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Kinetic and Removable of Amoxicillin Using Aliquat336 as a Carrier via a HFSLM

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***Abstract*—**Amoxicillin is an antibiotic which is widely used to treat various infections in both human beings and animals. However, when amoxicillin is released into the environment, it is a major problem. Amoxicillin causes bacterial resistance to these drugs and failure of treatment with antibiotics. Liquid membrane is of great interest as a promising method for the separation and recovery of the target ions from aqueous solutions due to the use of carriers for the transport mechanism, resulting in highly selectivity and rapid transportation of the desired metal ions. The simultaneous processes of extraction and stripping in a single unit operation of liquid membrane system are very interesting. Therefore, it is practical to apply liquid membrane, particularly the HFSLM for industrial applications as HFSLM is proved to be a separation process with lower capital and operating costs, low energy and extractant with long life time, high selectivity and high fluxes compared with solid membranes. It is a simple design amenable to scaling up for industrial applications. The extraction and recovery for (Amoxicillin) through the hollow fiber supported liquid membrane (HFSLM) using aliquat336 as a carrier were explored with the experimental data. The important variables affecting on transport of amoxicillin viz. extractant concentration and operating time were investigated. The highest $AMOX^-$ extraction percentages of 85.35 and Amoxicillin stripping of 80.04 were achieved with the best condition at 6 mmol/L [aliquat336] and operating time 100 min. The extraction reaction order (n) and the extraction reaction rate constant (k_f) were found to be 1.00 and 0.0344 min^{-1}, respectively.

***Keywords*—**Aliquat336, amoxicillin, HFSLM, kinetic.

I. Introduction

AMOXICILLIN is an effective drug which can inhibit the growth of bacterial infection and enables the body to fight infections [1]. Amoxicillin is an antibiotic that is widely used nowadays [2] and the structure is show as in Fig. 2 (a). It is used to treat infections in the respiratory tract, gastro-intestinal and urinary tract. The drug is effective against micro-organisms such as Streptococcus, Pneumococcus, Salmonella and Hemophilic influenza.

Amoxicillin cannot be destroyed by stomach acid but can be well absorbed in the gastro-intestinal tract. Thus, because the drug is absorbed in the intestine, it is used as an oral agent and can be used before or after meals [3]. Amoxicillin may cause allergic reactions and may interfere with normal bacteria in the digestive tract. The demand for drugs like Amoxicillin ensures a huge increase in industrial production [4]. Amoxicillin will always remain in the urine or feces. The production of amoxicillin increases the quantity of chemicals in the environment [5]. Over time, bacteria develop resistance to the drug and leads to an increased dose [6]. Thus, treatment with the drug amoxicillin will not be effective anymore [7]. Getting rid of amoxicillin residues in the environment is an important issue and one in which the pharmaceutical industry has been interested [8]. The pharmaceutical industry needs to treat wastewater with amoxicillin residue before releasing it to the water resources of the community [9]. It is necessary to extract and recover amoxicillin from synthetic wastewater.

In 1997, GC Sahoo studied the separation of antibiotics such as Cephalexin using a bulk liquid membrane (BLM) method [10]. In 1998, he continued to develop methods to separate emulsion liquid membrane extraction [11]. This program was costly because it used large quantities of solvents. However, a separate process with an efficient extraction method was developed resulting in extraction separation by membrane type with support i.e. (Supported Liquid Membrane) [12]. Another extraction system proved successful especially the hollow fiber supported liquid membrane (HFSLM). HFSLM had a higher surface area compared to most types of support plates (Flat Sheet) [13] and Spiral wound [14] as well as lower power consumption. The hollow fiber supported liquid membrane system can be easily adapted and expanded and can be applied on an industrial scale [15].

A. Theory

Amoxicillin (negative charge) was extracted and recovered by the mechanism of ion-exchanged. It reacts with quaternary amine (Aliquat 336, QCl). The ratio between amoxicillin (AMOX-) and quaternary amines is 1:1. The reaction of the extraction and recovery of amoxicillin is shown in (1) and (2), respectively. Fig. 1 shows the mass transfer of amoxicillin:

$$AMOX^-_{(f)} + Q^+Cl^-_{(o)} \longleftrightarrow Q^+ AMOX^-_{(o)} + Cl^-_{(f)} \quad (1)$$

$$Q^+AMOX^-_{(o)} + Cl^-_{(s)} \longleftrightarrow AMOX^-_{(s)} + Q^+Cl^-_{(o)} \quad (2)$$

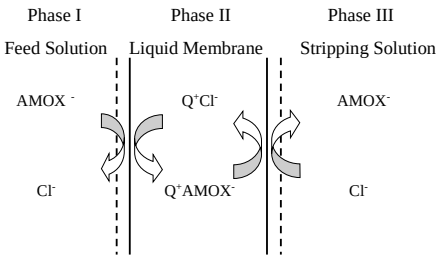

Fig. 1 The mass transfer of amoxicillin as the counter-transport

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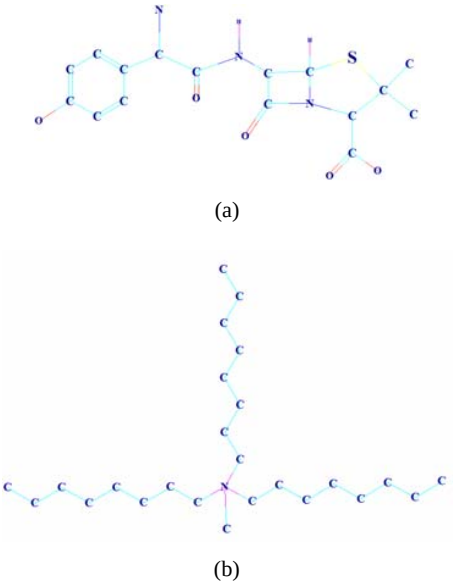

(a)

(b)

Fig. 2 (a) Structure of Amoxicillin (b) Structure of Aliquat336

II. Experiments

A. Chemicals and Reagents

Pharmaceutical grade amoxicillin ($AMOX^-$) was given by the Government Pharmaceutical Organization (Thailand). Aliquat 336 (Q^+Cl^-) was acquired from Sigma-Aldrich (Fig. 2 (b)), United states. Analytical grade reagents including sodium tetraborate, hydrochloric acid, citric acid, sodium citrate, 1-decanol and sodium chloride were obtained from Merck (Germany). Aqueous solutions were readied with distillation water all through the examination. Amoxicillin and borate buffer were used in feed phase. Aliquat 336 and 1-decanol were used in liquid membrane phase. Sodium chloride and citrate buffer were used in stripping phase.

B. Apparatus

This hollow fiber module utilizes Celgard (Membrana-Charlottle Company, USA) micro-porous polyethylene fibers that are woven into fabric and wrapped around a central tube feeder uniform fiber spacing that supplies the shell side fluid. This is leads to higher mass-transfer coefficients than those obtained with individual fibers. Physical characteristics of the hollow fiber module are reported in Table I.

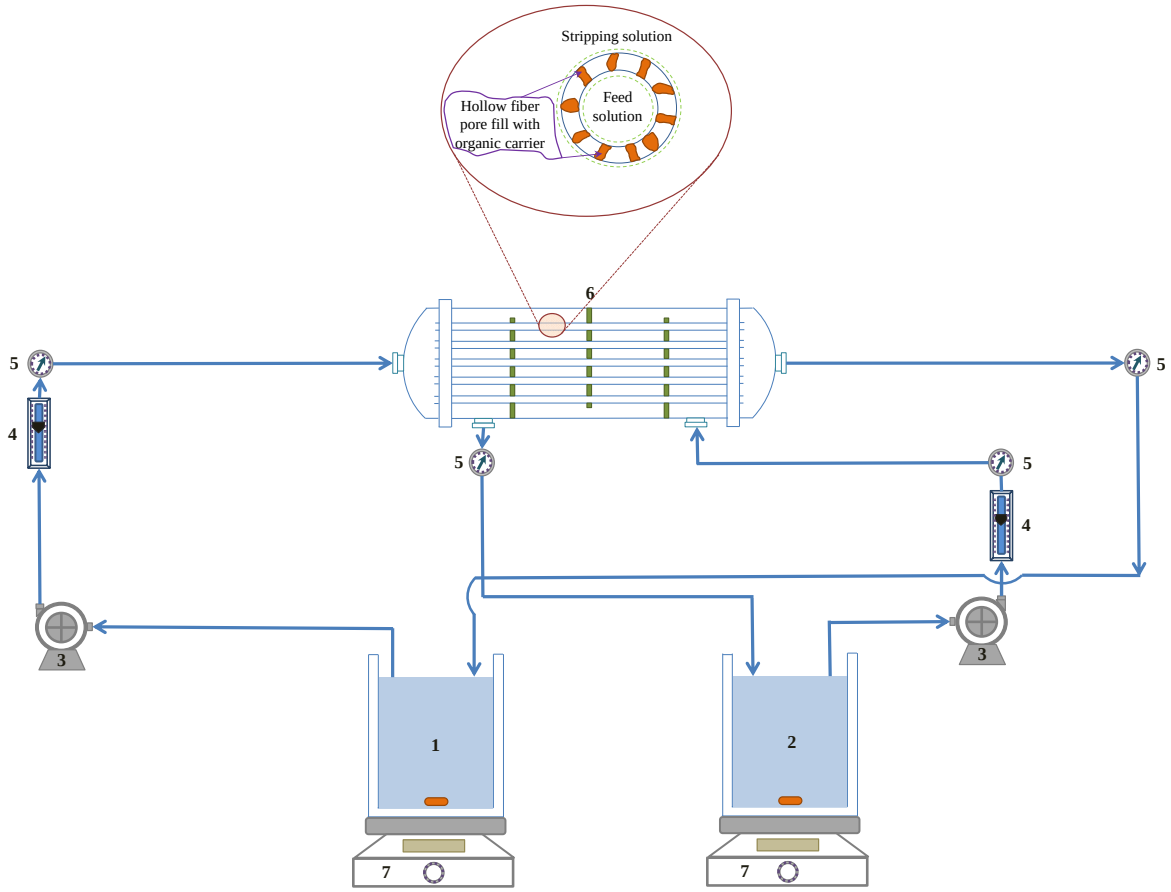

Fig. 3 Schematic counter-current flow diagram for operation in the hollow fiber supported liquid membrane: 1) feed reservoir 2) stripping reservoir 3) Gear pump 4) Rota meter 5) Pressure gauge 6) Hollow fiber module and 7) stirrer control

TABLE I
PHYSICAL CHARACTERISTICS OF THE HOLLOW FIBER MODULE (MEMBRANA-CHARLOTTLE COMPANY, USA)

Properties	Descriptions
Material	Polypropylene
Inside diameter of hollow fiber	240 μm
Outside diameter of hollow fiber	300 μm
Effective length of hollow fiber	15 cm
Number of hollow fibers	35,000
Average pore size	0.03 μm
Porosity	30 %

C. Procedure

Firstly, the liquid membrane is prepared by dissolving Aliquat336 in 1-deccanol about 500 ml. Secondly, it is fed into the tube and shell sides of the hollow fiber module for 50 min. This is to ensure that the extractant fill into the micro-pores of the hollow fibers. Then, the HFSLM system is set up as in Fig. 3. There is a feed reservoir tank and associated pump to provide continuous feed throughput for the module. Likewise, there is a stripping reservoir tank and its pump to provide stripping solution feed in a counter flow against the feed. The modules are filled with extractant solution, acting as liquid membrane or organic phase to separate the two aqueous phases.

III. RESULTS AND DISCUSSION

A. Effect of Operating Time

The extraction and recovery of amoxicillin was accomplished at the conditions as follows: 6 mmol/L Aliquat336 in the presence of 1-decanol, the pH value of 8.0, 6 mmol/L NaCl, feed and stripping flow rate of 100 ml/min. in the hollow fiber supported liquid membrane system. The concentration of amoxicillin in the feed solution decreased when retention time increased. In the feed phase, the maximum extraction of amoxicillin was attained at 100 min. as demonstrated in Fig. 4. And in the stripping phase, the maximum recovery of amoxicillin was attained at 100 min.

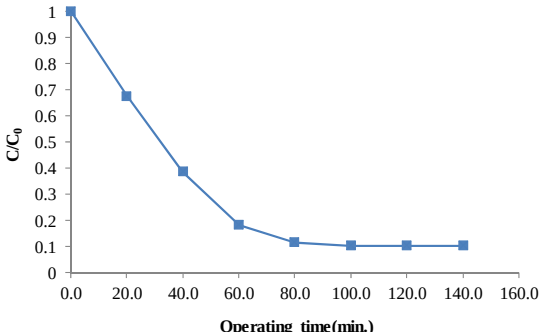

Fig. 4 Influence of operating time on C/C_0

B. Effect of Carrier Concentration in the Membrane Phase

The concentration of Aliquat336 in the organic phase has a significant effect on the transport of amoxicillin through HFSLM system. The extractant concentration studied range between 2.0 – 10.0 mmol/L. The results are graphically presented in Fig. 5. It showed that the concentration of amoxicillin in feed solution decreased when carrier concentration increased. Optimum concentration of carrier of work was 6 mmol/L. It was noted that the trend of extraction and recovery percentage decreased when the carrier concentration was higher than 6 mmol/L. This could be attributed to an increase in viscosity of the liquid membrane causes the reduction of ion diffusivity which eventually leads to a decrease in the recovery percentage of amoxicillin.

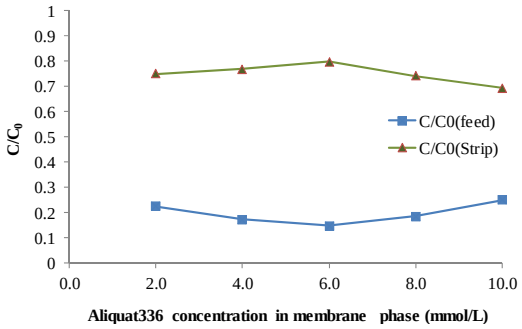

Fig. 5 Plot of C/C_0 in feed phase versus carrier concentration

C. The Reaction Order and the Reaction Rate Constant for Amoxicillin

Kinetics was used to determine the order of reaction and reaction rate constant for extraction and recovery of amoxicillin by applying an integral equation to plot the graph to determine the relationship of the two variables. The integral concentrations with respect to zero, first and second orders were plotted CA, ln(CA0/CA) and 1/CA against time at optimum conditions. The linear line of each reaction order is presented by the squared correction coefficients (R2). The integral concentrations with respect to the zero, first and second orders were plotted against time at optimum conditions which are shown in Fig. 6 and Table II. The results indicate that the linear line with respect to the extraction of first-order reaction (n = 1) provided the best line fitting. The extraction of reaction rate constant (ke,f) of 0.0344 min-1 for amoxicillin extraction is obtained.

TABLE II
VALUES OF THE EXTRACTION OF REACTION ORDERS (N) AND THE REACTION RATE CONSTANT ($K_{E,F}$)

n	Plot	$K_{e,f}$	R-square	Acceptability
0	C_A vs. t	0.9330 mg/L min	0.9047	No
1	$\ln(C_{A0}/C_A)$vs.t	0.0344 min^{-1}	0.9968	Yes
2	$1/C_A$ vs. t	0.8457 L/mg·min	0.8402	No

IV. CONCLUSION

The amoxicillin from synthetic feed solution was extracted and recovered via HFSLM using Aliquat336. Amoxicillin percentages of 85.35% extraction and 80.04% recovery were achieved at 6 mmol/L Aliquat336 and operating time of 100 min. The first order reaction and the extraction reaction rate constant (ke,f) 0.0344 min-1 were obtained.

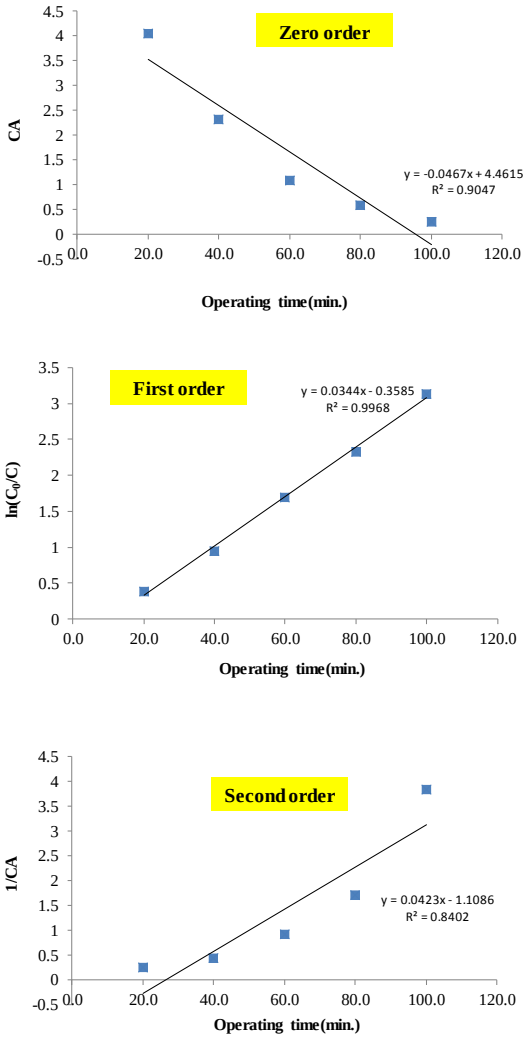

Fig. 6 The zero, first and second orders were plotted C_A, $\ln(C_{A0}/C_A)$ and $1/C_A$ against time

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