

CONSTRUCTION AND EVALUATION OF A SOLID STATE PHOTOMETER AS AN ALTERNATIVE TO CONVENTIONAL SPECTROPHOTOMETERS

Y.N. Lohdip*, A.K. Davies and J.D. Openshaw

Department of Chemistry and Applied Chemistry, University of Salford, M5 4WT, England

and

J.F. Iyem

Department of Chemistry, Ahmadu Bello University, Zaria, Nigeria

ABSTRACT

A Solid State Photometer has been constructed, using light emitting diodes (LEDs) as light source and a photodiode as photodetector. Rate constants as functions of reactant concentration, hydrogen ion concentration and ionic strength were obtained using the kinetic set and compared with those obtained from a Unicam SP 1750 uv-visible Spectrophotometer. Statistical parameters applied to the results obtained with the two systems showed that there was no significant difference between the two methods at 0.05 confidence level. The solid state photometer can be interfaced to a computer (Datadisc Pro for windows) to automatically record the rate of change of absorbance or transmittance. This arrangement provides the user with digitized version of the experimental signal which can be processed in a multitude of increasingly complex ways in order to extract as much chemical information as possible. Apart from the fact that the LEDs are cheap, compact and commercially available, equipment constructed from this system have small size, light weight, low power consumption and negligible warm up time. The solid state photometer is a rugged, reliable, low-cost alternative to commercially available spectrophotometers. Its use is therefore recommended as a compliment or an alternative to the expensive spectrophotometer.

INTRODUCTION

A solid state photometer is a system which employs light emitting diodes (LEDs) as sources of visible radiation and photodiodes as the detector components¹. This system has been shown to give comparable results with those obtained using a conventional spectrophotometer¹⁻³. The LEDs and photodiodes are cheap, compact and commercially available. The small size, light weight, low power requirement and negligible warm up time of equipment constructed from this system make them the obvious alternative to the expensive spectrophotometers. In addition, LEDs emit more than 5 times the radiant energy of a 40W tungsten lamp after using a monochromator to select the corresponding bandwidth⁴. The normalized intensity versus wavelength profiles⁵ for the most widely used LEDs are

shown in Figure 1. LEDs have also been used as sources of visible radiation in Flow Injection Analysis (FIA)^{2,3}, in ion exchange chromatography detector for determination of cations and in optoelectronic devices⁶⁻⁸. In this paper, we present the method of construction of the solid state photometer and the evaluation of it in comparison with the conventional spectrophotometer.

EXPERIMENTAL

Design and construction

The solid state photometer was constructed as represented by the block diagram in Figure 2. The arrangement is such that the light emitting diode (LED) and the photodetector are located behind two small focusing lenses enclosing the cuvette holder. A glass coil through which thermostated water can be circulated to the cuvette holder was also constructed. The coil and accessory are shown in Figure 3. The associated electronic component consisting of an LED driver circuit and a detector signal processing circuit was also

*Author for correspondence

*Present address: Department of Chemistry, University of Jos, P.M.B. 2084, Jos, Nigeria.

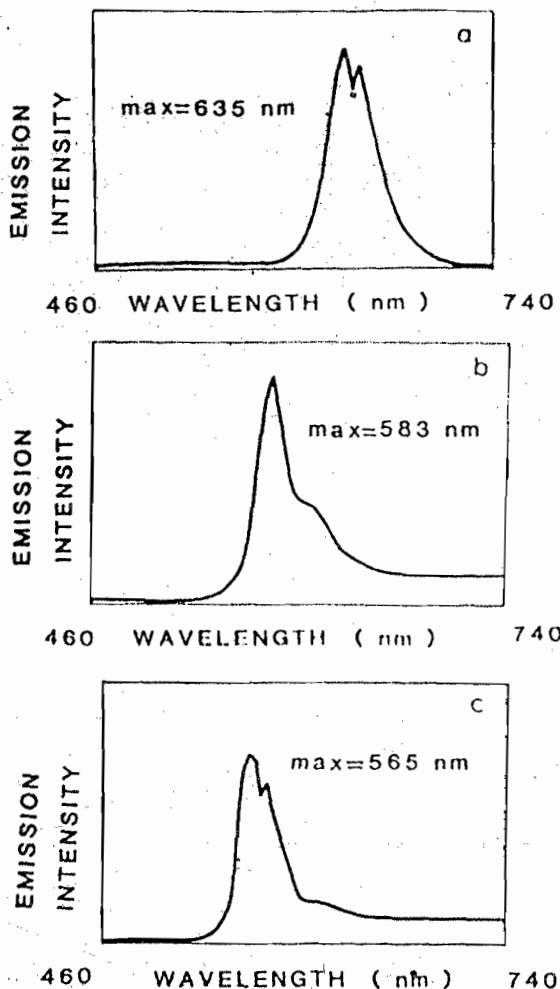


Figure 1: Normalized emission intensity versus wavelength profiles for (a) red, (b) yellow (amber), and (c) green light emitting diodes

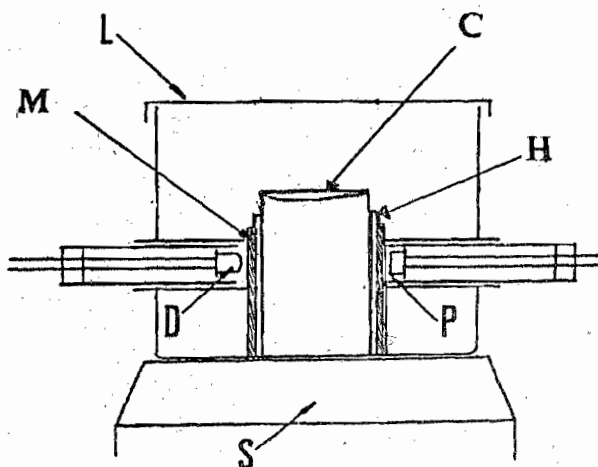


Figure 2: Cross section of the solid state photometer
 L = lid C = cuvette
 H = cuvette holder D = interchangeable LED
 P = photodiode S = circuit component
 M = focusing lens

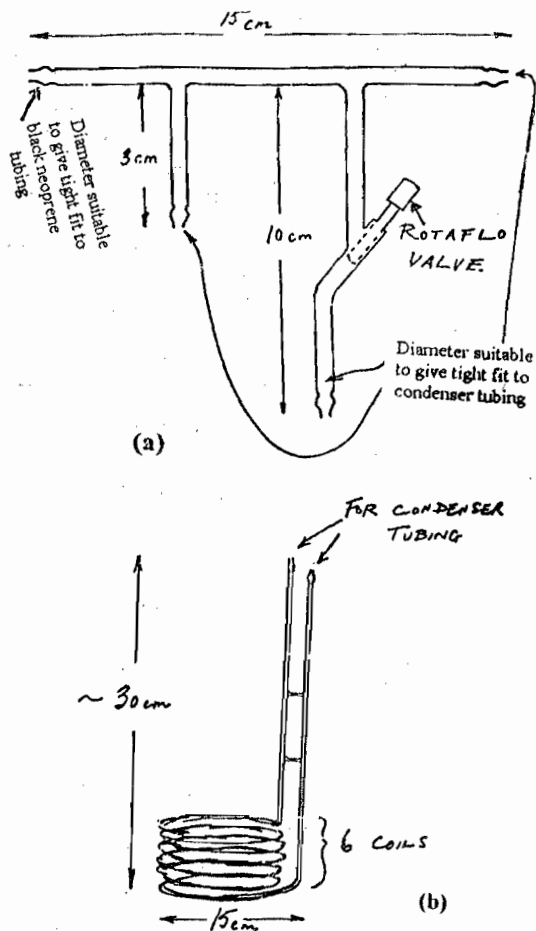


Figure 3: Parts of water flow system for thermostat (a) connecting accessory, (b) coil for the ice bath

constructed. The circuit diagram is shown in Figure 4. The solid state photometer has been interfaced with a microcomputer via a universal interface so that the reaction could be monitored automatically by using an appropriate software. The flow diagram for the solid state photometer indicating the interfacing relay, is shown in Figure 5.

Stability and sensitivity loss test

The stability and sensitivity loss of the apparatus constructed was tested as follows:- The solid state photometer was switched on and allowed on for a period of 4 hours under a stabilized source of power. This was repeated three times and the loss in transmittance after the 4 hour period was observed and recorded as shown in Table 1. T-test analysis was performed on the results as indicated in Table 1.

Table 1: Sensitivity loss of the solid state photometer

Time (minutes)	Transmittance (%)		
	A	B	C
0	100	100	100
15	99.9	99.9	99.8
30	99.9	100	99.9
45	100.1	100	100
60	100.1	100	100.1
90	100.2	100.1	100
120	100.3	100	99.9
150	100.2	99.9	100
180	100.1	100	100
210	100	100	100.1
240	99.9	99.9	100.1

$$t_{0.05}^A = 1.421 < t(1.812); t_{0.05}^B = 1.106 < t(1.812)$$

$$t_{0.05}^C = 0.369 < t(1.812); t_{0.05}^{AV} = 0.586 < t(1.697)$$

Comparability of results obtained using the solid state photometer

Rate constants as functions of concentration, hydrogen ion concentration and ionic strength, were obtained using Unicam SP 1750 uv-visible spectrophotometer and the correlation coefficients for the relationships were calculated. The same procedure was carried out on the solid state photometer. F-test analysis was also performed on the 2 sets of results.

RESULTS AND DISCUSSION

The block diagram of the solid state photometer and the glass coil constructed are shown in Figures 2 and 3 respectively. With the aid of a thermostated system, water is circulated to ensure constant temperature within the reaction system. The coil can be used in conjunction with a water circulator as a substitute for the thermostated system. When the coil is immersed in an ice bath, it will facilitate the study of the effect of temperature on the rate of a reaction.

The LED driver and detector signal processing unit are represented by the circuit diagram in Figure 4. This is a simple circuit system which can be constructed with minimal

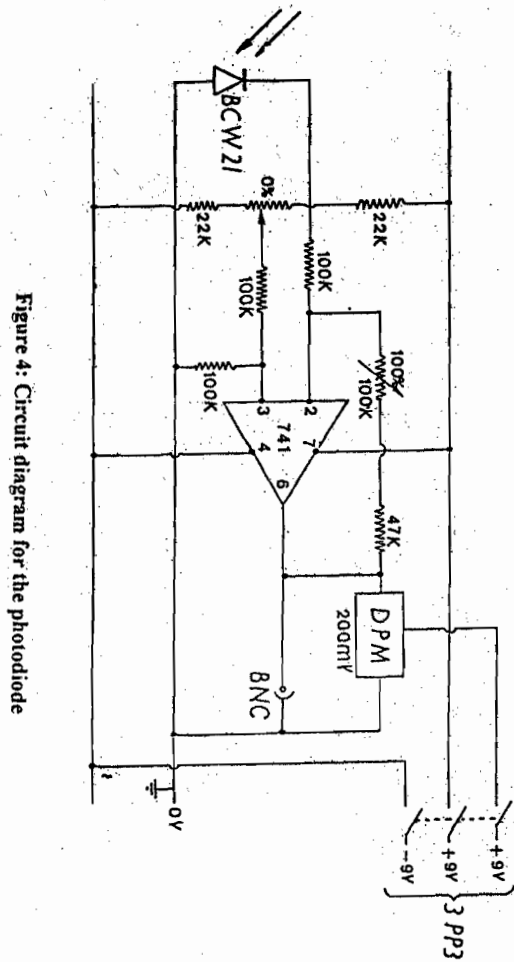


Figure 4: Circuit diagram for the photodiode

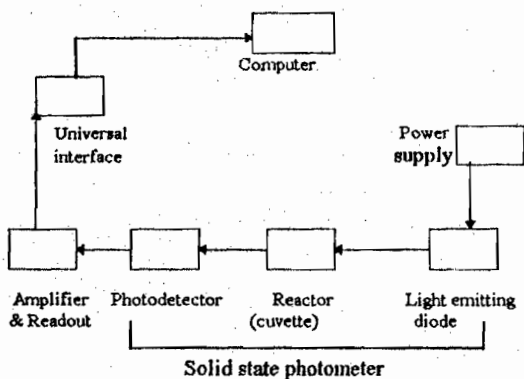


Figure 5: Flow diagram for the photometer showing the interfacing relay from the photometer to the computer