Pak. j. sci. ind. res., vol. 37, no. 9, September 1994

EXTENSION AND EVALUATION OF ICP TORCH LIFE SPAN FOR INDUCTIVELY COUPLED PLASMA EMISSION SPECTROMETRY

F. O. BAMIRO AND D. LITTLE JOHN*

Department of Chemistry, University of Agriculture, Abeokuta, Nigeria

(Received April 21, 1993; revised April 24, 1994)

The life span of melted Philips torch has been extended for laboratory use by modifying the damaged Philips torch and then compared with that of a standard Philips torch. The construction of the modified torch is simple, easy to assemble and replace, and is ideally suited for the analysis of sample solutions by inductively coupled plasma spectrometry. Evaluation of the modified torch reduced cost, usually caused by constant melting of ICP torch and also gave similar results in terms of precision, sensitivity and detection limits when compared with the conventional new ICP Philips torch (type 145).

Key words: Repair of damaged ICP torch, Formation of concentric qurtz tube, Performance evaluation.

Introduction

One of the main impediments to the acceptance of ICP-AES system has been the high operational cost and complexity with the ICP source itself. Many workers have sought to overcome the limitations by alteration of the design and operating conditions of the ICP, in the hope that power and argon requirements could be reduced, whilst retaining the analytical advantages of the source. The methods considered in pursuit of this aim include: (i) replacement of the argon outer gas flow by a cheaper gas, e.g. nitrogen (ii) the use of special torch desing (iii) the application of external cooling of the wall of outer tube by either water or pressurised air and (iv) miniaturisation of the torch, and increase in the radio frequency of the generator.

As part of the move to reduce the running cost of the argon ICP, some workers considered the use of N_2 gas as substitute for the argon outer gas flow [1-3]. Boumans *et al.* [4] and Montaser *et al.* [2] compared the use of N_2 as substitute for argon and reported increase in RF power level to maintain analytical performance coupled with poor detection limits.

As an alternative to the foregoing approaches, reduction in power and gas consumption can be achieved by miniaturisation of the torch. Hence a number of research groups [5-8] worked on this and observed that with a fixed frequency of RF generator, miniaturisation of torch was limited to a certain extent by (i) the skin depth of the plasma, which is the distance from the plasma boundary to that where energy coupling has fallen to 37% of its maximum value and (ii) the channel diameter, roughly defined as the diameter of the carrier gas nozzle.

For efficient heating of any cylinderical body in an induction coil, the radius R of the cylindr must be much greater than the skin depth (d). Boumans [9] showed that for efficient heating, the value R should be greater than 2.3d. Clearly, unless the skin depth of the ICP can be altered, there is little prospect of successfully reducing further the plasma's dimensions. It has been reported that a 9mm ICP can be operated at 100MHz successfully and with minimal matrix interferences [10,11].

As an alternative to the foregoing approach, an attempt had been made in this work to extend the life span of the normal ICP torch which is continuously faced with the problem of melting at a very high temperature of the plasma. The torch is expensive and requires constant change due to melting. The author observed that the part melted is about 2cm above the coil, without affecting the coolant, plasma and carrier gas flow pipes. A modified head was constructed to replace the top damaged part of the torch. Evaluation of the repaired torch was carried out and compared with the normal standard Philips torch.

Experimental

A Philips PV 8490 was employed for all analytical measurements. The ICP is operated at 50MHz and has an output power in the range 0.7 to 2Kw. Argon was used for all experiments. The Spectrametrics Inc. echelle spectrometer was used with the instrument. The conventional operational procedure was modified to give an output in arbitry intensity unit. The instrument signals were integrated for 5s, and 9 separate readings were taken. The computer provided the mean and standard deviation of the measured intensities.

Reconstruction of the melted ICP torch. The melted torch was cut at the very point of the destructed outer glass. This length is always about 2cm from the top of the torch down and is few mm above the tip of internal carrier gas flow tube. The two inner tubes are not always affected, but the outer layer only. Considerable care is required in the cutting to give

* University of Strathclyde, 105 Cathedral Street, Glasgow GIXL.

perfect cut so as to ensure the perfect concentricity of the tubes and rotational symmetry of the assembly, which are the vital requirements for prolonged ICP operation and analytical reproducibility. Typical example of the torch is shown in Fig. 1a, showing gas flow directions and dimensions of outer quartz tube. The apperance of the ICP formed inside the torch is shown in Fig. 1b as an intensely luminous, non-transparent core with a flamelike, less luminous tail. The core fills the region inside the coil and usually extends a few millimeters below and above the coil. The standard and melted torches are shown in Fig. 1c and 1d respectively.

After perfect removal of the melted torch head, a similar replacement glass of the same diameter and of the height lost was cut and neatly joined permanently by flame round the spot without any leakage (Fig. 1e).

The glass is made of the same material (quartz). Similar replacement tube described above was cut, but this time not joined. Towards the end of this tube was joined a suspended tube having marginal greater internal diameter and looks like a cap. This serves to create weight for perfect seating of the replacement tube (Fig. 1f). The last tube was just placed on the smoothly cut faulty torch without thermal joining. This has the advantage of being removed and replaced back, if any further damage is done.

Evaluation of the analytical performance of the modified torch. The standard Philips torch and the two modified torches were optimised to establish the best condition for good analytical performance by aspirating 0.5ppm of MnII, ZnI, CdI and CdII (hard line) and 0.5ppm of CuI, FeI and CrI (soft line) for each torch. At established optium conditions, the detection limits were determined for 10 elements and compared the results.

Results and Discussion

The optimum conditions for the three torches remain the same as shown in Table 1. The detection limits determined for the three torches are almost the same as shown in Table 2. The two modified torches compared favourably well with the standard Philips torch.

The ammended torch with removable cap has the advantage of easy replacement when there is any melting of the torch head. It is a question of just replacing the cap only since the base is not always melted. This approach really solved the problem of constant replacement of torch which is expensive and disgusting for ICP analyst.

Conclusion

The performance of a laboratory modified torch has been compared with a Philips standard torch. The study indicated that it is possible to ammend a melted standard Philips torch by

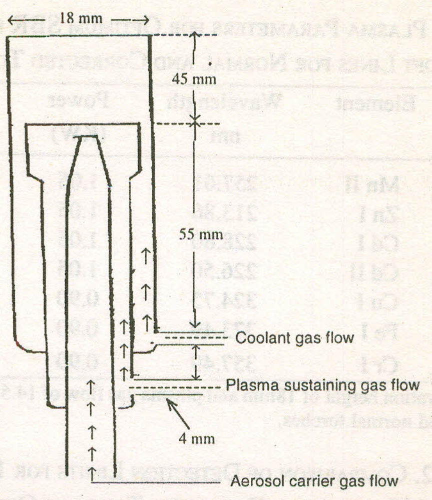


Fig. 1a. ICP torch showing dimension and gas flow.

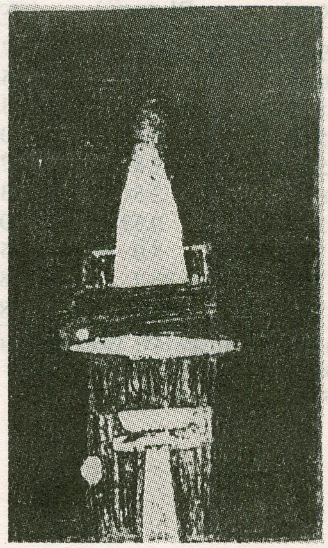
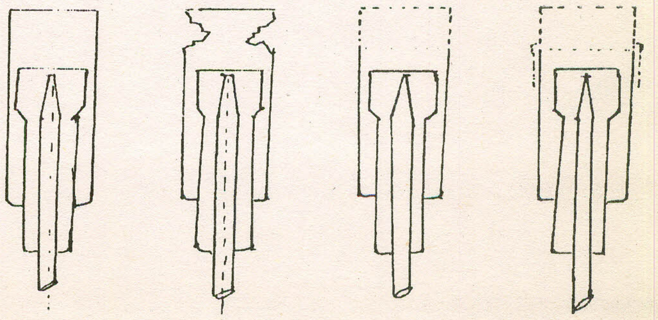


Fig. 1b. Plasma formation inside the torch.



1c 1d 1e 1f

Fig. 1c-1f. Correction of melted ICP torch.
1c = Normal ICP torch. 1d = Melted ICP torch. 1e = Thermally corrected ICP torch. 1f = Corrected ICP torch with suspended demountable glass cap.

TABLE 1. PLASMA PARAMETERS FOR OPTIMUM SBR FOR HARD AND SOFT LINES FOR NORMAL AND CORRECTED TORCHES.

	Element	Wavelength nm	Power (KW)	Carrier gas flow min
Hard line	Mn II	257.61	1.05	0.65
	Zn I	213.86	1.05	0.65
	Cd I	228.80	1.05	0.75
	Cd II	226.50	1.05	0.65
Soft line	Cu I	324.75	0.90	0.90
	Fe I	373.49	0.90	0.90
	Cr I	357.49	0.90	1.10

Same observation height of 18mm and plasma gas flow of 14.5l/min for the corrected and normal torches.

TABLE 2. COMPARISON OF DETECTION LIMITS FOR 10 LINES USING NOMRAL AND CORRECTED TORCH AT OPTIMUM PLASMA CONDITIONS.

Element	Wavelength (nm)	Normal torch I DL (µg/l)	Corrected DL µg/l torch II	Corrected DL µg/l torch II
As I	197.20	540.0	552.0	545.0
Mo II	202.03	5.4	5.5	5.5
Zn I	213.60	3.0	3.1	3.3
Mn II	257.61	0.35	0.36	0.35
Fe II	259.94	17.6	17.5	17.7
Cr II	264.72	3.5	3.4	3.45
Cu I	324.75	0.53	0.55	0.54
Cr I	357.49	5.0	5.20	5.50
Fe I	373.49	28.2	28.4	27.95
Mo I	379.83	17.9	18.4	18.10

Torch I = Normal ICP torch (type 145). Torch II = Thermally corrected torch with fixed glass cap. Torch III = Corrected torch with suspended demountable glass cap.

simple device and at the same time give analytical results comparable to the new standard Philips torch.

This result really prolong the life span of ICP torch without any loss in sensiti-vity. It also gives sanity to the user of the instrument who is always faced with constant loss of torch and constant delay in analytical work. A ready-made modified demountable glass cap will solve this problem for easy continuous analysis.

References

1. P. W. J. M. Boumans, Spectrochim. Acta, **37B**, 75 (1982).
2. A. Montaser, V. A. Fassel and Zalewiski, J. Appl. Spectrosc., **35**, 292 (1981).
3. P. W. J. M. Boumans and F. J. De Boer, ICP Inform. Newslett., **3**, 228 (1977).
4. P. W. J. M. Boumans and Lux Steiner, M. Ch., Spectrochim. Acta, **36B**, 97 (1981).
5. F. O. Bamiro, Ph. D. Thesis, University of Strathclyde, Glasgow (1984), Chap. 7.
6. F. O. Bamiro, International J. Chem., **1** (2), 51 (1990).
7. F. O. Bamiro, International J. Chem., **2** (1), 7 (1991).
8. R. C. Miller and R. J. Ayen, J. Appl. Phys., **40,** 5260 (1969).
9. P.W.J.M. Boumans, Nat. Lab. Technical Note Nr., 89/82 (1982).
10. P. W. J. M. Boumans, Philips Research Laboratories Eindhoven, Personal Communication (1983).
11. R. N. Savage and G. .M. Hieftje, Anal. Chem., **51,** 408 (1979).