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LAB REPORT:

PULFRICH REFRACTOMETER

For the partial fulfilment of the module submission requirement of

"**OPTICAL INSTRUMENTS**"

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INTRODUCTION:

This experiment from the Optical Instruments Laboratory aims to increase understanding of the fundamentals and practical applications of the Refractometer device. Refractometers are instruments that determine a material's refractive index when its absorption quality is very low or non-existent. There are two ways we can find an object's refractive index: Total Internal Reflection and Light Deflection. Finding a transparent substance or liquid's refractive index, commonly referred to as the index of refraction, is the goal of an experiment using a Pulfrich refractometer. This experimental setup is particularly useful for determining the refractive index of transparent materials, such as liquids, that are difficult to measure using other techniques. The Pulfrich refractometer works on the principle of total internal reflection and relies on the fact that when a beam of light passes from one medium into another with a different refractive index, it changes its direction i.e., refraction at the interface.

A material's refractive index, which indicates how much light varies in speed as it travels through it, is one of its basic optical properties. In many industrial and scientific applications, it is a crucial parameter. The link between the refractive indices of the two media involved and the angles of incidence and refraction is described by Snell's Law, which may be verified. By measuring the angles and refractive indices, the experiment seeks to validate Snell's Law. Refractive index measurements can be crucial for quality control in several industries, including chemistry, pharmaceuticals, and optics. The experiment's goal is to give precise and reliable refractive index measurements. Before use, the Pulfrich refractometer might require calibration.

To ensure accurate measurements, the instrument may need to be calibrated as part of the experiment. By comparing the refractive index of an unknown liquid to standards or known substances, the experiment may occasionally be used to identify an unfamiliar liquid. Typically, the Pulfrich refractometer experiment involves passing a light beam through the sample, determining the angles of incidence and refraction, and calculating the refractive index using Snell's Law. The quality of the apparatus and the meticulous execution of the measurements determine the experiment's accuracy and precision.

The refractometer which we use in this experiment is known as a Pulfrich-Refractometer. The Pulfrich-Refractometer is known to be a flexible one and hence, we can use it for our purpose of carrying out both methods of determining the Refraction Indices which are Light deflection and Total Internal Reflection. We use a set of prisms in both the methods and calculate the Abbe Number (v) for each prism. Hg/Cd Spectral lamp is used as a source in this experiment through which the spectrum with waves of different colours and wavelength are measured. This experiment makes use of the eyepiece, switch to change views, and rough and fine adjustment wheel of the refractometer.

CALCULATION OF ABBE NUMBER:

The formula for calculating Abbe Number (v) is given as below:

$$V = \frac{(n_e - 1)}{(n_{F'} - n_{C'})}$$

Equation 1: Calculation of Abbe Number

where,

n_e = Refractive Index of green colour,

$n_{F'}$ = Refractive Index of Blue colour &

$n_{C'}$ = Refractive Index of Red colour.

METHOD 1:

MEASUREMENT BY LIGHT DEFLECTION:

The refractometer's measurement prism has a V-shaped interface that is fitted with a precisely machined and polished prism. Light from the source after passing through the collimator strikes the first interface surface at the prism and is refracted between the liquid and the second interface surface. In this method of determination, Bromonaphthalene serves as the liquid interface having an index of refraction of 1.65. Finally, light exits at angle γ following these procedures. A refractometer is used to determine this by measuring the angle (nλ) through which light passes when it enters another transparent medium like a prism whose refractive index is known in advance. The refractive index can be calculated using the following formula:

$$n_\lambda = \sqrt{N_\lambda^2 - \cos\gamma_\lambda \sqrt{N_\lambda^2 - \cos^2\gamma_\lambda}}$$

Equation 2: Refractive index of required wavelength by Light deflection method

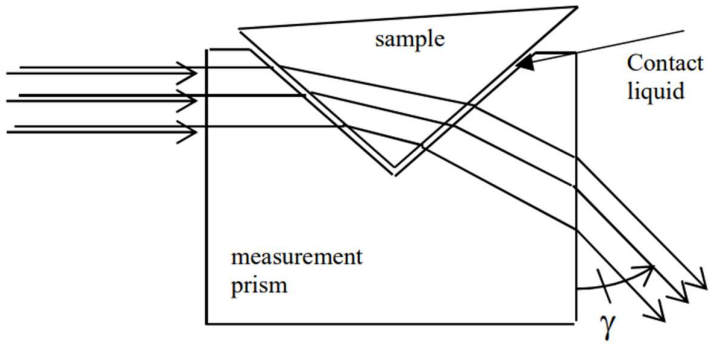

Figure 1: Simple light refraction at the Pulfrich Refractometer

PROCEDURE:

1. Apply the contact fluid which acts as Liquid Interface on the measurement prism.
2. Place the prism which is to be measured on the measurement prism of refractometer.
3. Observing from the eyepiece, identify the required coloured light as per the wavelength required.
4. Adjust the spectral image by using the rough and fine adjustments.
5. Change the view and note the angle from the scale in the refractometer for each wavelength (e, F'& C').
6. Continue the procedure for other sample prisms.
7. Calculate the Refractive indices and Abbe numbers for the Sample prisms.

OBSERVATIONS & CALCULATIONS:

S No.	Prism Number	Light Colour from Spectrum	Wavelength of light	Angle Observed	N_λ	n_λ	Abbe Number (V)
1	Prism 2	Hellblau (F') Gelbgrün (e) Rot (C')	479.99 546.07 643.85	72° 32, 70' 73° 16, 95' 73° 54, 20'	1.762415 1.748005 1.735155	1.605885 1.598789 1.588044	36.03
2	Prism 5	Hellblau (F') Gelbgrün (e) Rot (C')	479.99 546.07 643.85	95° 25, 10' 95° 10, 10' 94° 57, 80'	1.762415 1.748005 1.733951	1.807527 1.791845 1.774573	24.03
3	Prism 6	Hellblau (F') Gelbgrün (e) Rot (C')	479.99 546.07 643.85	83° 21, 35' 84° 13, 45' 84° 57, 35'	1.762415 1.748005 1.733951	1.702411 1.696189 1.687280	46.01

Table 1: observation & calculation by light deflection method

DISCUSSION:

In this method, we calculated the Abbe numbers of the Prisms using Pulfrich Refractometer and observing the angle by Light deflection. Our Observations and mentioned below:

- Prism 5 has low Abbe number which means the dispersion of light from this prism is more. These types of prisms can be used in Spectrometers or Devices which are designed to separate the light from its spectrum.
- Prism 6 has high Abbe number which means the dispersion of light from this prism is less. These types of prisms can be used in Optical instruments like microscopes, telescopes & cameras.

METHOD 2:

MEASUREMENT BY TOTAL INTERNAL REFLECTION:

By following this method, the liquid boundary between the surfaces of two objects is located amid the test prism and flat surface of the measuring prism. Using bromonaphthalene with refractive index equal to 1.65 as liquid for this procedure. Rays from a source are so incident onto the device that they fall at an angle of 90° at interface with which measuring side and sample prism meet. The values for refractive indices are then found by calculating θ, which is simply an angle made by reflected ray. This is expressed as follows:

$$n_\lambda = \sqrt{N_\lambda^2 - cos^2\,\gamma_\lambda}$$

Equation 3: Refractive index of required wavelength by Total internal reflection method

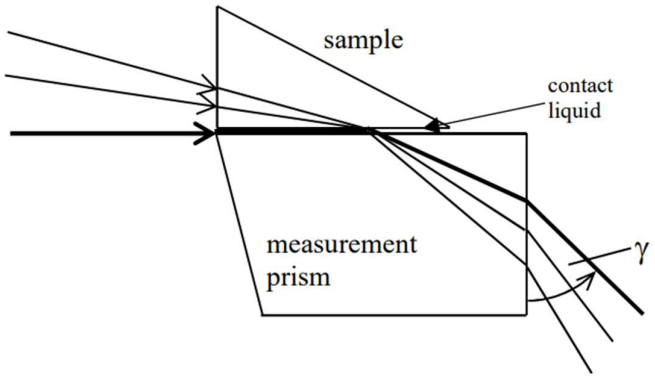

Figure 2: Total internal reflection at a refractometer by Pulfrich

PROCEDURE:

1. Apply the contact fluid which acts as Liquid Interface on the measurement prism.
2. Place the prism which is to be measured on the measurement prism of refractometer.
3. Observing from the eyepiece, identify the required coloured light as per the wavelength required.
4. Adjust the spectral image by using the rough and fine adjustments.
5. Change the view and note the angle from the scale in the refractometer for each wavelength (e, F'& C').
6. Continue the procedure for other sample prisms.
7. Calculate the Refractive indices and Abbe numbers for the Sample prisms.

OBSERVATIONS & CALCULATIONS:

S No.	Prism Number	Light Colour from Spectrum	Wavelength of light	Angle Observed	N_λ	n_λ	Abbe Number (V)
1	Prism 2	Hellblau (F') Gelbgrün (e) Rot (C')	479.99 546.07 643.85	43° 42, 50' 45° 29, 75' 46° 42, 30'	1.761206 1.746758 1.733883	1.604485 1.598861 1.590967	43.81

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Table 2: observation & calculation by Total Internal Reflection method

DISCUSSION:

In this method, we calculated the Abbe numbers of the Prisms using Pulfrich Refractometer and observing the angle of Total Internal Reflection. Our Observations and mentioned below:

- For Prism 5 & 6, we could not find the Critical angle which clearly indicates that the Refractive indices of these prisms are very low than the refractive index of the Contact fluid (Bromonaphthalene $n_D^{20} = 1.657$).

CONCLUSION:

The two methods of determining the refractive index are implemented successfully from the experimental values obtained by conducting these methods on the Pulfrich Refractometer on various prisms. As a result, we have calculated the Abbe Number for these prisms. By observing the Abbe numbers and range of refractive indices we can conclude the type of Prisms 2,5 & 6 are Flint glass prisms.