

APPENDIX A

SOME BASIC PRINCIPLE OF CONDUCTOMETRY

A.1 Basic principle of conductometry in solution

A conductance measuring cell consists of two inert electrodes that face each other and immerse in measuring solution. The inert electrode is generally platinum or stainless steel. The conductance cell for measuring of ionic mobility in solution can be demonstrated in Figure A1.

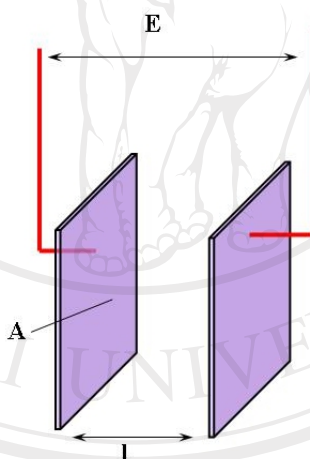


Figure A1 conductance cell for measuring in solution

The conductance is reciprocal of solution resistance and present as unit of Siemens (S). The conductance value which represent ionic mobility in solution depends on electrode area and electrode distance; different in cell configuration make different conductance value although it measures the same solution. In order to compensate such effect of measuring from various configuration cells, the

conductance was converted to be conductivity which represent as unit of conductance-electrode length per electrode area as explain with equation A1. Electrical conductivities are normally given in $\mu\text{S}/\text{cm}$ or mS/cm ($12.88 \text{ mS}/\text{cm} = 1288 \text{ mS}/\text{m}$; $5 \mu\text{S}/\text{cm} = 500 \mu\text{S}/\text{m}$). From equation A1, cell constant is ratio of electrode distance and electrode area. The cell constant can be calculated from known conductivity standard solution (for example conductivity of 5 mM of KCl at 25 °C is 720 $\mu\text{S}/\text{cm}$) [A1].

$$\sigma = \frac{1}{R} \times \frac{l}{A} = K_{cell} \times G \quad [A1]$$

Where

σ = conductivity, Scm^{-1}

R = resistance, Ω

G = conductance, S (Siemens)

K_{cell} = cell constant

l = electrode length, cm

A = electrode area, cm^2

A.2 Conductance model in hollow sphere soap film; the following method was developed by P.K. Dasgupta and W.L. Borst [A2]

The conductance model in bubble film can be considered a cross sectional view of a hollow bubble of uniform wall thickness δ and radius r_b . The electrodes at the polar caps each have an arc length $2r_e$ such that the arc r_e subtends an angle θ_o radians at the center of the bubble as shown in Figure A2.

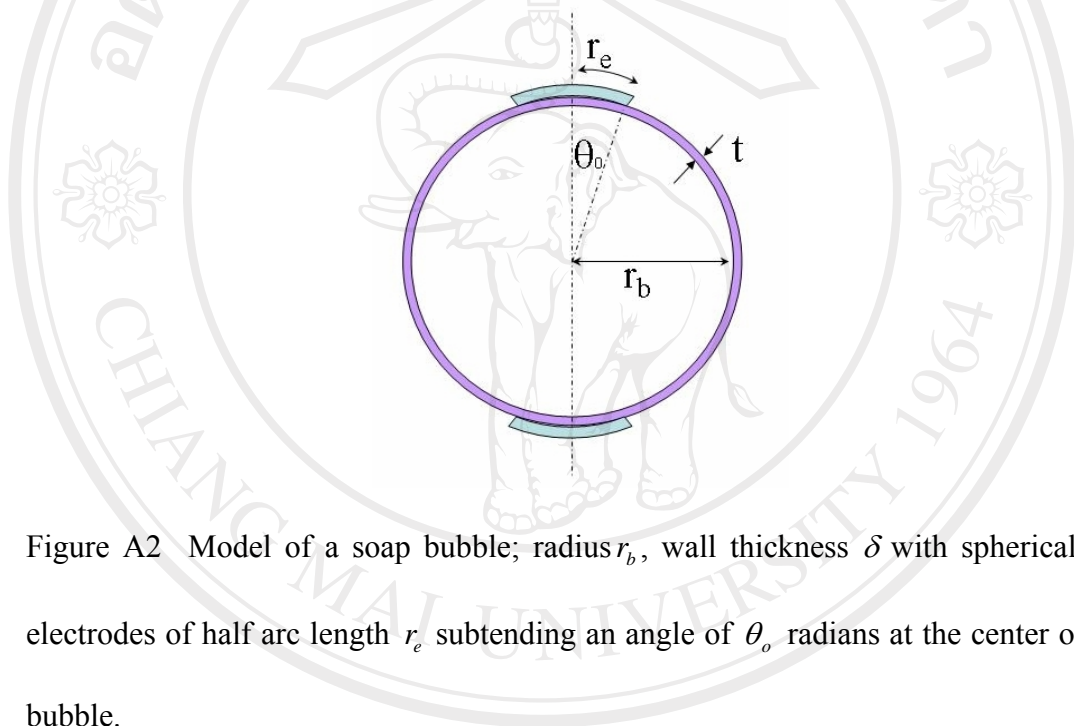


Figure A2 Model of a soap bubble; radius r_b , wall thickness δ with spherical cap electrodes of half arc length r_e subtending an angle of θ_o radians at the center of the bubble.

It should be noted that $r_b \gg r_e \gg \delta$. A voltage V is applied between the two electrodes. Ohm's law in differential form states that the current density \vec{J} is related to the specific conductance σ and the electric field strength \vec{E} by

$$\vec{J} = \sigma \cdot \vec{E} \quad [A2]$$

Equation A2 can be rewritten in the following form by noting that the current density \vec{J} and field \vec{E} point along the meridians of the bubble between the polar caps:

$$\frac{dI}{dA} = \sigma \cdot \frac{dV}{ds} \quad [\text{A3}]$$

Where dI is the current that flows along a meridian through an area dA given by

$$dA = \delta r_b \sin \theta d\phi \quad [\text{A4}]$$

Note that we have azimuthal uniformity of the current in this spherical coordinate system. Thus the area A through which the total current I flows is

$$A = 2\pi\delta r_b \sin \theta \quad [\text{A5}]$$

and thus

$$\frac{dI}{dA} = \frac{I}{A} = \frac{I}{2\pi\delta r_b \sin \theta} \quad [\text{A6}]$$

The infinitesimal arc length ds along a median is given by

$$ds = r_b d\theta \quad [\text{A7}]$$

Substituting equations A6 and A7 in A3 and integrating, we have:

$$V = \frac{I}{2\pi\delta\sigma} \int_{\theta_0}^{\pi-\theta_0} \frac{d\theta}{\sin \theta} \quad [\text{A8}]$$

The solution to this integral is:

$$\int_{\theta_0}^{\pi-\theta_0} \frac{d\theta}{\sin \theta} = \left[\log \left(\tan \frac{\theta}{2} \right) \right]_{\theta_0}^{\pi-\theta_0} = 2 \ln \left(\cot \frac{\theta_0}{2} \right) \quad [\text{A9}]$$

Hence the desired voltage-current relationship is given by

$$V = \frac{1}{\pi\delta\sigma} \ln \left(\cot \frac{\theta_0}{2} \right) \cdot I \quad [\text{A10}]$$

Comparing equation A10 with Ohm's law in integral form:

$$V = \frac{I}{G} \quad [\text{A11}]$$

One obtains the experimentally measured conductance G as:

$$G = \frac{\pi\delta\sigma}{\ln\left(\cot\frac{\theta_0}{2}\right)} \quad [\text{A12}]$$

The angle θ_0 (in radian) is given by (see Figure A2)

$$\theta_0 = \frac{r_e}{r_b} \quad [\text{A13}]$$

Thus one finally obtains

$$G = \frac{\pi\delta\sigma}{\ln\left(\cot\frac{r_e}{2r_b}\right)} \quad [\text{A14}]$$

It is interesting to note that the observed conductance is governed by the ratio of r_e and r_b and not by their individual values.

APPENDIX B

EVALUATION PARAMETER FOR SOAP FILM PERMEATION

The permeation performance in this experiment will be present with 3 parameters; ratio of permeation concentration and starting concentration (C_p/C_o), flux (F), and separation factor (α) [B1].

i) **Ratio of permeation and starting concentration (C_p/C_o).** It was calculated from concentration of α -pinene in permeated compartment and concentration of α -pinene in U-tube. This parameter indicates percentage of permeation.

ii) **Flux.** It can be defined as permeated mole per time per active area of soap film. This value shows ability of permeation and use for compare with other permeation systems.

$$F = \frac{n}{At} \quad [B1]$$

Where: F = Flux of transfer across soap film, mole/cm²min

n = permeation mole, mole

A = soap film area, cm²

t = flowing time, min

The permeation mole was calculated from concentration (from SPME-GC calibration and measurement) and volume of permeation compartment. This value can be considered as absolute permeated mole.

$$P = \frac{C_p V_p}{MW} \quad [B2]$$

When C_p = permeation concentration, g/ml (from SPME-GC calibration)

V_p = volume of permeated compartment, ml

MW = molecular weight of alpha pinene, = 136.23 g/mol

iv) **Separation factor (α)**. It is comparative ratio of permeated plus and minus form in permeation box. It can be calculated through equation:

$$\alpha = \frac{(C_{p(+)} / C_{0(+)})}{(C_{p(-)} / C_{0(-)})} \quad [B3]$$

Where

$C_{p(+)}$ = Concentration of plus (+) form in permeated compartment

$C_{0(+)}$ = Original concentration of plus (+) form which sampling from U-tube

$C_{p(-)}$ = concentration of minus (-) form in permeated compartment

$C_{0(-)}$ = original concentration of minus (-) form which sampling from U-tube

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PUBLICATIONS

1. T. Kanyanee, W. L. Borst, J. Jakmunee, K. Grudpan, J. Li, and P. K. Dasgupta, *Anal. Chem.* **78** (2006) 2786.

INTERNATIONAL CONFERENCE

1. T. Kanyanee, W. L. Borst, J. Jakmunee, K. Grudpan, J. Li and P. K. Dasgupta, *A Flow System with Soap Bubble for Gas Sampling Device*, 10th International conference on flow analysis. Porto, Portugal, 2006.
2. T. Kanyanee, K. Grudpan, P. K. Dasgupta, and J. Jakmunee, *Promising Flow System for Chiral Compounds Separation via Soap Liquid Thin Film*, 7th International Symposium on Flow-based Analysis, Chiang Mai, Thailand, 2007.

NATIONAL CONFERENCES

1. T. Kanyanee and W. Veerasai, *Electrochemical Conversion of Oxovanadium Species at Rh/Ti-Alloy Electrode in a Simple Redox Flow Cell (RFC)*, The First PERCH Annual Scientific Conference (PERCH Conference I), Thailand, 2002.

2. P. Boonpeng, T. Kanyanee, and J. Jakmune, *Fabrication of Reference Electrode for Chemistry Laboratory*, 29th Congress on Science & Technology of Thailand, 2003.



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THE RELEVANCE OF THE RESEARCH WORK TO THAILAND

With the global climate problem looming, air quality control and monitoring procedures are necessary in all countries. Suitable devices and methods for trace atmospheric gas analysis is needed by an atmospheric chemist. In Thailand, the emission control of toxic gases from industrial activity is especially necessary. The first step to atmospheric gas analysis is a gas sampling device.

An automated device for continuous gas sampling and analysis based on a flow system provides a rapid and convenient means for air quality monitoring. This research resulted in the development of soap bubble film based flow system for gas sampling device and analysis. Under computer control, soap bubble film can be formed automatically reproducibly. Toxic gases such as SO₂ can be collected and analyzed in-situ. An automated rapid gas sampling/analysis system can be achieved.

In addition, a selector-doped soap film was successfully developed for chiral or isomeric separations. The soap film acts as a unique liquid membrane without a solid support host; analyte vapor molecules can permeate across such a film. Soap solution films are thus inexpensive, easily renewable and generally environmentally friendly platforms for investigating selective collection or differential transport. An entirely new affordable avant-garde technology, with considerable economic importance can conceivably develop around the use of soap solution films as a membrane, not just in Thailand but also elsewhere.