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LAMINAR FLOW DICHHROISM POLARIMETER

Filed April 19, 1963

FIG. 1.

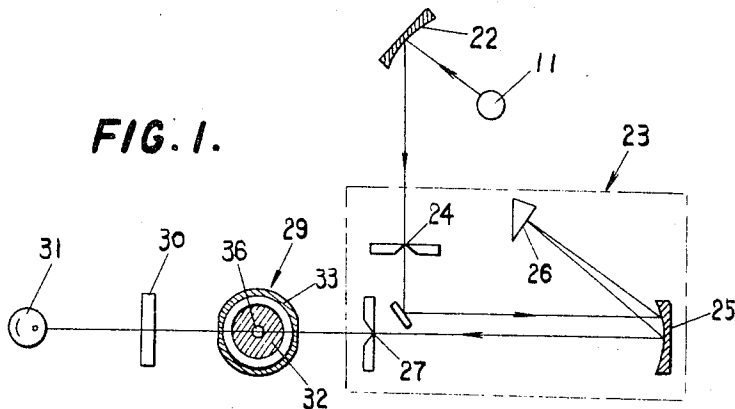


FIG. 2.

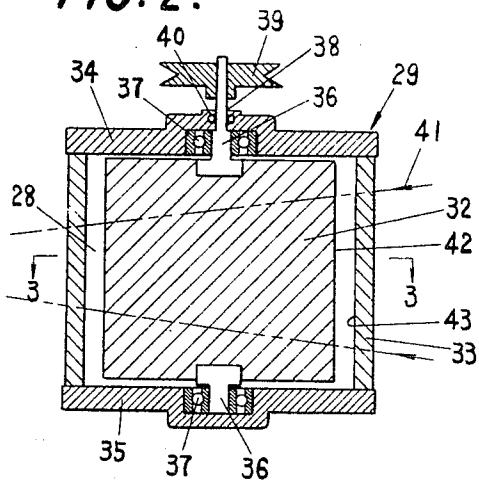


FIG. 3.

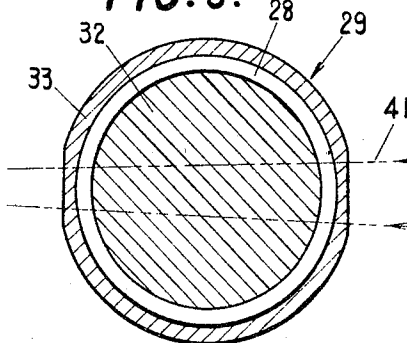


FIG. 5.

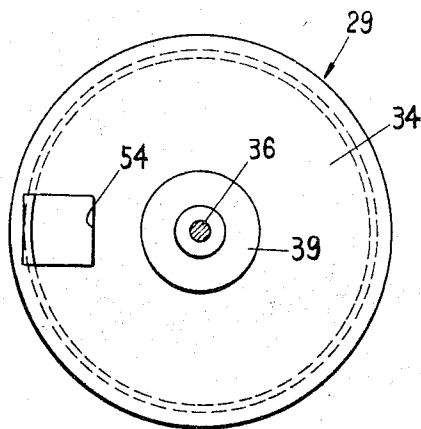
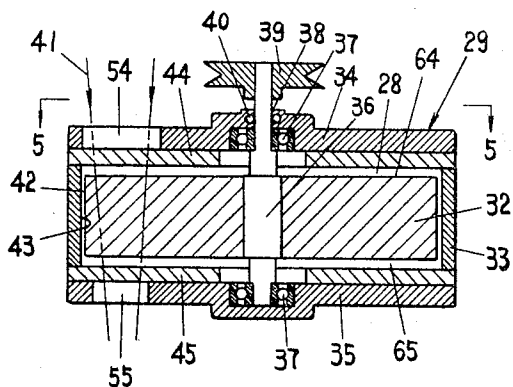


FIG. 4.



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LAMINAR FLOW DICHROISM POLARIMETER
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This invention relates to dichroism polarimeters and more particularly to flow dichroism polarimeters which are used for polarization analysis of high polymer materials in the liquid phase or in the state of solution.

As we shall see in discussing dichroic crystals, such materials exhibit a different degree of absorption for vibrations in two mutually perpendicular directions, showing two different colours. This property is called dichroism. The dichroism is also seen with respect to some particular liquid materials when a laminar flow is produced. To such liquid materials like these can be applied chemical analysis through the utilization of a polarization technique. The instruments or devices used for this purpose may be called "flow dichroism polarimeters" in view of the fact that the specimen is a laminar flow of fluid.

The primary object of the invention is to provide a flow dichroism polarimeter of novel and improved type which is used as an analytical tool for liquid materials whose laminar flow exhibits the dichroism.

The dichroism appears dependent on the structure of crystals of macromolecules and the orientation of residual radicals in the liquid materials. Another object is, therefore, to provide a novel and improved apparatus for measuring the crystallization of macromolecules and the orientation of residual radicals in the liquid sample. Among materials which can be studied with the device of the invention are albumin, nucleic acid, polystyrene and any other natural and synthetic high polymers.

Another object of the invention to provide a flow dichroism polarimeter which is simple in construction and operation, superior in accuracy of measurement, and economical to manufacture.

Other objects and advantages of the invention will become apparent from the detailed description which follows when taken in conjunction with the accompanying drawings in which:

FIG. 1 is a schematic view showing the optical system of the device of the invention;

FIG. 2 is a vertical sectional view of the sample cell according to the invention which is provided with means for producing a laminar flow;

FIG. 3 is a cross section taken along the line 3—3 of FIG. 2;

FIG. 4 is a vertical sectional view of another embodiment of the sample cell which is provided with means for producing a laminar flow; and

FIG. 5 is a plan view taken along the line 5—5 of FIG. 4.

Referring more particularly to the drawings wherein like characters of reference designate like parts throughout the several views, the basic system of the device of the invention is illustrated in FIG. 1. A light source 11 at one end of the optical path illuminates the system with one selected wave-length at a time through a monochromator generally indicated as 23. The monochromator 23 may be of any known type which comprises an inlet slit 24, a mirror 25, a spectroscopic prism 26 and an outlet slit 27. 22 denotes a condensing mirror disposed between the light source 11 and the monochromator 23. If the light source 11 is monochromatic by itself or with any other means such as a filter which allows only a

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selected single wave-length to pass therethrough, the monochromator 23 is not included in the system. The light leaving monochromator 23 passes through a liquid sample to be studied which is contained in a particular cell 29 according to the invention. While passing through the samples, the light is polarized as described hereinafter. The polarized light leaving the cell 29 passes through an analyzer 30. The analyzer 30 may be rotatable and formed of a circular sheet of light polarizing material which is conventional in polarimeters. The light leaving the analyzer 30 reaches a photoelectric cell 31 at the opposite end of the optical path where it is converted into an electrical signal.

According to the invention, the sample cell 29 illustrated in FIG. 1 is provided with means for producing a laminar flow of the sample liquid contained in the cell. This means comprises at least a pair of transparent face members facing each other with a simple liquid layer therebetween. These two face members should be arranged perpendicular to the direction of the optical path and movable relatively in the opposite directions within the respective surfaces which may be usually those of revolution.

A preferable embodiment of the sample cell including means for producing a laminar flow is illustrated in FIGS. 2 and 3, in which the sample cell 29 comprises a double cylinder structure consisting of an inner cylinder 32 and an outer cylinder 33 which are coaxially disposed. The inner cylinder 32 is a solid body while the outer cylinder 33 is hollowed. It is essential that both these inner and outer cylinders 32 and 33 are transparent for the ray used in measurement. The ray may be any of visible, ultraviolet and infrared rays. Among the transparent materials for the cylinders are glass, rock crystal and rock salt. The covers 34 and 35 at the opposite ends of the outer cylinder 33 may be made of an opaque material. The inner cylinder 32 is rotatable on the separated but aligned shafts 36 pivotally carried through the bearings 37 by the end covers 34 and 35 of the outer cylinder 33, while the outer cylinder 33 is kept stationary. The lower end cover 35 is closed while the upper end cover 34 is provided with an opening 38 through which the shaft 36 extends toward the external of the cylinder 33 where a driven pulley 39 is fixed on the shaft 36 for transmitting revolution from a motor (not shown) to the shaft 36. The numeral 40 indicates an O-ring seal which is inserted at the opening 38 of the end cover 34 for preventing the liquid sample enclosed in the cylinder 33 to leak out. The arrow line 41 indicates the projected ray having a selected wave-length.

Into the space 28 between the inner and outer cylinders 32 and 33 is put a liquid sample. The sample may, for instance, be a liquid specimen containing albumin, a solution of polystyrene, a solution of nucleic acid or any liquid substance of high polymer which can be measured polarimetrically with the device of the invention.

When the inner cylinder 32 rotates at a high speed such as 200 r.p.m. while the outer cylinder 33 is kept stationary, the liquid sample enclosed between the two cylinders 32 and 33 is forced to a laminar flow, macromolecules in the sample being arranged in a definite direction. The monochromatic light 41 coming from the outlet slit 27 of the monochromator 23 passes through the sample cell 29 containing the liquid sample in a direction perpendicular to the axis of the cell 29 (the direction of the rotating shafts 36). The orientation of the macromolecules in the liquid sample due to the laminar flow produced by rotation of the inner cylinder 32 polarizes the monochromatic light. The polarized light leaving the sample cell 29 passes through the analyzer 30 and reaches the photoelectric cell 31. If the plane of polarization of the analyzer 30 is aligned first with the

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direction of the laminar flow and after then with the direction perpendicular thereto to measure the respective spectral intensities at the photoelectric cell 31, the crystallization and orientation of the macro-molecule sample can be measured from the change in the spectral intensity.

The sample cell according to the invention may be modified as shown in FIGS. 4 and 5 wherein the sample cell comprises a double cylinder structure consisting of a pair of cylindrical members arranged coaxially as well as that shown in FIGS. 2 and 3 but the optical path passes through the sample cell in the direction to the axis of the double cylinder structure while in the embodiment illustrated in FIGS. 2 and 3 the optical path passes through the sample cell in the direction perpendicular to the axis of the double cylinder structure.

In the sample cell illustrated in FIGS. 4 and 5, the inner and outer cylinders 32 and 33 are coaxially arranged with a smaller space than that shown in FIGS. 2 and 3 between the peripheral surface 42 of the inner cylinder 32 and the inside wall 43 of the outer cylinder 33. The cover plates 34 and 35 of an opaque material at the opposite end of the outer cylinder 33 are lined with the transparent plates 44 and 45, respectively. The inner cylinder 32 is fixed on a single shaft which is pivotally carried through bearings 37 by the end covers 34 and 35. In this manner, the inner cylinder 32 can be more securely carried than with separated shafts as shown in FIG. 2. The cover plates 34 and 35 are provided near their peripheries with the respective windows 54 and 55. Both windows 54 and 55 are alined in a direction parallel to the shaft 36 so that the ray may come into the cell 29 through the window 54 and go out of the other window 55. It will be noted that the optical path should be taken along the direction parallel to the axis of the double cylinder structure. 39 is a driven pulley which is fixed on the shaft 36 for transmitting revolution from a motor (not shown) to the inner cylinder 32. The numeral 40 indicates an O-ring seal which is inserted at the opening 38 of the upper end cover 34 for preventing the liquid sample enclosed in the cylinder 33 to leak out.

When the inner cylinder 32 in the sample cell illustrated in FIGS. 4 and 5 is rotated, to sample liquid layers at the opposite sides of the inner cylinder 32, strictly to say, between the opposite end surfaces 64, 65 of the inner cylinder 32 and the transparent plates 44, 45 are forced into laminar flows, whereby the light passing through the sample cell is polarized. The polarized light passes through the analyzer 30 and reaches the photoelectric cell 31.

The structure illustrated in FIGS. 2 and 3 necessitates such a relatively large space in 10 mm. or more between the inner and outer cylinders 32 and 33 because with such a reduced space as 1 mm. or less between the two cylinders 32 and 33, the inner cylinder 32 supported with insufficient security by separated shafts is liable to touch with the outer cylinder 33. Accordingly, this structure is not available for a scarce quantity of sample liquid. To the contrary, in the structure illustrated in FIGS. 4 and 5 the inner cylinder 32 is securely supported by a single shaft 36 which passes through the whole length of the cylinder 32. The space between the inner and outer cylinders 32 and 33 can, therefore, be reduced to such an extreme extent as 0.01 mm. The sample cell of the type illustrated in FIGS. 4 and 5 is operable with a small quantity of liquid sample. In view of the fact that in case of infrared ray spectrum analysis such a minute space as 0.1 mm. to 0.01 mm. is often required between the two cylinders, this is of a great importance.

Only essential in the invention is to produce a laminar flow of the sample liquid in the sample cell. For this purpose, the sample cell in the optical path includes a pair of face members facing each other with a sample liquid layer between said face members being arranged perpendicular to the direction of the optical path and

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movable relatively in the opposite directions within their own surfaces. The peripheral surface 42 of the inner cylinder 32 and the inside wall 43 of the outer cylinder in the double-cylinder structure illustrated in FIGS. 2 and 3 are a couple of the face members in the above sense and the opposite end surfaces 64, 65 of the inner cylinder 32 and the transparent plates 44, 45 in the structure illustrated in FIGS. 4 and 5 are another.

The relative movement in the opposite directions between two face members may be achieved either by moving one face member in a direction while the other face member being kept stationary or by moving actually the two face members in the opposite directions. Consequently, in the above two embodiments, the inner cylinder 32 is revolved while the outer cylinder 33 remains stationary, but this may well be reversed for the outer cylinder 33 may be actually revolved in the direction opposite to that of the inner cylinder 32. The double-cylinder structure may be replaced by a pair of transparent disks spaced to each other with a sample liquid layer therebetween. In this case, the laminar flow may be produced either by rotating one disk while the other being kept stationary or by rotating both of them in the opposite directions. With such the construction like this, a single liquid layer is obtained and the space between the two disks will be liable to vary. In comparison with this manner, the embodiments illustrated before referring to FIGS. 2 to 4 are advantageous because there exist a pair of sample liquid layers with regard to the transmitting light so that the change in the thickness of one layer may conveniently be compensated by the other layer. In addition, the embodiments illustrated in FIGS. 2 to 4 can be easily designed and constructed.

In the measurement of the spectral intensity of the light which passes through the sample cell 29, any other photoelectric detector may be used. In case of employing the infrared ray in the measurement, such an infrared ray detector as a thermocouple can be used.

The sample cell 29 and the analyzer 30 may well be used by disposing them in front of the inlet slit 24 of the monochromator 23.

From the foregoing, it can be seen that simple, efficient and economical means have been provided for accomplishing all of the objects and advantages of the invention. Nevertheless, it is apparent that many changes in the details of construction, and arrangement of parts may be made without departing from the spirit of the invention as expressed in the accompanying claims and the invention is not limited to the exact matters shown and described as only the preferred matters have been given by way of illustration.

What I claim is:

1. A flow dichroism polarimeter comprising a light source at one end of a single optical path, photoelectric light receiving means at the opposite end of said optical path to convert light into electrical signals, a transparent sample cell in said optical path which is provided with means for producing a laminar flow of a liquid sample, and polarized light-analyzing means also in said optical path between said sample cell and said photoelectric light receiving means.

2. A flow dichroism polarimeter as defined in claim 1, in which said means for producing a laminar flow of the liquid sample comprises a pair of transparent face members facing each other with a sample liquid layer therebetween, said face members being arranged perpendicular to the direction of said optical path and movable relatively in opposite directions in paths defined by their own surfaces.

3. A flow dichroism polarimeter comprising a light source at one end of a single optical path, photoelectric light receiving means at the opposite end of said path to convert light into electrical signals, a transparent sample cell in said optical path which comprises a concentric double-cylinder structure consisting of an inner solid cy-

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lindrical body and an outer hollowed cylindrical body between which the sample liquid is enclosed, one of said two cylindrical bodies being rotatable about its axis while the other is kept stationary, said cylindrical bodies being so spaced that rotation of said one cylindrical body produces laminar flow in said sample, and polarized light-analyzing means also in said optical path between said sample cell and said photoelectric light receiving means.

4. A flow dichroism polarimeter as defined in claim 3 in which the optical path passes through the sample cell

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in a direction perpendicular to the axis of said double cylinder structure.

5. A flow dichroism polarimeter as defined in claim 3 in which the optical path passes through the sample cell in a direction parallel to the axis of said double cylinder structure.

No references cited.

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A. A. KASHINSKI, *Examiner*.