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STUDI POTENSIOMETRI DALAM MEMBRAN CAIR BERPENDUKUNG PTFE DENGAN AMINA SEKUNDER SEBAGAI PENGEMBAN DALAM UPAYA PENENTUAN PENISILIN

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ABSTRAK

Penisilin G atau benzilpenisilin merupakan antibiotik yang dihasilkan oleh jamur *Penicillium notatum*. Antibiotik ini merupakan jenis obat yang sering digunakan untuk pengobatan infeksi yang disebabkan oleh bakteri aerob dan anaerob. Penentuan kadar dari penisilin dalam sediaan farmasi biasanya diwajibkan untuk dilakukan dalam upaya menjaga kualitas sediaan farmasi yang dihasilkan. Elektroda selektif ion (ESI) merupakan sensor elektrokimia potensiometri yang berfungsi sebagai pengesan keberadaan dan kuantitas analit dan banyak digunakan karena selektif, peka, akurat dan batas deteksinya cukup rendah. Berdasarkan penelusuran metoda analisis untuk penisilin diketahui bahwa penentuan penisilin menggunakan elektroda selektif dalam membran cair berpendukung PTFE dengan amina sekunder sebagai pengemban belum pernah dilakukan. Agar respon potensiometri dari ESI yang dihasilkan dapat diprediksi dan ditingkatkan sensitivitas dan selektivitasnya, maka diperlukan studi potensiometrik dalam membran untuk memahami proses kinetika transfer muatan yang terjadi pada antarmuka larutan-membran. Tujuan penelitian ini adalah membuat ESI penisilin dalam membran cair berpendukung PTFE menggunakan amina sekunder sebagai pengemban yang memiliki karakteristik optimal untuk pengukuran analisis. Dari penelitian yang dilakukan diperoleh hasil : terdapat hubungan linier antara potensial dengan konsentrasi analit melalui pengukuran potensial membran pada arus nol. Dari karakterisasi non transport diketahui terjadi proses *swelling* pada membran yang telah diimpregnasi amina sekunder dengan volume efektif membran yang terisi pelarut sebesar 12,7%. Transport ion penisilin ke dan dari membran dipengaruhi oleh perbedaan konsentrasi dan pH. Dari hasil penelitian ini, terlihat adanya peluang bagi membran cair berpendukung PTFE dengan amina sekunder sebagai pengemban untuk digunakan sebagai sensor potensiometri pada penentuan penisilin.

Kata kunci : Penisilin, Politetrafluoroetilen (PTFE), amin Sekunder, ESI (elektroda selektif Ion), membran cair berpendukung

POTENTIOMETRIC STUDY ON PTFE SUPPORTED LIQUID MEMBRANE WITH SECONDARY AMINES AS A CARRIER FOR PENICILLIN DETERMINATION

ABSTRACT

Penicillin G or benzylpenicillin is an antibiotic produced by *Penicillium notatum* mould. Due to its large activity, this antibiotic is often used against both aerobic and anaerobic bacteria. Its determination in pharmaceutical formulations is very important for quality control in pharmaceutical industry. An ion selective electrode (ISE) is a potentiometric electrochemical sensor which is capable of recording besides indicating analyte concentration. Determination of penicillin using a selective electrode in PTFE supported liquid membrane with secondary amine as a carrier never been developed. In order to predict and improve sensitivity and selectivity of the potentiometric response of the ISE, it is necessary to do potentiometric study in membranes to understand charge transfer process kinetic happened at a membrane-solution interface. The research is aimed to develop penicillin ISE in PTFE supported liquid membrane with secondary amine that is appropriate for analytical measurement. The measurement of the membrane potential at zero current showed linear correlation between potential and analyte concentration. The swelling process happened in the membrane impregnated with secondary amine, and the effective volume membrane filled with solvent is 12,7%. The penicillin ion transport was influenced by concentrations and pH differences. The results showed, PTFE supported liquid membrane with secondary amine as a carrier could be developed as potentiometric sensor for determination of penicillin.

Key words : Penicillin, Polytetrafluoroetylene (PTFE), secondary amines, ISE (Ion Selective Electrode), supported liquid membrane

INTRODUCTION

Penicillin G or benzylpenicillin is an antibiotic produced by *Penicillium notatum* mould, which include the structure of β-lactamic ring and a carboxylic group. Due to its large activity, this antibiotic is often used against both aerobic and anaerobic bacteria, being an important drug used in prevention and treatment of bacterial infections. Its determination in pharmaceutical formulations is very important for quality control that generally required in pharmaceutical industry. The development of pharmaceutical, clinic and environmental analyses has led to the need of chemical sensors which are robust and easy to construct and to miniaturize, and which require no maintenance during the life period (Sun, 2007).

Ion Selective Electrode (ISE) are electrochemical sensors functioned as sensors to identified and quantified analyte, ISE are the most frequently one due to its selectivity, accuracy, sensitivity and low detection limit. Polytetrafluoroetylene (PTFE) polymer has good chemical resistance, temperature and pH (Mulder, 1994), with its characteristic ISE manufactured from PTFE polymer assumed to have longer life time. From purification of penicillin using supported liquid membrane, it had been known that penicillin can be transfered into membrane using secondary amine as carrier (Lee *et*.al 1994). Based on literature quest, penicillin determination using ISE in PTFE supported liquid membrane with secondary amines never been developed (Santos *et*.al 2004). In order to predict and improve sensitivity and selectivity of the potentiometric response of the ISE, it is necessary to do potentiometric study in membranes to understand charge transfer process kinetic that happened at membrane-solution interface. The aim of the research is to get a membrane which have optimum characteristic as ISE membranes, construct penicillin ISE based on PTFE supported liquid membrane which have optimum characteristic for analytical measurement, characterize penicillin ion transport through potential measurement at zero current, characterize non transport penicillin ion through membrane structure elucidation, construct penicillin ISE based on coated wire electrode to get another ISE with optimum characteristic for comparison.

MATERIAL AND METHODS

Reagent and Solutions

Analytical grade chemicals were used without any additional purification: benzilpenisilin (Aldrich), didecilamine (Aldrich), dihexylamine (Aldrich), PTFE membrane 0,45 μm and 0,22μm (Pall Corporation), bue tip 1 mL, coaxical wire RG-58, Ag wire (0,2 mm), Pt wire (0,5 mm), $NaClO_4$ (Merck), Na_2HPO_4 (Merck), NaH_2PO_4 (Merck), KCl (Merck), Aquabidest

Method

Electrode construction

The ISE construct from 0,45 μm PTFE membrane impregnated 24 hours with secondary amine with different concentrations ranging from 0,001-0,004 M. Electrode construction made from blue tip with 1 mL internal solution, 6 cm height. The electrode has different internal solution consist of KCl 0,1 M and penicillin with variable concentration ranging from 10^{-3} – 10^{-5} M. The electrode construction is depicted in Figure 1.

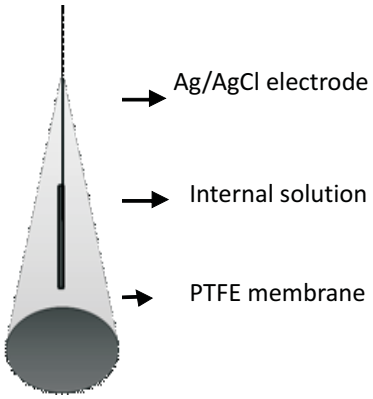

Figure 1. Membrane Construction

Membrane transport characterization

Transport characterization was done through determination of membrane potential at zero current. Determination done using two flexy glass separated by membrane and filled with penicilline in different concentration ranging from 10^{-3} – 10^{-5} M. In area I filled with constant concentration of penicilline, and in area II with different concentration of penicilline. The potential emerge being plot with logarithmic value of ratio concentration between area I and area II. Characterization was done to get characteristics of Penicillin ISE's in PTFE supported liquid membrane.

Membrane non transport characterization

Non transport characterization was done using Fourier Transport Infra Red (FTIR) and Scanning Electron Microscope (SEM) toward pure PTFE membrane and PTFE membrane impregnated with secondary amine. The research method outline can be seen in the Figure 2 bellow :

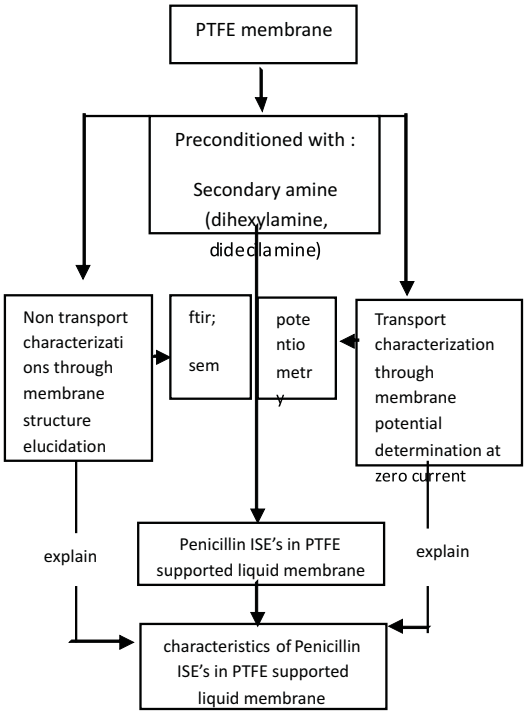

Figure 2. Research method

RESULTS AND DISCUSSION

Potential measurement at zero current if membrane separated two different electrolyte solution was done using concentration cell bellow :
Hg I Hg_2Cl_2 I KCl sat'd II penicillin (a^{II}) I membrane I penicillin (a^{I}) II KCl sat'd I Hg_2Cl_2 I Hg or Ag I AgCl I KCl sat'd II penicillin (a^{II}) I membrane I penicillin (a^{I}) II KCl sat'd I AgCl I Ag

Because of compounds that cross membrane selectively was ionic and their selective transport characteristic can cause electricity potential effect, ion flux can be detected quantitatively through potential different (Mears, 1986 a). Based on that, in order to get a membrane with optimum characteristic as ISE membranes, membranes impregnated with different condition and than the quantity of penicilline transport through membrane measure at zero current. First membrane was impregnated with secondary amine only, the concentrations vary from 0,001-0,004 M. The result depicted in the Figure 3.

From the Figure 2, Nernst factor 60,56 mV/decade generated from ISE construct with membrane impregnated with didecillamine 0,002 M. The internal solution consist of KCl 0,1 M and penicillin 10^{-5} M. But the correlation coefficient (R^2) of the linear regression only 0,8 that showed less linier curve condition. From the measurement of penicillin standard solution in phosphate buffer pH 7 with ISE made from membrane impregnated with secondary amine only, ISE not to give good response on penicillin ion.

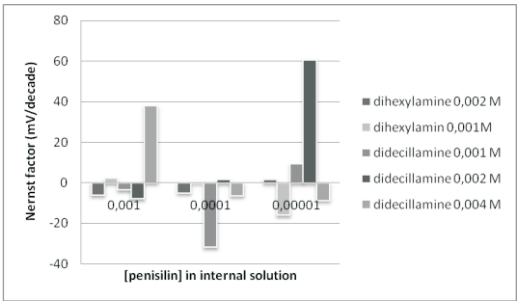

Figure 3. Effect of Penicilline composition in internal solution to nernst factor in membrane impregnated with secondary amines

To have better response, membrane impregnated with secondary amine and penicillin. The concentration vary from 0,001-0,004 M and 10^{-3} – 10^{-5} M. The result depicted in the Figure 3.

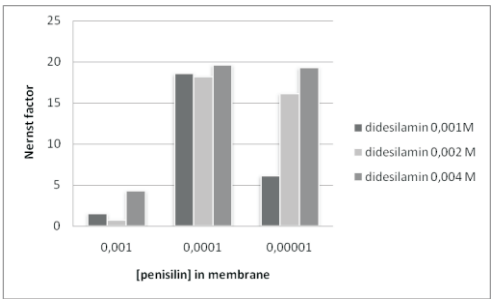

Figure 4. Nernst factor in membrane impregnated with Didecillamine and Penicilline (Internal Solution KCl 0,1 M and Penicilline 10^{-4} M)

From the Figure 4, relatively constant response observe. Better and relatively constant response with coefficient correlation between 0,9 generated from ISE construct from membrane impregnated with didecillamine 0,001-0,004 M and penicillin 10^{-4} M. The internal solution consist of KCl 0,1 M and penicillin 10^{-4} M in pH 7 phosphate buffer.

To see influence of the pH in penicillline transport, composition of the internal solution altered. The internal solution consist of KCl 0,1 M and penicillin 10^{-4} M in phosphate buffer pH 8 , with sample solution in phosphate buffer pH 7. The measurement done using membrane impregnated with didecillamine 2 x 10^{-3} M and peniciline 10^{-4} M. The result can be seen in Figure 5.

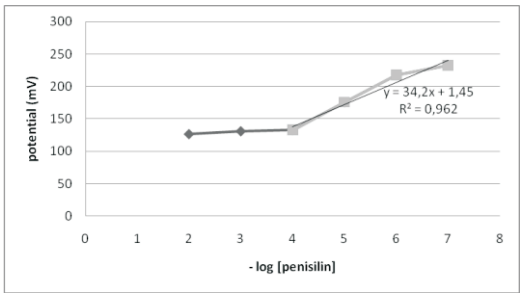

Figure 5. Nernst factor measurement from membrane impregnated with Didecillamine 2 x 10^{-3} M and Penicilline 10^{-4} M with internal solution KCl 0,1 M and Penicilline 10^{-4} M in pH 8 Buffer Phosphate

From Figure 5, compare to the same condition of membrane impregnation but using internal solution in phosphate buffer pH 7 there's significance change in Nernst factor. This phenomena suitable with reaction of secondary amine and penicillin bellow (Santoso, 2007) :

$RR'NH(org) + H^+(aq) + peniciline\ G^-(aq)$
$peniciline\ G\text{-}RR'NHH\ (org)$
RR'NH = secondary amine
Peniciline G-RR'NHH = ion association complex

To see non ionic transport characteristic, membrane structure being elucidated using Fourier Transform Infra Red (FTIR). FTIR carried out to detect membrane component interaction and substances infiltrated into membrane. Analysis done to pure PTFE membrane, PTFE membrane impregnated with didecylamine. The result depicted Figure 6 and Figure 7.

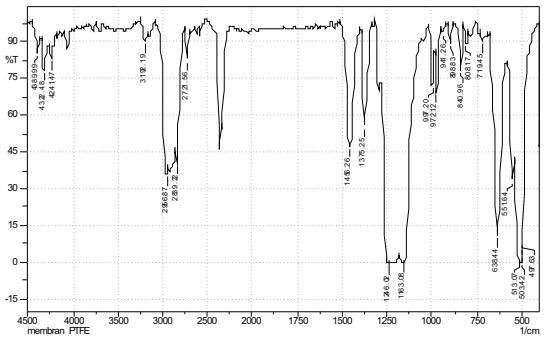

Figure 6. FTIR Spectra of PTFE Membrane

From membrane structure elucidation using FTIR, there's no difference in membrane structure before and after being impregnated with secondary amine or penicillin 24 hours.

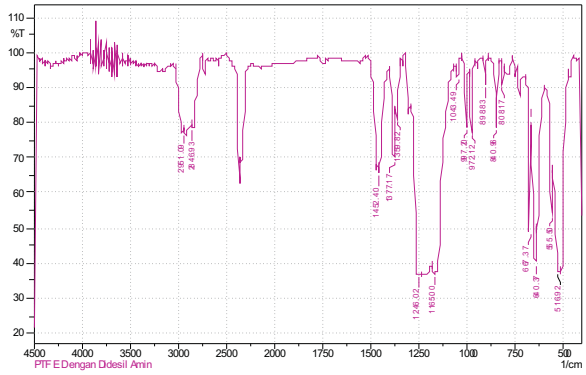

Figure 7. FTIR Spectra PTFE membrane impregnated with Didecillamine

This phenomena maybe because the amount of secondary amine infiltrated into membrane are to small to be detect with FTIR. Further, analysis membrane structure using Scanning Electron Microscope (SEM) are done. The result depicted in Figure 8 and Figure 9 bellow:

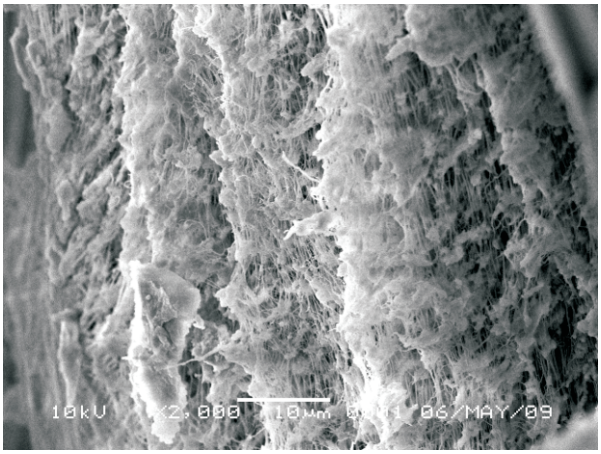

Figure 8. PTFE membrane using scanning electron microscope

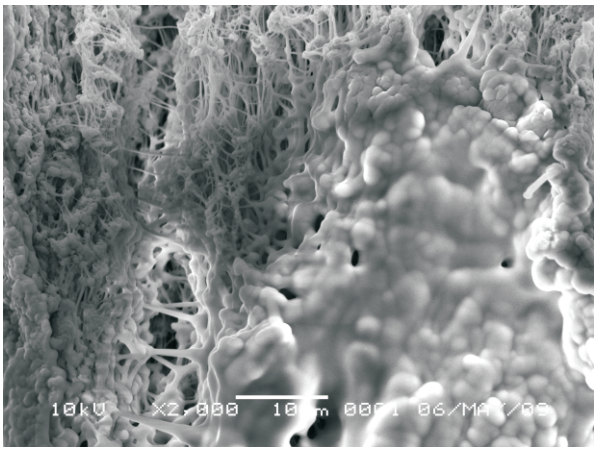

Figure 9. PTFE membrane impregnated with Didecillamine 4 x 10^{-3} M using scanning electron microscope

From SEM analysis, swelling process happen to membrane impregnated with didecillamine 4 x 10^{-3} M for 24 hours. The process show that solvent has infiltrated into membrane. The amount of solvent infiltrated into membrane being calculate and the result was 12,7% volume membrane filled with solvent.

To see ionic transport, determination of membrane potential at zero current being done. Determination carried out using two flexy glass separated by membrane (Tongwei and Weihuang 2001) and filled with penicillin solution. Membrane made with diverse condition : pure membrane, membrane impregnated with penicillin for 24 hours, membrane impregnated with penicillin and secondary amine for 24 hours. In compartement I filled with constant concentration of penicillin, and in compartement II with different concentration of penicillin. From the experiment, there are linear correlation between potential change and concentration change. Result indicate,there's diffusion process of penicillin ion in membrane.

CONCLUSION

The study undertaken has shown that membrane potential measurement at zero current showed linear correlations between potential and analyte concentration. Swelling process happened to membrane impregnated by secondary amine with 12,7%. membrane filled with solvent. Didecilamine is the best kind of secondary amine. Penicillin ion transport through membrane was influenced by differences in concentration and pH. PTFE supported liquid membrane using secondary amines as carrier have a chance to be used as potentiometric sensor in penicillin determination.

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