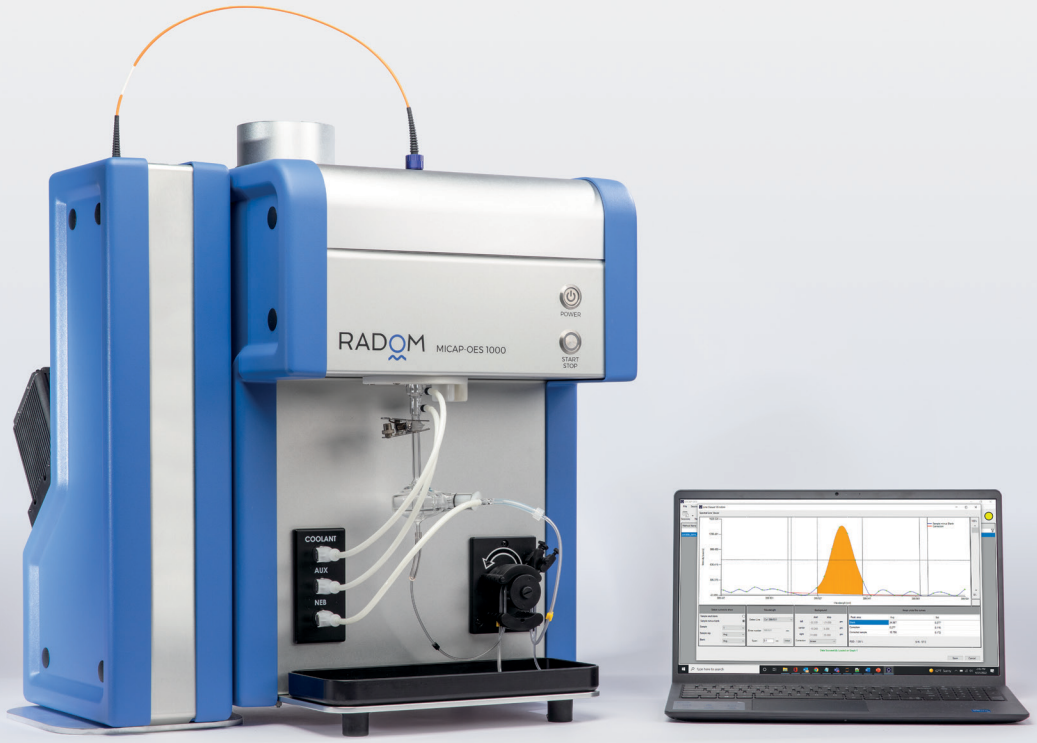
RADOM™
INSTRUMENTS

MICAP-OES 1000
N_2 ICP-OES INSTRUMENT DETECTION LIMITS



MICAP

Detection Limits

Detection limits (DL) of an instrument are an especially important factor in determining capabilities for various applications. The DL values indicate where the technique can start to measure the presence of an analyte on top of any background in optimal conditions. The limits achievable are impacted by multiple factors such as:

- **Sample preparation procedures**
- **Sample introduction accessories used** - nebulizers, spray chambers, etc.
- **Amount of data acquisition time**

In this document the DL values of the MICAP™-OES 1000 are presented under two different data acquisition conditions. To provide typical expected performance, the DL values presented are the averages of values obtained from three different MICAP instruments.

An instrument detection limit is commonly defined as the concentration value calculated from three times the standard deviation of 10 measurements of a blank solution, performed at the emission wavelength of interest. The standard deviation is multiplied by a factor of three based on the Student's t-test table, which provides a confidence level of 99%.

DL = 3x (Std Dev of 10 blank measurements)

As it is typical in ICP-OES sample analysis to collect multiple measurements and average these to report the final concentration, each of these 10 replicates is the average result of 3 repeat measurements.

The detection limit obtained is also dependent upon the total integration time used to collect the analyte signals. To demonstrate the impact of this variable this data was first collected on the sCMOS camera at a shorter integration time of 10 seconds. With 3 repeat measurements this results in a relatively quick 30 second sample analysis time. Then a more typical, longer integration time of 30 seconds was collected that produces a total sample analysis time of 90 seconds. The average DL values determined from three MICAP systems are presented here to provide comparison between two different signal integration times.

Experimental Conditions

Table 1 below provides a listing of the sample introduction components and instrument conditions utilized for these detection limit studies.

Table 1. MICAP Instrument settings and conditions

Parameter	Value
Torch	Quartz 1-piece, 1.5mm injector
Spray Chamber	Single pass cyclonic
Nebulizer	Concentric glass
Sample Tubing	Blk/Blk PVC (0.76 mm ID)
Drain Tubing	Blu/Yel PVC (1.52 mm ID)
Coolant Gas Flow	14 L/min N_2
Auxiliary Gas Flow	0.3 L/min N_2
Nebulizer Gas Flow	0.7 L/min N_2
Peristaltic Pump	35 rpm
Plasma Viewing	Axial
10 sec Exposure	1000 ms @ 10 replicates
30 sec Exposure	3000 ms @ 10 replicates
# of Repeats	3

Figure 1. Closeup of MICAP sample introduction area

Results

Table 2 presents the average detection limits obtained across the three MICAP systems utilized for this work, measured at both exposure times as previously described. Note that for most elements, the collection of 3x longer integration times has very little (if any) significant difference in the detection limits obtained. Figure 2 provides typical analysis detection limits (obtained at 30 sec exposure time) presented within a periodic table arrangement. Also provided are typical resolution values obtained at various locations across the spectrum covered by the MICAP N_2 ICP-OES system.

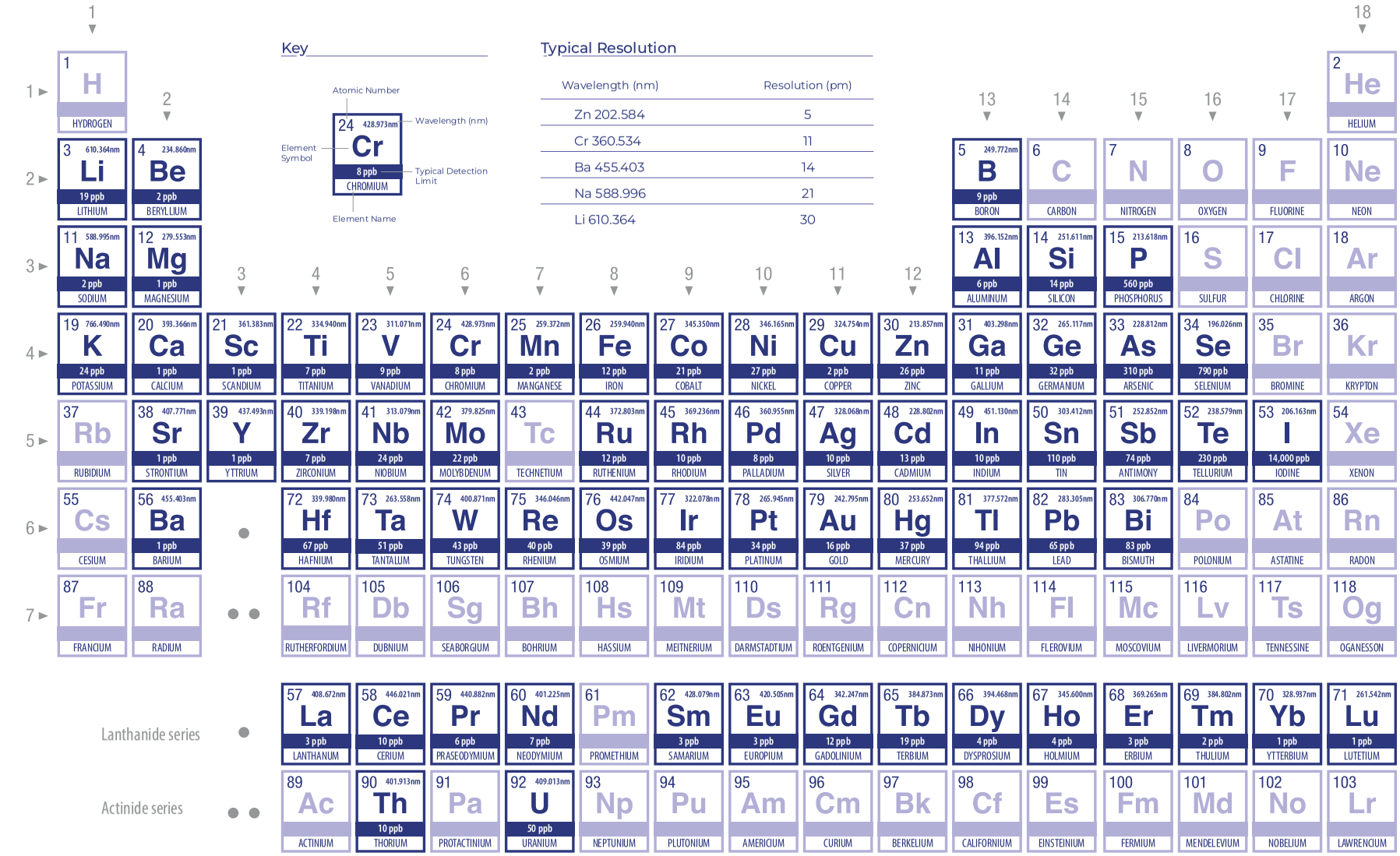
Table 2. MICAP detection limits (µg/L) measured at short and typical exposure times

Element	Wavelength (nm)	MICAP DL 10s (ppb)	MICAP DL 30s (ppb)
Ag	328.068	8	10
Al	396.152	6	6
As	228.812	480	310
Au	242.795	27	16
B	249.772	10	9
Ba	455.403	1	1
Be	234.86	1	2
Bi	306.770	69	83
Ca	393.366	1	1
Cd	228.802	16	13
Ce	446.021	8	10
Co	345.350	22	21
Cr	428.973	8	8
Cu	324.754	3	2
Dy	394.468	4	4
Er	369.265	6	3
Eu	420.505	3	3
Fe	259.940	16	12
Ga	403.298	16	11
Gd	342.247	12	12
Ge	265.117	34	32
Hf	339.980	56	67
Hg	253.652	52	37
Ho	345.600	4	4
I	206.163	27000	14000
In	451.130	10	10
Ir	322.078	105	84
K	766.490	33	24
La	408.672	3	3
Li	610.364	17	19
Lu	261.542	2	1
Mg	279.553	2	1
Mn	259.372	4	2
Mo	379.825	22	22

Element	Wavelength (nm)	MICAP DL 10s (ppb)	MICAP DL 30s (ppb)
Na	588.995	2	2
Nb	313.079	44	24
Nd	401.225	10	7
Ni	346.165	38	27
Os	442.047	50	39
P	213.618	649	560
Pb	283.305	65	65
Pd	360.955	10	8
Pr	440.882	5	6
Pt	265.945	59	34
Re	346.046	44	40
Rh	369.236	20	10
Ru	372.803	20	12
Sb	252.852	115	74
Sc	361.383	1	1
Se	196.090	1320	790
Si	251.611	17	14
Sm	428.079	7	3
Sn	303.412	186	110
Sr	407.771	1	1
Ta	263.558	103	51
Tb	384.873	29	19
Te	238.579	354	230
Th	401.913	15	10
Ti	334.940	9	7
Tl	377.572	132	94
Tm	384.802	6	2
U	409.013	59	50
V	311.071	15	9
W	400.871	54	43
Y	437.493	1	1
Yb	328.937	1	1
Zn	213.857	34	26
Zr	339.198	12	7

MICAP - OES 1000

Typical Limit of Detection and Resolution



Detection limits are averaged from multiple systems.
Values are calculated from 3x the standard deviation of 10 measurements of a blank; each with three, 30 second replicates.

Figure 2. Typical limit of detection and resolution

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