SPECTROSCOPIC STUDY OF ULTRAVIOLET REGION OF THE SPECTRUM OF THE WALL STABILIZED ARC

Presented

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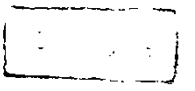

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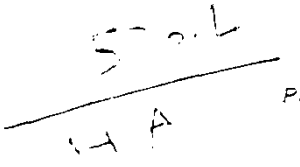

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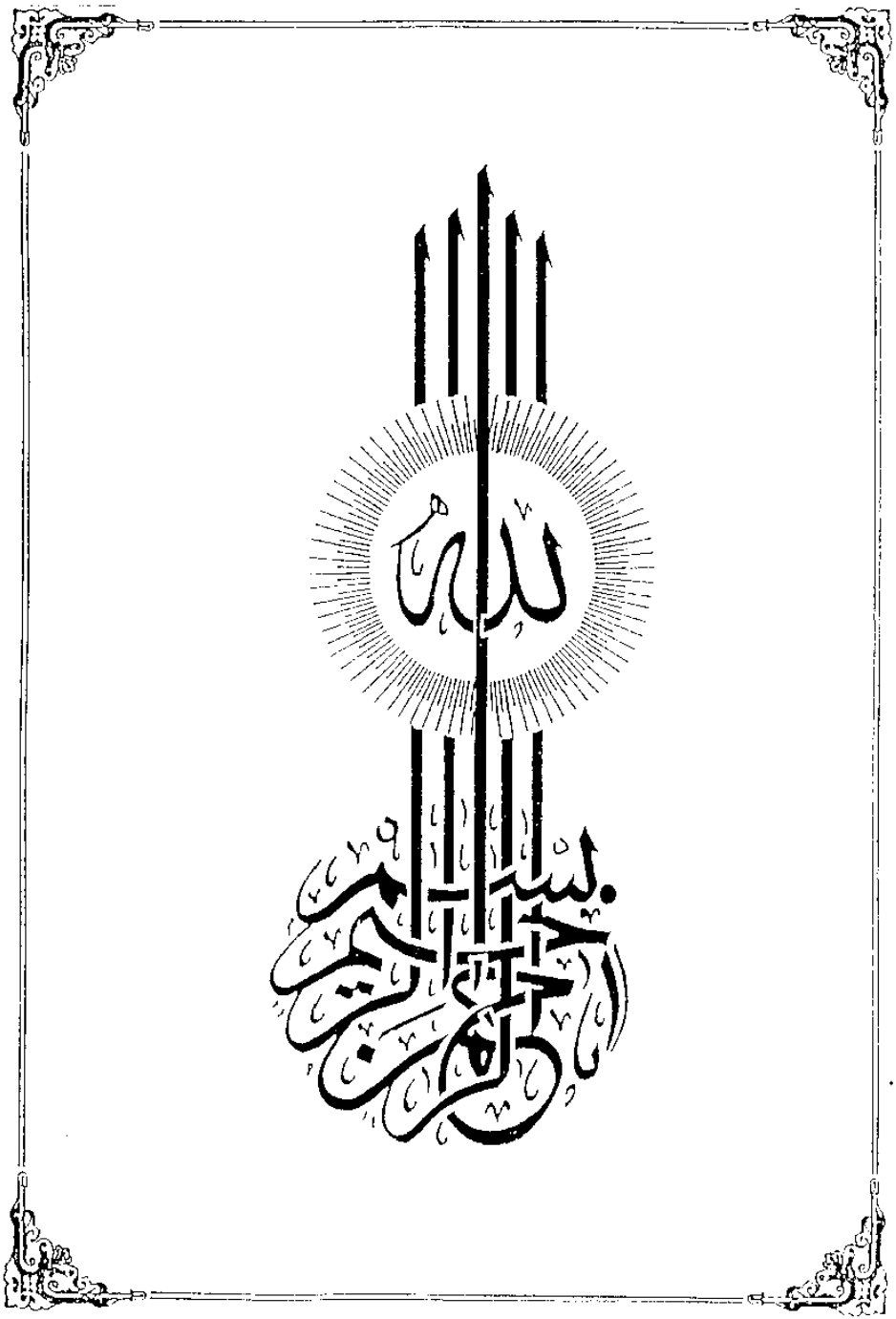

SPECTROSCOPIC STUDY OF ULTRAVIOLET REGION OF THE SPECTRUM OF THE WALL STABILIEZD ARC

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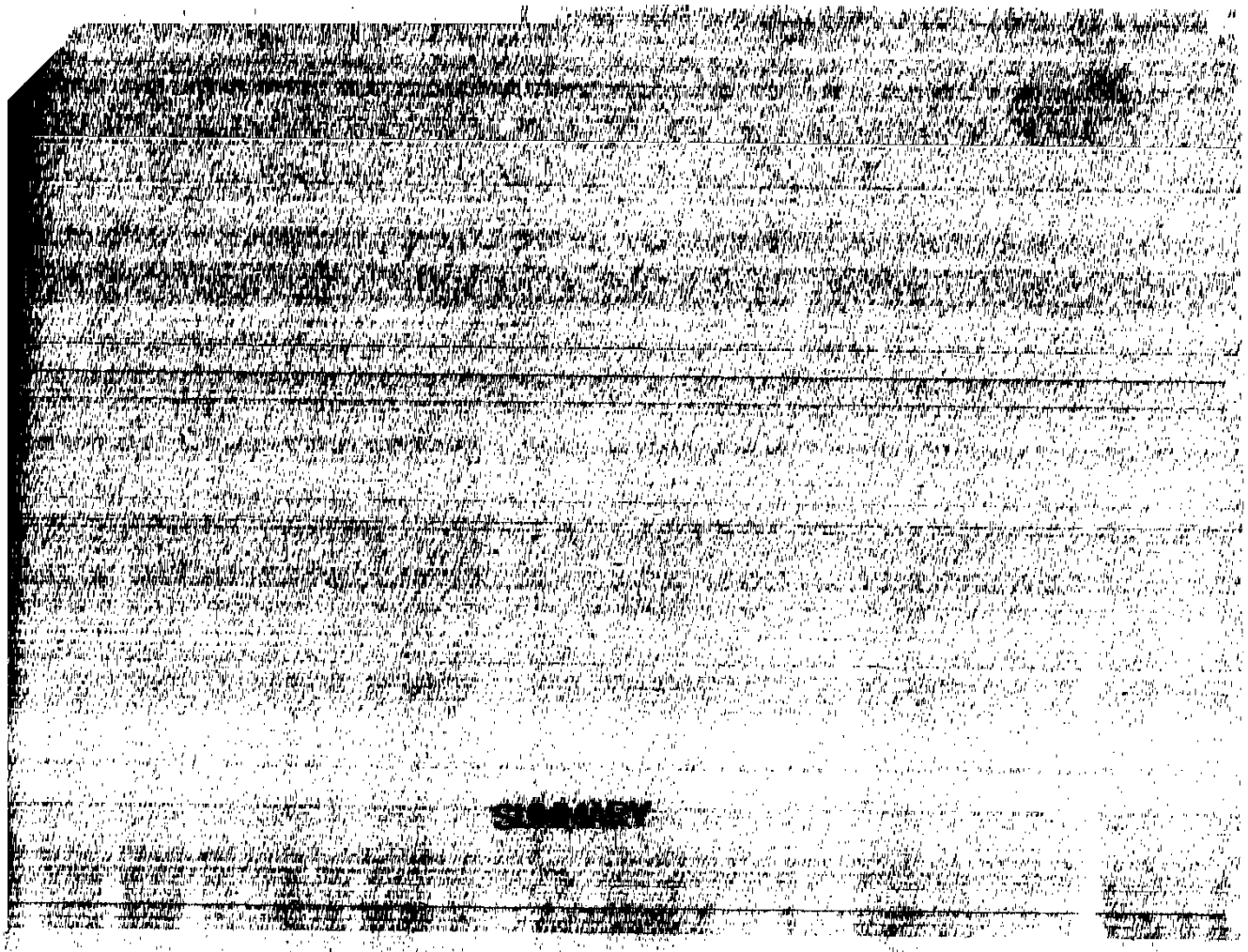

SUMMARY

The present work has been devoted for the study of the UV-region (200-300 nm) of the spectrum of the low-temperature wall-stabilized plasma arc. This arc has been constructed at the spectroscopy department, National Research Centre (NRC) and has proved to be a suitable excitation source for the determination of trace and minor concentrations of elements in a variety of samples. However, all previous investigations were carried out in the wavelength region > 300 nm, which was the sensitive region of the photomultiplier used.

In the present work a photomultiplier tube Hamamatsu R300, sensitive in the range 185-600 nm is used and therefore, most of the present work has been carried out in the region 200-300 nm. The study of this spectral region aimed to select the most sensitive spectral lines of different elements which are emitted in this region and can be recommended for the determination of trace amount of these elements. A considerable part of the present work has been devoted for the selection of spectral lines which can be used for the diagnostic of the arc plasma. Lines for excitation temperature as well as lines for ionization temperature could be selected. The present thesis is divided into five chapters:

Chapter I, the introduction discusses in general optical emission spectroscopy and the plasma sources used in this field as excitation sources for elemental determination. The principle features of the present excitation sources are also discussed. This chapter is ended with the aim of the present investigation.

Chapter II, gives a brief account on the theories describing the emission of radiation from plasmas. In this chapter the most important expressions relating the intensity of spectral lines as well as their shapes with the parameters of the emitting plasma are also discussed. These expressions are those which are used for the determination of temperatures and electron density in the plasma.

Chapter III, gives a review dealing with two important parts of the thesis. The first part of this chapter reviews the different standard radiation sources used for the calibration of spectrometric systems. The standard radiators are divided into two groups, the primary standards as the black body and the electron synchrotron radiators and the secondary standards including the different incandescent lamps, gas discharge lamps and arc sources. The second part of this chapter reviews the most important present plasma excitation sources. These are: the direct current plasma (DCP), the inductively coupled plasma, (ICP), and the microwave induced plasma (MIP).

Chapter IV, deals with the experimental work and is divided into three main parts :

1- The first part of this chapter describes the experimental set up and its calibration. The experimental setup consists of three main parts namely, the excitation source, the illumination system, and the spectrometric equipment. The excitation source is the wall-stabilized arc. This is a 10 cm argon arc constricted by the thermal pinch effect to a diameter of 5mm. The middle part of this arc is the analytical chamber in which the sample is introduced as aerosol into the arc. This part of the arc is seeded with KCl in order to attain the low temperature arc. In this region the arc column is much wider in diameter and its radial gradient of the temperature permits the easy introduction of the aerosol into the plasma of the arc. The light from the analytical chamber illuminates the slit of the monochromator using a three lens system. This illumination system permits the selection of an area 4X4 mm of the arc to fully illuminate the aperture of the monochromator. The spectral equipment is a 1m McPherson scanner monochromator whose dispersive element is a plane grating of 1200 g mm^{-1}. As a detector, a Hamamatsu R300 side-on photomultiplier tube is used. The photocurrent is measured in the linear mode of the McPherson logarithmic ratiometer type

782 whose measuring range lies between 10^{-8} and 10^{-5} amperes in four steps. The current can be measured directly from scale or recorded on a strip chart recorder. For the calibration of the spectral system an Euler's carbon arc is used. In this arc the two electrodes are at right angle to each other. The horizontal electrode is the anode whose radiation is considered as a black body radiation and has been measured by different investigators. This light source is considered as a secondary standard. The sensitivity curve of the spectral equipment has been determined.

2- The second part of chapter IV deals with the study of the analytical application possibilities of the spectral lines emitted by the arc in the wavelength region under investigation. For this purpose the spectra of 20 elements in this region were recorded and the most sensitive lines of these elements were determined. For these lines the line-to-background ratios which represent the measure of the analytical sensitivity of these lines as well as the limits of detection attainable with them were determined. The elements studied are Al, Ba, Bi, Cd, Cr, Cu, Fe, Hf, In, Li, Lu, Mg, Mn, Mo, Ni, Pb, Si, Sr, V, and Zn. Moreover, the spectral lines of some elements namely Fe, Al, and Mg were applied for their determination in some real samples. The samples chosen were five phosphate samples from the Abu Tartur area, Western Desert,

Egypt, one standard phosphate sample of Nuclear Material Cooporation, Egypt and a standard silicate sample (No. 199 NIS). The samples were dissolved using an acid digestion procedure. Analytical calibration curves were constructed using standard solutions of the elements. The results obtained are in good agreement with the certified values of the standard samples which prove the suitability of the selected spectral lines for accurate determination of the elements.

3- The third part of the experimental work deals with the selection of groups of lines in the investigated spectral region for the spectroscopic diagnostics of the plasma of the arc. For the determination of excitation temperature two groups of spectral lines could be selected which can be applied for this purpose. These are a group of CuI lines and a group of MoI lines. The Boltzmann plots obtained with these lines are linear and yield temperature values which are in good agreement with that obtained by the commonly used set of FeI lines in the wavelength region 371.99 nm to 376.38 nm. Moreover spectra of different elements were studied to select atom/ion line pairs for the determination of ionization temperature using the Saha-Boltzmann equation. For this purpose atom/ion line pairs of Fe, Ni, Cd, Mg, and Mo were used. All lie in the spectral region 200-300 nm. Two procedures were followed for the determination of the ionization temperature. In the first