The Use of Opto-Electronics in Viscometry

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In a relatively short period of time, great advances in the field of microelectronics have revolutionized the design of scientific instruments.[1] The discovery of new materials, improved methods of design together with a drastic reduction in the cost of components have provided industry and research establishments with instruments capable of performing intricate and complex functions.

In the field of chemistry, many experiments are tedious and time consuming in their requirement for purely repetitive measurements. The use of microprocessors in these areas of experimental chemistry is both desirable and essential. First, it releases the student from purely routine work and allows more time to be dedicated to other aspects, notably the theroetical principles involved and the planning of future experiments. Second, it alerts the student to the need to adapt to changing conditions and to take advantage of technological innovations and new discoveries.

The determination of the viscosity of a liquid is of great importance in industry and in research. In the case of a solution, it is usually more important to determine the specific viscosity, η, which can be calculated from the relation:

$$\eta = \frac{t - t_0}{t_0}$$

where t and t_0 are the times taken for the solution and the pure solvent, respectively, to flow freely through the two fixed points of a viscometer. The technique requires both skill and practice[2] and depends upon the coordination of eye and hand.

This paper describes a semi-automatic viscometer which incorporates a microprocessor system and uses optoelectronics to detect the flow of liquid through the capillary, the flow time being displayed on a timer with an accuracy of 0.01 s. If required, the system could be made fully automatic with an additional microprocessor circuit and the inclusion of a pump.

The Viscometer

Although the photograph shows a Ubbelodhe dilution viscometer, any viscometer which works on the principle of capillary flow can be used. However, the two fixed marks are no longer necessary since the light-activated switches, LAS, which view the falling meniscus are, themselves, acting over a constant length of capillary tube.

The Circuit

Two circuit diagrams are given. Circuit 1 must be used in conjunction with an ordinary counter/timer, the type which may be purchased from any educational supplier. Circuit 2 is for the more ambitious who would like to construct an all solid state timer similar to the one shown in the photograph.

Lamp and LAS Housing

The housing was made from two ebonite blocks with the holes for lamps and light-activated switches drilled in pairs to facilitate alignment. The blocks were clamped together, and then a hole was drilled straight through the blocks using a size 60 drill. The holes (32 mm apart) were then counterbored to accept LES bulb holders in one block and light-activated switches in the other, thus leaving just pinholes to accept the light. The two light-activated switches were mounted on a single piece of strip board, and connections were made to a 5 V supply.

The viscometer is held in position by two small Terry® clips situated approximately where the fixed marks would normally be and positioned in such a way as not to interfere with the beams of light passing through the glass. The blocks and wiring should be sealed so that the entire unit (viscometer and housing) can be immersed in a thermostatically controlled bath. We have used Perspex® end caps and rubber gaskets with the wiring run through PTFE sleeving. The holes have been sealed with thin Perspex® on both blocks.

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