APPENDICES

APPENDIX A

Manifold Design

The FI manifold consisted of all parts of the FI system including the tubing, pumps, etc. The manifold designed can affect the dispersion. Three types of manifolds were designed and tested as shown in Figure A.1.

Manifold-a

Manifold-b

Manifold-c

Figure A.1 Three types of the manifolds: S = sample; R1= HCl; R2 = KI; R3 = Rhodamine B/NaOAc/PVA; P = pump; M = mixing reactor; D = detector; REC = recorder; and W = waste.

A solution of potassium iodide was injected via a rotary valve into merged stream of sample and/or standard solution and HCl solution as shown in Figure C.1 (manifold-a). The injection of complexing agent via the rotary valve into the merged stream of KI solution and mixed stream between sample and/or standard solution and HCl solution was shown in manifold-b (Figure C.1). In manifold-c, the sample and/or standard solution was injected into the HCl stream, the resulting acidified sample solution was treated with KI solution and mixed with the complexing agent stream lastly. The peak heights were obtained by introducing the selenite standard solutions with concentrations of 10.0 and 20.0 ppm. The experimental results are shown in Table A.1.

Table A.1 Effect of three types of manifolds on peak height.

[se(IV)] (ppm)	Peak height*					
	Manifold-a		Manifold-b		Manifold-c	
	cm	mV	cm	mV	cm	mV
10.0	0.25	1.00	2.05	8.20	0.17	0.68
20.0	0.58	2.32	5.17	20.68	0.30	1.20

* average of triplicate results

By comparing the results obtained form three manifolds, it was found that higher peak height was obtained with manifold-b. Therefore this manifold was chosen as a suitable manifold for this work.

APPENDIX B

Statistic Formulae

1. Calculation of precision [63]

Arithmetic mean is given by the equation:

$$X = \frac{\sum X_i}{N}$$

X is arithmetic mean or average of several determinations

X_i is an individual result of a single determination

$\sum X_i$ is sum of observations

N is the total number of determinations

Standard deviation uses to estimate the standard deviation of a set of replicated measurements or results.

$$SD = \frac{\sum (X_i - X)^2}{N-1}, \quad N < 20$$

$$SD = \frac{\sum (X_i - X)^2}{N}, \quad N > 20$$

SD is standard deviation

N is number of replicate measurements or results

X_i is individual measurement or result

X is arithmetic mean of the set

N-1 is number of degrees of freedom

Relative standard deviation (RSD) or coefficient of variation (CV) may be expressed as a fraction less than 1 or as a percentage; this uses to calculate the relative precision for comparative purposes.

$$RSD = \frac{SD}{X}$$

$$\%RSD = \frac{SD \times 100}{X}$$

RSD is relative standard deviation or relative precision

SD is standard deviation

X is arithmetic mean of the set

2. Calculation of relative accuracy [63]

$$\text{Relative accuracy} = \frac{\text{experimental value} \times 100\%}{\text{true value}}$$

3. Calculation of error [63]

$$E = X-X_t$$

E is absolute error

X is experimental value

X_t is true value

RE, relative error (percentage error), is given by equation:

$$\%RE = \frac{(X-X_t) \times 100}{X_t}$$

4. Calculation of detection limit [64]

The detection limit is the minimum concentration of analyte that can be detected and can be calculated from following equation:

$$S_m = S_{bl} + kSD_{bl}$$

Where S_m is the minimum analytical signal

S_{bl} is the mean blank signal

SD_{bl} is the standard deviation of blank

k is the confidence level of detection : 3

The detection limit is the analyte concentration providing the minimum analytical signal.

4. Calculation of sample throughput

$$\text{Sample/hour} = \frac{3600 \text{ sec}}{t_{base}} \times \frac{1 \text{ sample}}{1 \text{ hour}}$$

5. Calculation of injection volume

Teflon tubing (0.107 cm i.d.) was varied in length to obtain various injection volumes as calculated from the equation:

$$\text{Length of loop (cm)} = \frac{\text{Volume of injection loop } (\mu l)}{\pi \times r^2 \ (cm^2)}$$

where r is radius of tubing in cm

6. Calculation of irradiation time

For optimization of irradiation time teflon tubing (0.086 cm i.d.) was varied in length to obtain various irradiation time as calculated from equaiton:

$$\text{Length of reactor (cm)} = \frac{\text{Irradiation time (s)} \times \text{flow rate (ml/min)}}{\pi \times r^2\ (\text{cm}^2)}$$

where r is radius of tubing in cm

APPENDIX C

Standard of Drinking Water

Table C.1 Standard of drinking water [65]

Standard of Drinking Water (WHO)
(Physical and Chemical)

Toxic Substance	Maximum Allowable (mg/l)
Lead (as Pb)	0.05
Selenium (as Se)	0.01
Arsenic (as As)	0.05
Chromium (as Cr hexavalent)	0.05
Cyanide (as CN)	0.20
Cadmium	0.01

Substance Affecting the Potability of Water

Substance	Max. Acceptable	Max. Allowable
Total Solid	500.0 mg/l	1,500.0 mg/l
Color	5.0 units	50.0 units
Turbidity	5.0 units	25.0 units
Taste	Unobjectionable	
Odor	Unobjectionable	
Iron (Fe)	0.3 mg/l	1.0 mg/l
Manganese (Mn)	0.1 mg/l	0.5 mg/l
Copper (Cu)	1.0 mg/l	1.5 mg/l
Zinc (Zn)	5.0 mg/l	15.0 mg/l

Table C.1 (continued)

Standard of Drinking Water (WHO) (Physical and Chemical)		
Calcium (Ca)	75.0 mg/l	200.0 mg/l
Magnesium (Mg)	50.0 mg/l	150.0 mg/l
Sulfate (SO_4^{2-})	200.0 mg/l	400.0 mg/l
Chloride (Cl^-)	200.0 mg/l	600.0 mg/l
pH range	7.0-8.5	
Magnesium + Sodium Sulfate	500.0 mg/l	1,000.0 mg/l
Phenolic Substances (as Phenol)	0.001 mg/l	0.002 mg/l
Carbon Chloroform Extract	0.2 mg/l	0.5 mg/l
Alkyl Benzyl-Sulfonates	0.5 mg/l	1.0 mg/l

Standard of Bacteriological Quality

90% of Samples in year negative for Coliform i.e.

90% of Samples MPN < 1.0

No Sample MPN > 10

MPN 8-10 not to occur in Consecutive Sample

APPENDIX D

Conditions of ICP-AES

Table D.1 Experimental conditions of ICP-AES for selenium determination.

Parameter	Condition
Wavelength (nm)	196.026
Power (W)	1000
Normal speed pump (l/min)	20
Sheath gas pump (s)	3.0
Nebulization flow rate (l/min)	0.05
Nebulization pressure (bar)	1.0
$NaBH_4$ concentration (% w/v)	1
(in 0.5% w/v NaOH)	
HCl concentration (M)	6

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