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CONSTRUCTION OF FLASH MONITOR FOR USE IN FLASH PHOTOLYSIS EXPERIMENTS

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The construction of a flash monitor for monitoring light intensity of flash lamp during flash photolysis experiments is described in this paper. The monitor makes use of a photodiode to convert light signal into electrical signal which can be measured by an oscilloscope. The linearity of flash monitor signal versus the radiant energy dissipated by the flash lamp was checked by flash photolysing nitrous oxide saturated ferrocyanide solution. Results indicate that the response of flash monitor is linear and it can be used for estimating the light intensity of a flash lamp.

INTRODUCTION

Flash photolysis is an important technique for producing high concentration of transient species by a short and intense flash of light, and studying their behaviour in chemical and biological systems. Unlike steady-state photolysis, flash excitation can generate short-lived intermediates such as radicals, excited states and ions in concentrations high enough for direct observations. This makes it possible to study physical properties of the transients, such as absorption, conductivity and excited state behaviour as well as fast reaction kinetics which are difficult to study otherwise. The principle of flash photolysis is that the system is subjected to a short, intense light flash from a flash lamp which produces observable concentration (order of several micromolar) of excited species, radicals and ions in a very short interval of time (order of microsecond). Since nearly all compounds absorb light, and many reactions can be initiated by light, the technique of flash photolysis has established itself as one of the most versatile and effective methods for producing transient species and studying fast chemical and biological reactions [1-5].

For flash photolysis, the source of excitation is normally one or more gas filled flash lamps, attached to a pair of electrodes which are connected to a bank of capacitors. When discharged, a flash of very short duration is produced which can generate sufficient concentrations of reactive species in a sample. Flash lamps with different designs and spectral characteristics have been constructed and emit energies from ten to several thousand joules [2, 6], depending on the voltage applied to the electrodes. For quantitative studies, an estimate of flash intensity was needed to check changes in the intensity from one flash to the other and to normalize the results to a common flash intensity. Here in this paper is described a flash monitor to determine flash intensity of the flash lamp.

MATERIAL AND METHODS:

The flash monitor consisted of a light sensitive diode (RCA model C30808) powered by two 9.0 volt batteries. The optical flash energy from the cell compartment was transferred to the diode using 10 cm long fiber glass light guide, after passing through an interference filter (Baird Atomic, band pass of 8.4 nm at 50% T_{max} at 366.1 nm), and attenuated by a neutral density filter to avoid photodiode saturation. The circuit diagram for the flash monitor is shown in Fig. 1.

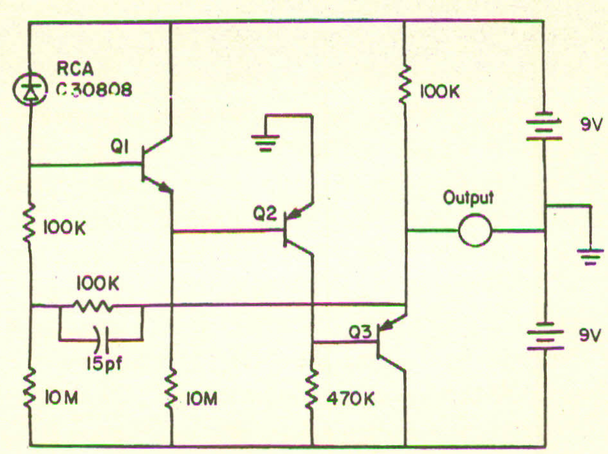

Fig. 1. Circuit diagram for flash monitor.

Potassium ferrocyanide, K_4 [Fe $(CN)_6$], used for standardizing flash monitor signal, was of reagent grade and its solution in water was kept away from room light to minimize photolysis. Water purified by Millipore Super-Q system was used in all experiments. $[Fe(CN)_6]^{4-}$ solutions were degassed and then saturated with ultrahigh pure nitrous oxide (Metheson, 99.99%). Details of procedure for transfer of degassed solutions, flash photolysis set-up data acquisition and analysis have been explained elsewhere [7].

RESULTS AND DISCUSSIONS:

The main objective of the flash monitor was to convert light signal of the flash lamp into the electrical signal that can be measured using a suitable device. The light guide, made of optical fiber with one end fixed inside the cell compartment containing flash lamp and sample cell, and the other end fixed into the flash monitor, was used to transfer light signals to the monitor. The output signal from the flash monitor, which was proportional to the flash intensity, was fed into the second channel of a double beam oscilloscope (Tektronix model 556) that was being used for flash photolysis experiments. This signal produced a trace on the oscilloscope screen corresponding to the flash intensity.

The linearity of the flash monitor's signal versus the radiant energy from the flash lamp can be checked by photolyzing a compound with known photochemistry. The compound selected for this purpose was K_4 $[Fe(CN)_6]$ whose photochemistry and flash photolysis behaviour have been well studied [8-10]. One of the important reactions on flash photolysing $]Fe(CN)_6]^{4-}$ is photoelectron production.

$$[Fe(CN)_6]^{4-} \; h\nu \; [Fe(CN)_6]^{3-} + e^-_{aq}$$

This reaction can be followed by observing the formation of [Fe $(CN)_6]^{3-}$ which has an absorption maximum at 420 nm. When a higher voltage is applied to the electrodes, more intense flash is produced and a correspondingly higher concentration of [Fe $(CN)_6]^{3-}$ is formed. Therefore, flash monitor signal can be calibrated with the absorption level of [Fe $(CN)_6]^{3-}$ at 420 nm. For this purpose N_2O saturated $1x10^{-3}$M K_4 $[Fe(CN)_6]$ solution was flash photolyzed. The absorption of resulting [Fe $(CN)_6]^{3-}$ was measured at 420 nm for different capacitor applied voltages (7.0-11.5 kv). The absorption was plotted against the flash monitor signal intensity. The resulting plot, shown in Fig. 2, shows a linear relationship at lower flash intensities. However at higher flash intensities, the points are scattered which may

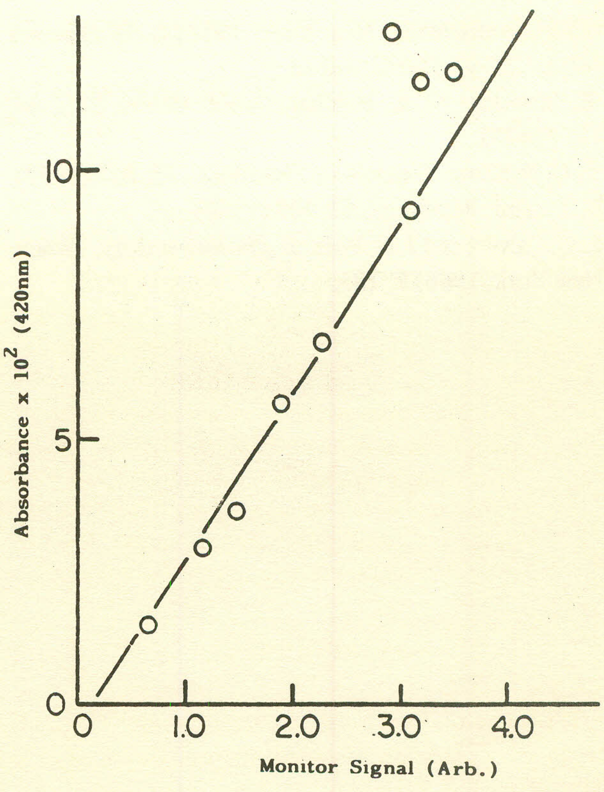

Fig. 2. Flash Monitor response. Absorption of [Fe $(CN)_6]^{3-}$ at 420 nm versus intensity of flash monitor signal.

suggest photodiode saturation. This saturation can be avoided and a linear response at higher flash intensities can be obtained if an extra neutral density filter is introduced in the flash monitor before photodiode.

These experiments suggest that the flash monitor can be used for monitoring flash lamp intensities during flash photolysis experiments. The monitor signal can also be used for normalizing spectra of transients, generated by flash photolysis, to a common flash intensity. Furthermore, it can also indicate any abrupt change in the flash intensity of a particular flash during photolysis experiments.

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