



## Analysis of Dialysis

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### 1 Introduction

Dialysis is a method of removing toxic substances (impurities or wastes) from the blood when the kidneys are unable to do so. ICP-OES is particularly suitable to measure the dialysis solutions for the high accuracy analysis of Na, K, Ca, Mg and Cl. This Application Note presents the preparation and analysis results of two dialysis samples.

### 2 Principle

#### 2.1 Technique used

The elemental analysis of these samples was undertaken by Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES). The sample is nebulized then transferred to an argon plasma. It is decomposed, atomized and ionized whereby the atoms and ions are excited. We measure the intensity of the light emitted when the atoms or ions return to lower levels of energy. Each element emits light at characteristic wavelengths and these lines can be used for quantitative analysis after a calibration.

#### 2.2 Wavelength choice

The choice of the wavelength in a given matrix can be made using the "profile" function, or by using Win-IMAGE, which is rapid semi-quantitative analysis mode using multiple wavelengths. The principle is the same in either case: record the scans of analytes at low concentration, and of the matrix. By superimposing the spectra, we see possible interferences.

### 3 Sample preparation

Two dialysis samples were analyzed, labeled S1 and S2. These samples contain K, Ca, and Mg in the chloride form. In sample S1, Na is present as a mixture of chloride and acetate. It is at a total concentration of 140 mmol/L, with the acetate compound concentration of 35 mmol/L. In S2,

the Na is present as the chloride and is at a concentration of 102 mmol/L.

As the level of acetate is considered as negligible, a solution of NaCl 6 g/L (105 mmol/L) was prepared to matrix match the standards. Four standards for K, Ca and Mg were prepared with 250 ml of the Na solution and using 1,000 mg/L Spex\* Standards. Four standards were also prepared for Na and Cl at concentrations of 5, 6, 7 and 8.2 g/L of NaCl.

### 4. Instrument specification

The work in this Application Note was undertaken on a JY 2000. The specifications of this instrument are listed in Tables 1 and 2.

**Table 1: Specification of spectrometer**

Parameters	Specifications
Mounting	Czerny Turner
Focal length	0.64 m
Nitrogen purge	Yes
Variable resolution	Yes
Grating number of grooves	2400 gr/mm
1 <sup>st</sup> order resolution	0.016 nm

**Table 2: Specification of RF Generator**

Parameters	Specifications
Type of generator	Solid state
Observation	Radial
Frequency	40.68 MHz
Control of gas flowrate	by computer
Control of pump flow	by computer
Cooling	air

(\*: SpexCertiprep [www.certiprep.com](http://www.certiprep.com))





## 5 Operating conditions

Two series of analyses were made. The first was a direct analysis, without dilution and the second was with a 1:10 dilution using deionized water. The operating conditions are listed in Table 3 below.

**Table 3: Operating conditions**

Parameter	No dilution	Dilution
RF Generator power	1400 W	1400 W
Plasma gas flowrate	13 L/min	13 L/min
Auxiliary gas flowrate	0.4 L/min	0 L/min
Sheath gas flowrate	0.35 L/min	0.2 L/min
Nebulizer gas flowrate	0.67 L/min	0.67 L/min
Nebulizer flowrate	2.8 bars (41 psi)	2.8 bars(41 psi)
Sample uptake	1 mL/min	1mL/min
Type of nebulizer	Concentric	Concentric
Type of spray chamber	Cyclonic	Cyclonic
Argon humidifier	Yes	Yes
Injector tube diameter	3.0 mm	3.0 mm

## 6 Wavelength selection and analytical conditions

The line with the highest sensitivity was used for analysis of each element, as there were no problems with interferences. The analysis conditions were the same for all elements.

**Table 4: Analytical conditions**

Element	Slits ( $\mu\text{m}$ )	Analysis mode	Integration time (sec)
All elements	20 x 15	Gaussian	2

**Table 5: Background correction**

Element	Wavelength (nm)	Background correction (nm)
Ca	317.933	0.0325
Cl	725.665	0.0233
K	769.898	0.0372
Mg	279.806	0.0349
Na	588.995	0.0381

## 7 Discussion

### 7.1 Semi-quantitative analysis

The semi-quantitative method allows for the determination of 36 elements in less than three minutes. Background correction is used for each element to compensate for background shifts caused by matrix or acidity differences. Table 6 on the following page gives the result, expressed in  $\mu\text{g/L}$  (except where indicated) obtained for the semi-quantitative analysis and for a certified sample (NBS 1643d).

An alternative to the semi-quantitative method is an option called Win-IMAGE, which offers full spectrum acquisition within 2 minutes. Full spectrum acquisition gives the capability to undertake a semi-quantitative analysis, to perform retrospective analysis and to use multiple wavelengths for an analysis of an element to improve accuracy.

### 7.2 Results

The two samples were measured three times each with three replicates for each measurement, both directly and with a dilution of 1:10. The results are presented in Tables 7 to 12, with the concentrations given in mg/l and the RSD in %.

The Cl was not measured in the diluted samples because the 725 nm Cl line was not sufficiently sensitive. In the diluted samples, the far UV option would be necessary to measure the Cl at the 134 nm line. This is the most sensitive line for Cl and gives an LOD < 1000 ppb on the JY 2000, and < 200 ppb for the ULTIMA.



Table 6: Semi-quantitative results

Element	Wavelength (nm)	S2	S1	1643d	1643d certified value
Ag	328.07	10	18	8	
Al	308.21	-	15	117	114.6
Al	396.15	10	22	132	114.6
As	189.04	-	-	85	82.1
B	208.96	1	-	120	119.0
B	249.77	4	1	119	119.0
Ba	455.40	4	22	45.4	45.6
Be	313.04	195	22	16	
Ca	317.93	75 mg/L	57 mg/L	41 mg/L	
Cd	214.44	-	-	10	
Co	228.62	-	-	27	
Cr	267.72	-	-	1.2	
Cu	324.75	14	14	25	
Fe	259.94	13	10	102	106.9
Hg	184.89	-	-	-	
K	766.49	89 mg/L	83 mg/L	2.7 mg/L	
Li	670.78	12	10	19	16.5
Mg	279.55	23	20	9	
Mn	257.61	2	2	34	35.1
Mo	202.03	280	-	103	104.3
Na	589.59	1988 mg/L	2239 mg/l	12.6 mg/L	
Ni	231.60	4	-	49	60.6
P	178.23	-	4	1.8	
Pb	220.35	-	-	40	35.3
S	181.98	94	95	127	
Sb	206.83	-	-	4	
Se	196.03	22	5	-	
Si	251.61	14	9	20	
Sr	407.77	26	24	254	263.6
Ti	334.94	-	-	6	
Tl	190.86	18	-	-	
V	292.40	-	-	27	
W	207.91	-	-	-	
Zn	213.86	8	36	77	73.9
Zr	343.82	-	-	-	

Table 7: Expected concentrations for Sample S1

Element	Minimum concentration	Expected concentration	Maximum concentration
Ca	66.53	70.14	73.75
Cl	3799.54	3988.46	4187.00
K	74.29	78.2	82.11
Mg	23.09	24.31	25.52
Na	3138.1	3218.6	3299.1

Table 8: Expected concentrations for Sample S2

Element	Minimum concentration	Expected concentration	Maximum concentration
Ca	66.53	70.14	73.75
Cl	3688.0	3882.10	4076.2
K	74.29	78.20	82.11
Mg	23.09	24.31	25.52
Na	2286.4	2345.0	2403.6

**Table 9: Results for Sample S1, no dilution**

Element	Measure 1		Measure 2		Measure 3		Mean Conc.	RSD (%)
	Conc.	RSD	Conc.	RSD	Conc.	RSD		
Ca	70.47	0.40	71.31	0.90	71.55	0.70	71.11	0.80
Cl	3930.93	2.50	32974.53	2.30	3953.56	1.80	3932.30	1.05
K	78.24	1.50	78.42	0.80	78.23	1.40	78.30	0.15
Mg	23.05	0.90	22.94	1.40	23.05	1.10	23.02	0.30
Na	3193.78	1.10	3149.56	1.10	3142.61	0.50	3161.98	0.90

**Table 10: Results for Sample S2, no dilution**

Element	Measure 1		Measure 2		Measure 3		Mean Conc.	RSD (%)
	Conc.	RSD	Conc.	RSD	Conc.	RSD		
Ca	71.37	0.80	71.61	0.90	70.82	0.65	71.27	0.55
Cl	4060.49	2.10	3910.38	1.20	3926.32	1.20	3925.73	2.00
K	80.92	0.60	79.91	1.20	80.62	0.45	80.48	0.65
Mg	23.03	0.90	23.23	0.70	23.21	0.60	23.16	0.50
Na	2287.94	0.15	2290.47	1.10	2349.15	0.90	2309.19	1.50

**Table 11: Results for Sample S1, with dilution**

Element	Measure 1		Measure 2		Measure 3		Mean Conc.	RSD (%)
	Conc.	RSD	Conc.	RSD	Conc.	RSD		
Ca	70.91	0.35	71.00	0.50	71.15	0.65	71.02	0.15
K	78.90	1.20	78.30	0.45	78.80	0.85	78.67	0.40
Mg	22.81	0.90	22.26	0.30	22.32	0.80	22.46	1.30
Na	3163.09	0.95	3124.85	0.25	3183.71	0.45	3157.22	0.95

**Table 12: Results for Sample S2, with dilution**

Element	Measure 1		Measure 2		Measure 3		Mean Conc.	RSD (%)
	Conc.	RSD	Conc.	RSD	Conc.	RSD		
Ca	70.26	1.30	71.000	0.30	71.18	0.20	70.81	0.70
K	81.23	0.75	80.93	1.10	81.30	0.85	81.15	0.25
Mg	22.43	0.70	22.65	0.65	22.62	0.45	22.57	0.55
Na	2343.97	0.75	2390.82	0.60	2352.13	0.90	2362.31	1.05

## 8 Summary

This application report shows that the ICP-OES is a suitable technique for the analysis of dialysis samples. The accuracy for the major elements can be improved by using Yttrium as internal standard. Dilution is not necessary because of the argon

humidifier, sheath gas and the large internal diameter of the injector available. Because of these three features, solutions with very high level of salts can be run with ease.



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