APPENDIX A

Determination of the Swelling Ratio

The swelling ratio of hydrogel was calculated using the Eq. 1.1. The results were shown in **Table 3.3**, **Table 3.10**, **and Table 3.14**.

$$\text{Swelling ratio} = \frac{W_2 - W_1}{W_1}$$

where W_1 and W_2 are the weights of hydrogels at initial time and time t, respectively.

For example:

From the values appeared in **Table 3.3** of the SF hydrogel at 2 min soaking time

$W_1 = 0.050$ g

$W_2 = 0.072$ g

$$\text{Swelling ratio} = \frac{0.072 - 0.050}{0.050} = 0.44$$

APPENDIX B

Calibration Curves of Nitrogen, Phosphorus and Potassium

B.1 The calibration curve of nitrogen

Absorbances of a set of standard nitrogen solutions were measured at 635 nm at room temperature. The results from the measurement are shown in **Table B.1.1** and the plot of calibration curve is shown in **Figure B.1.1**.

Table B.1.1 Absorbances of the nitrogen solutions at various concentrations

Nitrogen Concentration (ppm)	Abs. at 635 nm
0	0.000
0.02	0.023
0.04	0.028
0.1	0.107
0.2	0.225
0.4	0.439
0.6	0.634
0.8	0.850
1	1.067

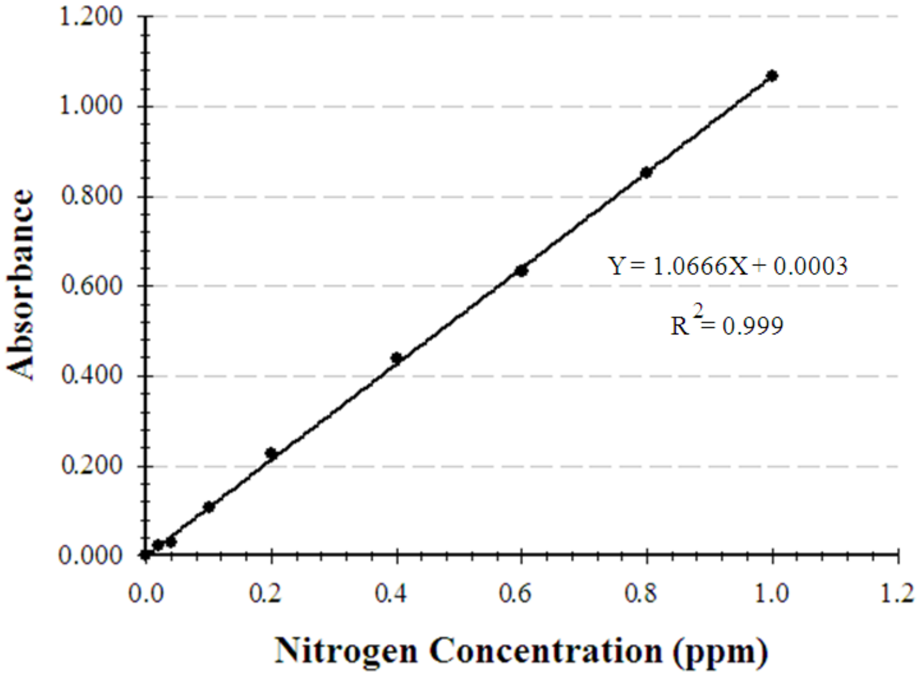

Figure B.1.1 A calibration curve of nitrogen

Equation of the calibration curve:

$$y = 1.0666x+0.0003$$

where y = absorbance and x= nitrogen concentration (ppm)

$$\% \text{ Nitrogen release} = \frac{\text{nitrogen concentration in the soaking solution (ppm)}}{\text{Initial nitrogen concentration (ppm)}} \times 100$$

For example:

Result from **Table 3.4** for the SF/gelatin hydrogel (25:75) after soaking in water for a day; absorbance = 0.282

$$0.282 = 1.0666x+0.0003$$

$$x = 0.263$$

Initial nitrogen concentration = 0.755 ppm

$$\% \text{ Nitrogen release} = \frac{0.263}{0.755} \times 100$$

$$= 35.0$$

B.2 The calibration curve of phosphorus

Absorbances of a set of standard phosphorus solutions were measured at 350 nm at room temperature. The results from these measurements are shown in **Table B.2.1** and the calibration curve plotted from these results is shown in **Figure B.2.1**.

Table B.2.1 Absorbances of the phosphorus solutions at various concentrations

Phosphorus Concentration (ppm)	Abs. at 350 nm
0	0.000
0.25	0.069
0.5	0.134
1	0.292
2	0.573
3	0.862
4	1.029

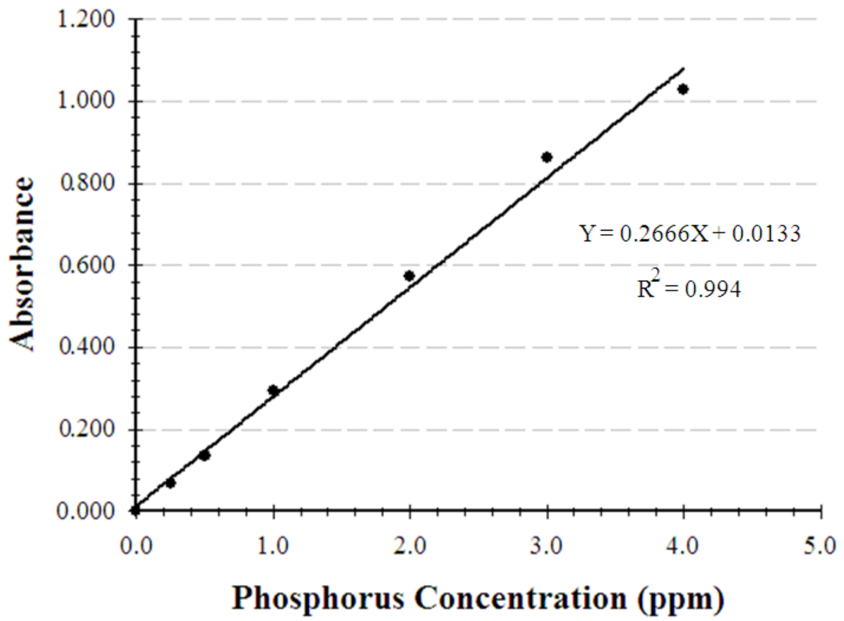

Figure B.2.1 A calibration curve of phosphorus

Equation of the calibration curve: y = 0.2666x+0.0133

where y = absorbance and x= phosphorus concentration (ppm)

$$\% \text{ Phosphorus release} = \frac{\text{phosphorus concentration in the soaking solution (ppm)}}{\text{Initial phosphorus concentration (ppm)}} \times 100$$

For example:

Result from **Table 3.5**, SF:gelatin (25:75) at 1 day soaking; absorbance = 0.544

0.544 = 0.2666x+0.0133

x = 1.99

Initial phosphorus concentration = 4.649 ppm

$$\% \text{ Phosphorus release} = \frac{1.99}{4.649} \times 100$$

$$= 42.8$$

B.3 The calibration curve of potassium

Emission signals of the potassium solutions were measured by a flame photometer. The results from these measurements are shown in **Table B.3.1** and the calibration curve plotted from these results is shown in **Figure B.3.1**.

Table B.3.1 Emission signals of the potassium solutions at various concentrations

Potassium Concentration (ppm)	Ems.
0	0.0
10	13.4
20	24.0
30	33.4
40	42.2
50	51.5
60	60.0

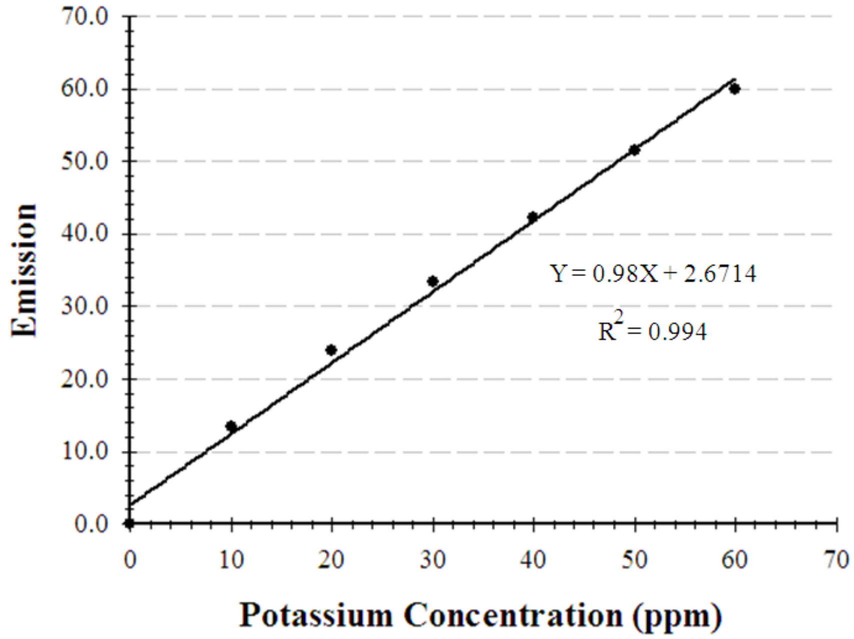

Figure B.3.1 A calibration curve of potassium

Equation of the calibration curve: y = 0.98x+2.6714

where y = emission and x= potassium concentration (ppm)

$$\% \text{ Potassium release} = \frac{\text{potassium concentration in the soaking solution (ppm)}}{\text{Initial potassium concentration (ppm)}} \times 100$$

For example:

Result from **Table 3.6**, SF:gelatin (25:75) at 1 day soaking; emission signal = 27.6

$$27.6 = 0.98x+2.6714$$

$$x = 25.4$$

Initial potassium concentration = 48.4 ppm

$$\% \text{ Potassium release} = \frac{25.4}{48.4} \times 100$$

$$= 52.6$$

APPENDIX C

Determination of Percent Porosity

The percent porosity of hydrogel was calculated from the equation 2.1. The results were shown in **Table 3.13**.

$$\varepsilon = \frac{V_1 - V_3}{V_2 - V_3} \times 100$$

For example:

From the values appeared in **Table 3.13**, at the concentration of CS equals to 0 php

V_1 = 6.0 mL

V_2 = 6.3 mL

V_3 = 5.95 mL

$$\varepsilon = \frac{6.0 - 5.95}{6.3 - 5.95} \times 100 = 14.3$$

APPENDIX D

Determination of Water Solubility

The water solubility of hydrogel was calculated from the Eq. 2.2. The results were shown in **Table 3.14**.

$$WS = \frac{W_1 - W_3}{W_1}$$

where, W_1 and W_3 are the weights of the dried hydrogel before immersing in water and the dried swollen hydrogel, respectively.

For example:

From the values appeared in **Table 3.14**, at CS 0 php

$$W_1 = 0.0500 \text{ g}$$

$$W_3 = 0.0335 \text{ g}$$

$$WS = \frac{0.0500 - 0.0335}{0.0500} = 0.329$$

APPENDIX E

Modeling and Release Kinetics

From the Eq. 1.6,

$$\frac{M_t}{M_\infty} = kt^n \tag{1.6}$$

$$\log \frac{M_t}{M_\infty} = \log k + n \log t \tag{E.1}$$

where M_t and M_∞ are the amount of fertilizer released at time t and as the time approaches infinity, respectively; k is a constant incorporating geometrical and structural characteristics of the macromolecular network system and the fertilizer; n is the release exponent, indicative of the transport mechanism.

The release exponent; n and release rate constant; k of each hydrogel were obtained from the plot of log (M_t/M_α) versus log (times)

Example, from the linear equation for nitrogen release of the SF hygrogel (SF:gelatin at the weight ratio of 100:0)

$$y = 0.4087x - 0.3170$$
$$n = 0.4087$$
$$\log k = -0.3170$$
$$k = 0.4819$$

Table E.1.1 Linear equation for nitrogen release of the SF/gelatin hydrogels at various weight ratios of SF:gelatin

SF:gelatin (weight ratio)	Linear equation
100:0	y = 0.4087x-0.3170; R^2 = 0.9933
75:25	y = 0.4698x-0.4149; R^2 = 0.9925
50:50	y = 0.4578x-0.3974; R^2 = 0.9899
25:75	y = 0.4257x-0.3436; R^2 = 0.9969

Table E.1.2 Linear equation for phosphorus release of the SF/gelatin hydrogels at various weight ratios of SF:gelatin

SF:gelatin (weight ratio)	Linear equation
100:0	y = 0.3626x-0.2800; R^2 = 0.9983
75:25	y = 0.3984x-0.3434; R^2 = 0.9857
50:50	y = 0.3900x-0.3319; R^2 = 0.9906
25:75	y = 0.3846x-0.3028; R^2 = 0.9987

Table E.1.3 Linear equation for potassium release of the SF/gelatin hydrogels at various weight ratios of SF:gelatin

SF:gelatin (weight ratio)	Linear equation
100:0	y = 0.2888x-0.1662; R^2 = 0.9850
75:25	y = 0.3571x-0.3095; R^2 = 0.9820
50:50	y = 0.3344x-0.2453; R^2 = 0.9849
25:75	y = 0.2953x-0.1914; R^2 = 0.9562

Table E.1.4 Linear equation for nitrogen release of SF/gelatin/CS hydrogels with CS composition of 0 php, 20 php, 40 php, 60 php, 80 php and 100 php

CS (php)	Linear equation
20	y = 1.2299x-1.2749; R^2 = 0.9645
40	y = 1.2458x-1.2902; R^2 = 0.9784
60	y = 1.2610x-1.3033; R^2 = 0.9592
80	y = 1.2632x-1.3473; R^2 = 0.9971
100	y = 1.2877x-1.3970; R^2 = 0.9843

The diffusion coefficient (D) was determined using Eq. 1.5.

$$\frac{M_t}{M_\infty} = 4\left(\frac{Dt}{\pi l^2}\right)^{1/2}$$

The D value of each hydrogel was evaluated from the plot of $\frac{M_t}{M_\infty}$ versus $\frac{t^{1/2}}{l}$

$$\text{Slope} = 4\left(\frac{D}{\pi}\right)^{1/2}$$

$$\frac{\text{Slope}}{4} = \left(\frac{D}{\pi}\right)^{1/2}$$

$$\left(\frac{\text{Slope}}{4}\right)^2 = \frac{D}{\pi}$$

$$D = \frac{\text{Slope}^2 \times \pi}{16}$$

Example, from the linear equation for nitrogen release; SF:gelatin (100:0)

$$y = 1.6337\times10^{-5}x$$

$$\text{Slope} = 1.6337\times10^{-5}$$

$$D = \frac{(1.6337\times10^{-5})^2 \times \pi}{16}$$

$$D = 0.52 \times 10^{-10}$$

Table E.1.5 The linear equation for nitrogen release of SF hydrogel, and SF/gelatin hydrogels with SF:gelatin weight ratios of 100:0, 75:25, 50:50 and 25:75

SF:gelatin (weight ratio)	Linear equation
100:0	$y = 1.6337\times10^{-5}x+0.0780$; $R^2 = 0.9795$
75:25	$y = 1.4750\times10^{-5}x+0.0052$; $R^2 = 0.9887$
50:50	$y = 1.4875\times10^{-5}x+0.0293$; $R^2 = 0.9942$
25:75	$y = 1.5581\times10^{-5}x+0.0703$; $R^2 = 0.9972$

Table E.1.6 The linear equation for phosphorus release of SF hydrogel, and SF/gelatin hydrogels with SF:gelatin weight ratios of 100:0, 75:25, 50:50 and 25:75

SF:gelatin (weight ratio)	Linear equation
100:0	$y = 1.5835\times10^{-5}x+0.1155$; $R^2 = 0.9841$
75:25	$y = 1.2794\times10^{-5}x+0.1552$; $R^2 = 0.9880$
50:50	$y = 1.2809\times10^{-5}x+0.1693$; $R^2 = 0.9926$
25:75	$y = 1.3312\times10^{-5}x+0.1933$; $R^2 = 0.9979$

Table E.1.7 The linear equation for potassium release of SF hydrogel, and SF/gelatin hydrogels with SF:gelatin weight ratios of 100:0, 75:25, 50:50 and 25:75

SF:gelatin (weight ratio)	Linear equation
100:0	$y = 1.3424\times10^{-5}x+0.3581$; $R^2 = 0.9916$
75:25	$y = 1.1476\times10^{-5}x+0.2388$; $R^2 = 0.9897$
50:50	$y = 1.2694\times10^{-5}x+0.2702$; $R^2 = 0.9679$
25:75	$y = 1.2983\times10^{-5}x+0.3255$; $R^2 = 0.9786$

Table E.1.8 The linear equation for nitrogen release of SF/gelatin/CS hydrogels with CS composition of 0 php, 20 php, 40 php, 60 php, 80 php and 100 php

CS (php)	Linear equation
20	$y = 2.1701\times10^{-5}x-0.7819$; $R^2 = 0.9738$
40	$y = 2.1550\times10^{-5}x-0.7821$; $R^2 = 0.9813$
60	$y = 2.1450\times10^{-5}x-0.7758$; $R^2 = 0.9747$
80	$y = 2.0224\times10^{-5}x-0.7464$; $R^2 = 0.9927$
100	$y = 1.9144\times10^{-5}x-0.7105$; $R^2 = 0.9846$

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International Conference Participation The NRU summit III: Prelude to World Class University between July 31-August 1, 2014 at Bangkok Convention Center, Centara Grand at Central World, Bangkok, Thailand.

International Presentation “Effect of Gelatin on Secondary Structure, Crystallinity and Swelling Behavior of Silk Fibroin-Gelatin Hydrogels and Its Application in Controlled Release of Nitrogen” in the 3rd International Conference on Advanced Engineering Materials and Technology between May 11-13, 2013, Zhangjiajie, China.