APPENDIX A

Table A.1 Bottled Drinking Water Quality Standard defined by pollution control department, ministry of natural resources and environment (WHO 2006) [68].

Properties	**Parameters**	**Units**	**Maximum Allowable Concentration**
Physical	1. Colour	Hazen	20
	2. Odour	-	None
	3. Turbidity	Silica scale unit (SSU)	5
	4. pH	-	6.5-8.5
Chemical	5. Total Solids	mg/l	500
	6. Total Hardness as $CaCO_3$	mg/l	100
	7. Arsenic (As)	mg/l	0.05
	8. Barium (Ba)	mg/l	1.0
	9. Cadmium (Cd)	mg/l	0.005
	10.Chloride as Chlorine	mg/l	250
	11.Chromium (Cr)	mg/l	0.05
	12.Copper (cu)	mg/l	1.0
	13.Iron (Fe)	mg/l	0.3
	14.Lead (Pb)	mg/l	0.05
	15.Manganese (Mn)	mg/l	0.05
	16.Mercury (Hg)	mg/l	0.002

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Table A.1 (Continued).

Properties	**Parameters**	**Units**	**Maximum Allowable Concentration**
	17.Nitrate as Nitrogen (NO_3 - N)	mg/l	4.0
	18.Phenol	mg/l	0.001
	19.Selenium (Se)	mg/l	0.01
	20.Silver (Ag)	mg/l	0.05
	21.Sulphate (SO_4)	mg/l	250
	22.Zinc (Zn)	mg/l	5.0
	23.Fluoride as Fluorine (F)	mg/l	1.5
	24.Aluminium (Al)	mg/l	0.2
	25.Alkylbenzene Sulfonate	mg/l	0.2
	26.Cyanida (CN)	mg/l	0.1
Bacterial	27.Coliform	MPN/100 cm^3	2.2
	28.*E.Coli*	MPN/100 cm^3	None
	29.Disease causing bacteria	MPN/100 cm^3	None

Note 1 mg = 1000 µg

MPN = Most Probable Number

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APPENDIX B

The student t-Test [66]

$$t = \frac{\bar{x}_d \sqrt{n}}{S_d}$$

$$S_d = \sqrt{\frac{\sum(x_i - \bar{x})^2}{n-1}}$$

$$\bar{x}_d = \frac{\sum x_d}{n}$$

Where; x_d the difference between two method

$\bar{x}_d$ the mean difference

S_d the standard deviation

n number of sample

n-1 number of degree of freedom

The Table B.1 gives the concentration of iron (mg L^{-1}) determined by the proposed FIA and ICP-MS methods for each eight test portions.

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Table B.1 Calculation of *t*-test for iron determination of FIA.

Water samples	Concentrations (mg L^{-1})		$\bar{x}$	s_d	$\bar{x}_d$	$t_{calculated}$
	FIA*	ICP-MS*				
Amtech	0.007	0.007	0.007	0.000577	-0.000333	-1.001
Big Bell	0.015	0.017	0.015	0.000577	-0.001667	-5.004
Double Elephants	0.010	0.013	0.010	0.002550	-0.002667	-1.811
Mont Blanc	0.009	0.010	0.009	0.002646	-0.000333	-0.218
Nam Petch	0.006	0.006	0.006	0.001155	-0.000333	-0.499
Nasibee	0.016	0.018	0.016	0.001000	-0.002000	-3.464
Polestar	0.006	0.007	0.006	0.000707	-0.000667	-1.633
Wang Nam Kang	0.008	0.010	0.008	0.001527	-0.001667	-1.891

*average of triplicate results

For example: **Amtech**

$$\bar{x} = \frac{\sum x_i}{n}$$

$$= \frac{0.006 + 0.007 + 0.007}{3}$$

$$= 0.007$$

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$$S = \sqrt{\frac{\sum(x_i - \bar{x})^2}{n-1}}$$

$$= \sqrt{\frac{0.000000666}{3-1}}$$

$$= 0.000577$$

$$\bar{x}_d = \frac{(0.006 - 0.007) + (0.007 - 0.007) + (0.007 - 0.007)}{3}$$

$$= -0.000333$$

$$T = \frac{\bar{x}_d \sqrt{n}}{S_d}$$

$$= \frac{-0.000333\sqrt{3}}{0.000577}$$

$$= -1.001$$

The iron content found in water sample by the proposed FIA procedure and ICP-MS was compared and then the results were given in Tale B 1. The *t* calculated values for samples Amtech, Big Bell, Double Elephants, Mont Blanc, Nam Petch Nasibee, Polestar and Wang Nam Kang are -1.001, -5.004, -1.811, -0.218, -0.499, -3.464, -1.633 and -1.891, respectively, for FIA and ICP-MS methods. The tabulated critical value of *t* at 95% confidence level and two degrees of freedom is 4.30, Since the calculated values is less than the critical value from the Table B.3, that here is no statistically significant difference between the two methods.

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Table B.2 Calculation of *t*-test for iron determination of SIA.

Water samples	Concentrations (mg L^{-1})		$\bar{x}$	s_d	$\bar{x}_d$	$t_{calculated}$
	FIA*	ICP-MS*				
Amtech	0.006	0.007	0.006	0.001155	-0.001000	-1.500
Big Bell	0.016	0.017	0.016	0.001000	-0.001000	-1.732
Double Elephants	0.012	0.013	0.012	0.001581	-0.000667	-0.730
Mont Blanc	0.009	0.010	0.009	0.000707	-0.001333	-3.266
Nam Petch	0.006	0.006	0.006	0.000577	-0.000333	-1.001
Nasibee	0.017	0.018	0.017	0.001528	-0.000667	-0.756
Polestar	0.006	0.007	0.006	0.000707	-0.000667	-1.633
Wang Nam Kang	0.009	0.010	0.009	0.001528	-0.000667	-0.756

*average of triplicate results

For example: **Mont Blance**

$$\bar{x} = \frac{\sum x_i}{n}$$

$$= \frac{0.008 + 0.009 + 0.009}{3}$$

$$= 0.009$$

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$$S = \sqrt{\frac{\sum(x_i - \bar{x})^2}{n-1}}$$

$$= \sqrt{\frac{0.000001}{3-1}}$$

$$= 0.000707$$

$$\bar{x}_d = \frac{(0.008 - 0.010) + (0.009 - 0.010) + (0.009 - 0.010)}{3}$$

$$= -0.001333$$

$$T = \frac{\bar{x}_d \sqrt{n}}{S_d}$$

$$= \frac{-0.001333\sqrt{3}}{0.000707}$$

$$= -3.266$$

The iron content found in water sample by the proposed SIA procedure and ICP-MS was compared and then the results were given in Tale B 2. The *t* calculated values for samples Amtech, Big Bell, Double Elephants, Mont Blanc, Nam Petch Nasibee, Polestar and Wang Nam Kang are -1.500, -1.732, -0.730, -3.266, -1.001, -0.756, -1.633, and -0.756, respectively, for SIA and ICP-MS methods. The tabulated critical value of *t* at 95% confidence level and two degrees of freedom is 4.30, Since the calculated values is less than the critical value from the Table B.3, that here is no statistically significant difference between the two methods.

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Table B.3 Values of *t* for various levels of confidence interval.

Degrees of freedom	**Confidence interval**			
	80%	**90%**	**95%**	**99%**
1	3.08	6.31	12.70	63.7
2	1.89	2.92	4.30	9.92
3	1.64	2.35	3.18	5.84
4	1.53	2.13	2.78	4.60
5	1.48	2.02	2.57	4.03
6	1.44	1.94	2.45	3.71
7	1.42	1.90	2.36	3.50
8	1.40	1.86	2.31	3.36
9	1.38	1.83	2.26	3.25
10	1.37	1.81	2.23	3.17
15	1.34	1.75	2.13	2.95
20	1.32	1.72	2.09	2.84
30	1.31	1.70	2.04	2.75
60	1.30	1.67	2.00	2.66
α	1.29	1.64	1.96	2.58

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CURRICULUM VITAE

Name Miss. On-Anong Wechjan

Date of Birth November 10, 1982

Academic status

- High school, Muang Suratthani, 2001
- B.Sc. (Chemistry), Prince of Songkla University, Hat Yai, 2005
- M.Sc. (Analytical Chemistry), Chiang Mai University, 2008

Awards/Scholarship

- Center for Innovation in Chemistry: Postgraduate Education and Research Program in Chemistry (PERCH-CIC)

Work Experiences

- Demonstrator in Chemistry laboratories for first year, Department of Chemistry, Faculty of Science, Chiang Mai University, 2006

List of publications

1. O. Wechjan, T. Pojanagaroon, S. Liawruangrath, **"Flow Injection Spectrophotometric Determination of Iron using Eriochrome Cyanine R and Cetyltrimethylammonium bromide"** *The 34th Congress on Science and Technology of Thailand, Bangkok*, 2008.

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THE RELEVANCY OF THE RESEARCH WORK IN THAILAND

In the recent years, the development of science and technology and population growths leads to the ever-increasing demand for analyses in pharmaceutical, clinical, agricultural, industrial, process analytical control and environmental led to the development of automatic and user-friendly analytical method. An increasingly great demand for small and powerful analytical systems concerns, particularly application in field measurements of environmental analysis. In such analyses analytical tasks usually take up a lot of time owing to a large number of samples to be analyzed. Therefore, analytical techniques with high sample throughput and minimum consumption of reagent/sample are required. This research group has been terms "α-flow" group since 1990 as soon as most of our on-going researches are based on flow analysis which are greener analytical methods and application to real samples such as water, food and pharmaceutical.

The aims of this research are to develop a flow injection and sequential injection methods for determining iron in bottled-drinking water samples. In term of economic and environmental point of view, this research consume little reagent with minimum waste release and reduce cost of analytical instrumentation and sample analysis. This would be able to help the Thai Government to improve the economy and environmental problem of Thailand in the near further.

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