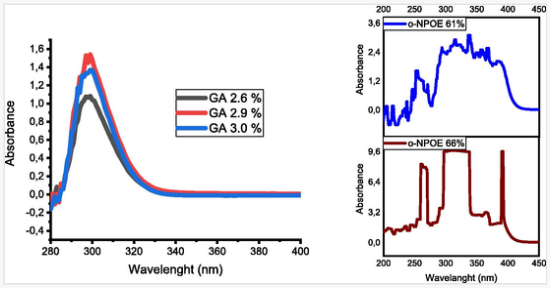
No keyword abbreviations are available

1 Introduction

Modification of the indicator electrode membrane layer started from (1) PVA-Enzyme/PVC-KTpClPB [1,2] PVA-Enzyme/GA-2.9 %/PVC-KTpClPB [1–3] PVA-Enzyme/GA-2.9 %/PVC-KTpClPB-o-NPOE, [4] PVA-Enzyme/GA-2.9 %/PPy + H_2SO_4/PVC − KTpClPB-o-NPOE, PVA-Enzyme/GA-2.9 %/PPy + Sulfonic Acid/PVC-KTpClPB-o-NPOE.

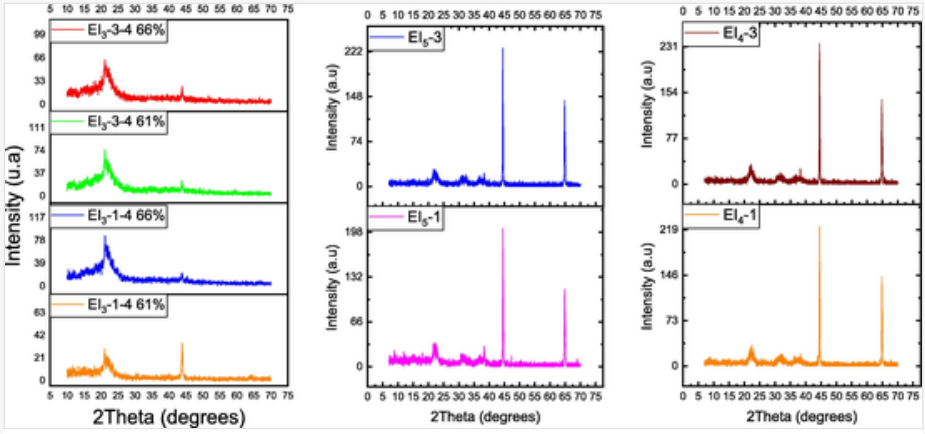
Each indicator electrode is given the notation EI_1, EI_2, EI_3, EI_4 and EI_5. EI_1 narrow absorbance spectrum pattern resulting in a small detection range modified to EI_2. EI_2 was modified by adding a GA layer at variations of 2.6 %, 2.9 % and 3.0 % in PVA-Enzyme from EI1. The GA solution was analyzed by UV−vis. The absorbance spectrum pattern increases the width of the absorption peak which affects the detection range (see Fig. 1a). EI_2 modification was continued by adding o-NPOE solution at variations of 61 % and 66 % in PVC-KTpClPB solution. The PVC-KTpClPB-o-NPOE solution was analyzed by UV−vis to produce the absorbance spectrum pattern seen in Fig. 1b. EI_2 analysis with XRD produces an amorphous spectral diffraction pattern around the 2theta angle of 20–25 degrees accompanied by a decrease in energy intensity, see Fig. 2a. The formation of an amorphous spectrum pattern and a decrease in intensity.

Fig. 1



UV–vis analysis of solutions (a) GA 2.6%, 2.9% and 3.0%, (b) PVC-KTpClPB-o-NPOE 61%, 66%.

Fig. 2



Analysis of the XRD diffraction spectrum pattern of the indicator electrode (a) EI_3-1–4 61%, EI_3-1–4 66%, EI_3-3–4 61% and EI_3-3–4 66%, (b) EI5-1 and EI_5-3, (c) EI_4-1and EI_4-3.

Based on Figs. 1 and 2, the researchers continued to modify the indicator electrode membrane with a conducting polymer material, namely PPy. This PPy can only dissolve in H2SO4 and Sulphonic Acid. H_2SO_4 is soluble at a concentration of 8 M while sulfonic acid is soluble at a concentration of 1 M. Modification of the electrode membrane

in sequence (1) PVA-Enzyme/GA-2.9 %/PPy + H_2SO_4/PVC-KTpClPB-o-NPOE, denoted EI_4-1 (2) PVA-Enzyme/GA-2.9 %/PPy + Sulfonic Acid/PVC-KTpClPB-o-NPOE denoted EI_5-1. Modification procedures EI_4-1 and EI_5-1, variations in the number of drops of urease enzyme are one drop and three drops, the results of the analysis can be seen in Fig. 2b, c and Table 1. The electrode membrane layer consists of four layers, the first layer is PVA-Enzyme, the second layer GA 2.9 %, third layer PPy + H_2SO_4 or PPy + Sulfonic Acid, fourth layer PVC-KTpClPB-o-NPOE 61 %. Selected o-NPOE 61 % from the UV–vis analysis of Fig. 1. Compared to Fig. 2b, c and Table 1, the XRD diffraction spectrum pattern analysis showed a very large decrease in the amorphous spectrum pattern followed by an increase in the crystal spectral pattern (see Fig. 3).

Table 1

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Analysis of the EDX spectrum pattern of the indicator electrode (a) EI5-1, (b) EI5-3, (c) EI4-1, (d) EI4-3.

2Theta	EI_5-1	EI_5-3	EI_4-1	EI_4-3
44.48	140	220	166	236
44.5	164	228	210	216
44.54	204	176	224	172

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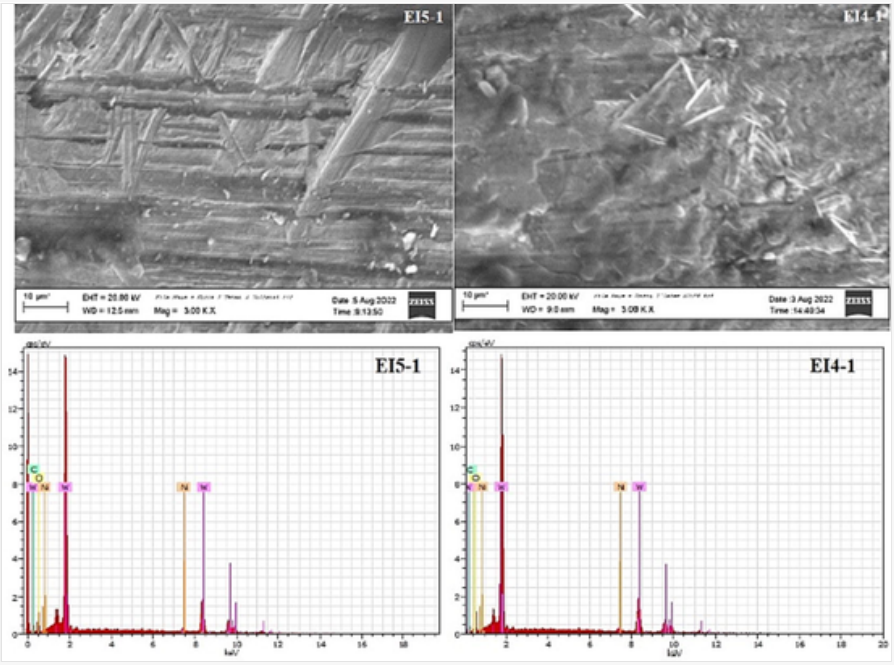
Fig. 3



SEM morphology and Spectrum pattern of intensity to EDX energy from indicator electrode (a) EI_5-1, (b) EI_4-1.

This indicator electrode sample was selected to select the best electrode according to the layer modification which had analyzed the absorbance spectrum pattern of the PVA-enzyme immobilized layer; layer two GA crosslinks; PPy conduction polymer triple layer; and a layer of four o-NPOE plasticizers on PVC-KTpClPB [3]. After XRD analysis of samples EI5-1, EI5-3, EI4-1, EI4-3, the best samples were EI5-1 and EI4-1. Both samples were analyzed by FTIR, cell response potentiometer and linear curve analysis determining sensitivity, detection range, detection limit and R^2.

2 Methods

The method in this study is the biosensor potentiometric method [4–6] immobilization technique [7] urease enzyme which analytes urea, using potentimetric cells to determine the feasibility of urea sensors based on (1) response time of samples EI_5-1 and EI_4-1, (2) through linear curve analysis. Materials consist of 1.0 mm diameter tungsten 267 562 99.99 %, PVA [–CH_2CHOH-]n, enzyme EC 3.5.1.5 (Urease) U4002, Glutaraldehyde (GA), PPy, H_2SO_4, Sulphonic acid, PVC (CH_2CHCl) n, potassium tetrakis 4-chlorophenyl borate $(ClC_6H_4)_4BK$, tetrahydrofuran C_4H_8O, o-NPOE, KCl. Potentiometer (Keithley 199 DMM, USA), tungsten indicator electrode (W), Ag/AgCl MF-2052 rE-5B reference electrode in a microcomputer assembled electrochemical cell (ADI Powerlab instruments, Australia), magnetic stirrer and flow injection (FIA).

3 Result and discussion

Fig. 1, shows the analysis of the indicator electrode with UV–vis [8–11] on GA solution [2] and o-NPOE solution in PVC-KTpClPB (PVC-KTpClPB-o-NPOE) [1,16–18]. The absorbance spectrum pattern with respect to the wavenumber of both shows a widening of the absorbance spectrum pattern for both GA and PVC-KTpClPB-o-NPOE. Analysis of Fig. 1a and 1b selected the best 2.9 % GA and PVC-KTpClPB-o-NPOE (o-NPOE 61 %). on the basis of coated indicator electrodes for the second and fourth layers.

Fig. 2, shows the analysis of the XRD diffraction spectrum pattern [18] for the indicator electrodes (a) EI_3-1-4 61 %, EI_3-1-4 66 %, EI_3-3-4 61 % and EI_3-3-4 66 %, (b) EI_5-1, EI_5-3, (c) EI_4-1, EI_4-3. In Fig. 2a the XRD diffraction spectrum pattern from EI_3-1-4 61 %, EI_3-1-4 66 %, EI_3-3-4 61 %, amorphous and crystalline spectrum patterns are formed with low intensity. In contrast to Fig. 2b EI_5-1 and EI_5-3, 2c EI_4-1 and EI_4-3 [19], a low amorphous spectrum pattern and high intensity crystals are formed. So it is clear that the pattern of the indicator electrode layers EI_5-1, EI_5-3 and EI_4-1, EI_4-3, varies in the number of drops of urease enzyme, one drop and three drops, respectively. The peak height of energy intensity with respect to the diffraction angle of 2theta can be seen in Table 1 (a) EI_5-1 high intensity 204 (a.u) at a diffraction angle of 44.54 degrees, (b) EI_5-3 high intensity 228 (a.u) at a diffraction angle of 44.5 degrees, (c) EI_4-1 high intensity 224 (a.u) at a diffraction angle of 44.54 degrees, (d) EI_4-3 high intensity 236 (a.u) at a diffraction angle of 44.48 degrees.

Researchers are still continuing the analysis with SEM-EDX and FTIR [20] for clear assurance of the material used in the indicator electrodes (a) EI_5-1, (b) EI_5-3, (c) EI_4-1, (d) EI_4-3 as one sample best.

SEM morphology analysis with 3 Kx magnification at a voltage of 10 m 20 Kv resulted in a difference in energy intensity of 13.5 cps/keV 1 M sample EI_5-1 and energy intensity 14.7 cps/keV 8 M sample EI_4-1. Based on Table 1, it was obtained that the intensity of XRD analysis increased, Table 2 obtained that the data discrepancy was greater in weight percent EI_4-1 than weight percent EI_5-1. While the FTIR analysis in Fig. 4 and Table 3 increases the transmittance for the indicator electrodes EI_5-1 and EI_5-3, on the contrary, the transmittance decreases for the indicator electrodes EI_4-1 and EI_4-3. XRD, FTIR and SEM-EDX analysis [6,21,22] then the best samples are EI_5-1 and EI_4-1.

Table 2

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Weight percentage of indicator electrodes from the EDX spectrum pattern of samples EI_5-1 and EI_4-1.

Indicator Electrodes	Material	unn. C [wt.%]	norm. C [wt.%]	Atom. C [at.%]	Error (1 Sigma) [wt.%]
EI_5-1	W 74 L-series	69.07	76.86	29.23	2.28
EI_4-1	W 74 L-series	81.95	83.86	32.85	2.65

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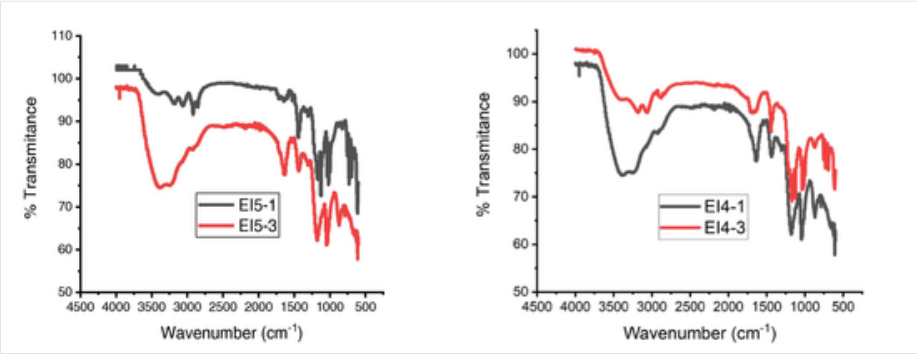
Fig. 4



The pattern of the transmittance spectrum against the wavenumber of the indicator electrodes (a) EI_5-1, EI_5-3, (b) EI_4-1, EI_4-3.

Table 3

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Table of transmittance ranges for sample wave numbers (a) EI4-1, (b) EI5-1.

Wavenumber (cm^{-1})	Transmittance (%)			
	EI_4-1	EI_4-3	EI_5-1	EI_5-3
600	60.8895	75.5583	75.9339	48.5782
4000	97.9351	100.9955	102.5625	100.8259

After selecting two samples of indicator electrodes EI_5-1 and EI_4-1, according to the biosensor poenstiometry method, a potentiometer cell was used to test the feasibility of the indicator electrode response time (Fig. 5). The best response time analysis [6] Fig. 5a and b were obtained on the EI_5-1 sample also supported by the data in Table 4 that the EI_5-1 indicator electrode has a sensitivity of 41.56 mV/decade, a detection range of 10^{-4}–10^{-1} M, detection limit is 10^{-4} M and $R^2 = 97.51$ % [5,23]. The detection range of EI_5-1 is greater than that of EI_4-1, the detection range is 10^{-3}–10^{-1} M, the detection limit is 10^{-3} M, while R2 = 98.83 % [13,25,26].

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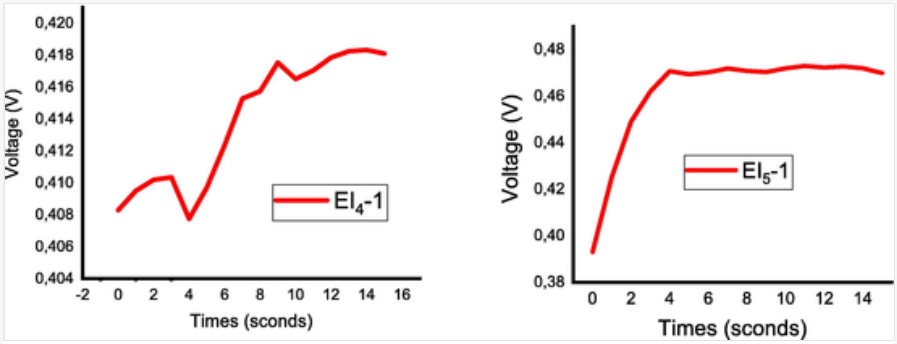
Fig. 5



Response time (a) EI4-1, (b) EI5-1.

Table 4

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Linear curve of indicator electrodes EI_4-1 and EI_5-1.

Indicator electrode membrane layer	Sensitivity mV/decade	Detection range (M)	Detection limit (M)	R-square (R^2) (%)
EI_4-1	43.79	10^{-3}–10^{-1}	10^{-3}	98.83
EI_5-1	41.56	10^{-4}–10^{-1}	10^{-4}	97.51

In electrochemical detection, the signal associated with the interaction of the analyte is measured through the electrode. Measurements can be made by (a) connecting current and voltage, namely voltammetric and conductor metric biosensors; (b) current or voltage with respect to time, i.e., amperometric or potentiometric; (c) the imaginary versus the real part of the impedance, i.e., impedometric; (d) drain current versus line voltage in a FET biosensor [6], agreement with previously reported analyzes (i.e., FTIR, XRD, and SEM) [22] and confirming interactions with added organic modifiers (see Fig. 6).

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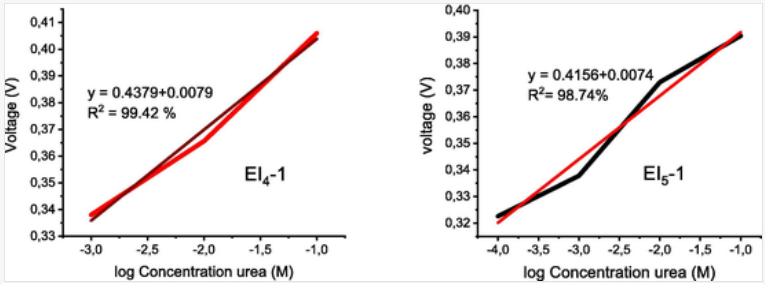
Fig. 6



Analisis kurva linear (1) EI_5-1, (b) EI_4-1.

The procedure of this study followed (a) Analysis of transmittance, edx, xrd [27], edx, xrd, linear curve, sensitivity and detection range [28], transmittance, concentration, sensitivity [29–31]; (b) The biosensor system [20], namely (1) selectivity, (2) sensitivity, (3) linearity response, namely the concentration range of the target analyte to be measured, (4) reproducibility of signal response, samples having a different concentration. the same analyzed several times should give the same response, (5) fast response time and recovery time for reusability of the biosensor system, (6) stability and operating life; (c) The [7] immobilization technique was developed based on three important mechanisms, namely (1) physical adsorption, (2) covalent immobilization, (3) streptavidin–biotin immobilization. Achieving high sensitivity and selectivity requires minimization of nonspecific adsorption and stability.

4 Conclusion

As a conclusion from XRD, SEM-EDX and FTIR analysis, response time and linear curve analysis, the best sample is the EI_5-1 indicator electrode with four layer modifications, namely PVA-Enzyme/GA-2.9 %/PPy + Sulfonic Acid/PVC-KTpClPB-o-NPOE.

Uncited references

[12,14,15,24].

~~Declaration of Competing Interest~~

~~The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.~~

Acknowledgement

I would like to thank Medan State University for obtaining Applied Research in 2022, as well as data analysis collaboration with the Universitas Sumatera Utara.

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The corrections made in this section will be reviewed and approved by a journal production editor. The newly added/removed references and its citations will be reordered and rearranged by the production team.

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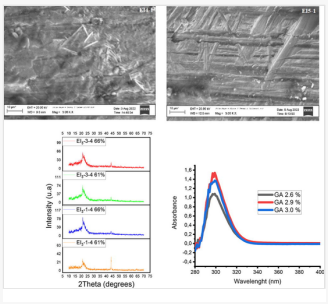

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Reply-To: Open Access Support <oasupport@elsevier.com>
To: abdhakims@unimed.ac.id

Dear Dr. Abd Hakim,

Article Ref. No.: MSET_317
Invoice: KEI1000000382

Thank you for your e-mail which was forwarded to us in Open Access Support.

Upon checking, your payment was not reflected on our end yet.

However, with this proof of payment. Let me contact our finance team for the allocation of payment.

I will get back to you once this has been allocated.

In the meantime, your utmost patience and kind understanding are highly appreciated.

Kind regards,

Jovelyn Lantao
Researcher Support
Open Access
ELSEVIER

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- Visit the Author Guide to Editorial Manager for a guided walkthrough of author key tasks, such as manuscript submission process and how to track your manuscript.
- Visit the Reviewer Guide to Editorial Manager for a guided walkthrough of reviewer key tasks.

From: Administrator
Date: Friday, December 02, 2022 10:47 PM GMT

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Thank you for contacting Elsevier Researcher Support.

To help us jump right into the solution, please ensure you have provided as much information as possible.

While you wait, you can take a look at our Journal Article Publishing Support Center where you can review FAQs and 'how to' videos, use live chat or request a call.

To help ensure a fast response, please do not change the subject line of this email when replying. For any future correspondence, remember to quote your unique reference number provided in the subject line.

We will respond to you within 48 hours.

Regards,

Elsevier Researcher Support

From: Keerthana (ELS-CON) R
Date: Friday, December 02, 2022 10:47 PM GMT

Dear Team,

Good morning.

Please see the below author message and do the needful. Now the Milestone is "CORR PRF".

Thank you for your valuable support.

Kind regards,

Ms Keerthana R

Data Administrator

Elsevier

E-Mail: K.R1@Elsevier.Com

From: Abdhakims . <abdhakims@unimed.ac.id>
Sent: 29 November 2022 10:36
To: R, Keerthana (ELS-CON) <K.R1@elsevier.com>
Cc: k.radhakrishnan@elsevier.com
Subject: waiting for author reply - Confirming Payment of Publication

Dear Sir/Madam,

I have finished publication payment. Please attach a file. Thank you. Regards

---

Open Access Support <oasupport@elsevier.com> Tue, Dec 6, 2022 at 9:40 PM
Reply-To: Open Access Support <oasupport@elsevier.com>
To: abdhakims@unimed.ac.id

Dear Dr. Abd Hakim,

Article Ref. No.: MSET_317
Invoice: KEI1000000382

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I wish to inform you that I am already in contact with the finance team for payment allocation.

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From: Jovelyn Lantao
Date: Sunday, December 04, 2022 06:28 PM GMT

Dear Dr. Abd Hakim,

Article Ref. No.: MSET_317
Invoice: KEI1000000382

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---

Abdhakims . <abdhakims@unimed.ac.id> Wed, Dec 7, 2022 at 9:17 PM
To: Open Access Support <oasupport@elsevier.com>

Dear Dr. Lantao and team,

Thank you for your email. I would like to wait for responses from you. Thank you

On Tue, Dec 6, 2022 at 9:40 PM Open Access Support <oasupport@elsevier.com> wrote:

> Dear Dr. Abd Hakim,
>
> Article Ref. No.: MSET_317
> Invoice: KEI1000000382
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Invoice: KEI1000000382

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---

Gmail

Abdhakims . <abdhakims@unimed.ac.id>

[MSET] [317] - Revised proof for Approval

3 messages

Narayanan, Arjun (ELS-CHN) <a.narayanan@elsevier.com> Thu, Dec 8, 2022 at 6:07 PM
To: "abdhakims@unimed.ac.id" <abdhakims@unimed.ac.id>

Dear Dr. Abd Hakim,

I hope this email finds you well.

Please find attached the revised proof of article **MSET_317** for your review and approval.

I request you to check and provide us with your comments at your earliest convenience.

Look forward to hearing from you.

Regards,

Arjun N

Journal Manager

e-mail: a.narayanan@elsevier.com

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Line Manager: Lavanya Ashwin
l.ashwin@elsevier.com

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2 attachments

317v1_202212002389121324.pdf
1187K

317grabsv1_202212002389121320.pdf
129K

Abdhakims . <abdhakims@unimed.ac.id> Thu, Dec 8, 2022 at 6:27 PM
To: "Narayanan, Arjun (ELS-CHN)" <a.narayanan@elsevier.com>

Dear Dr. Arjun,

Thank you for your email. I have been done checking the attachment files.

Thank you very much.
[Quoted text hidden]

Narayanan, Arjun (ELS-CHN) <a.narayanan@elsevier.com> Thu, Dec 8, 2022 at 6:31 PM
To: "Abdhakims ." <abdhakims@unimed.ac.id>

Dear Dr. Hakim,

Thank you for your email.

I understand you have approved the proofs without any corrections, and I am proceeding to finalize and publish the article as is.

Please let me know of any further assistance.

Regards,

Arjun N

Journal Manager

e-mail: a.narayanan@elsevier.com

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Line Manager: Lavanya Ashwin
l.ashwin@elsevier.com

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Taramani

Chennai 600 113

From: Abdhakims . <abdhakims@unimed.ac.id>
Sent: Thursday, December 8, 2022 4:57 PM
To: Narayanan, Arjun (ELS-CHN) <a.narayanan@elsevier.com>
Subject: Re: [MSET] [317] - Revised proof for Approval

***** External email: use caution *****

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Abdhakims . <abdhakims@unimed.ac.id>

PLEASE TAKE ACTION - Share your article [MSET_317]

1 message

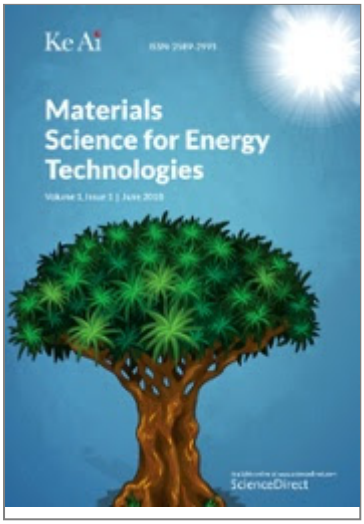
Elsevier - Article Status <Article_Status@elsevier.com> Fri, Dec 9, 2022 at 5:45 PM
To: abdhakims@unimed.ac.id

ELSEVIER

Share your article!

Dear Dr. Abd Hakim,

We are pleased to let you know that the final open access version of your article *Manufacture and characterization of indicator electrodes from PPy+H2SO4 and PPy+Sulfonic acid as a urea sensor using urease enzyme immobilization technique in PVA* is now available online, containing full bibliographic details.



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