Step-Index Fiber Intensity Modulated Glass Refractometer – Determination of Refractive Index of Certain Medicinal Oils

Dr. S. Venkateswara Rao[1], S. Srinivasulu[2]

[1&2] *Department of Physics, JNTUH College of Engineering Hyderabad – 500085, Telangana State, India.*

ABSTRACT: A new approach has been adopted to study and analyze the refractive index of certain medicinal oils in the present paper. Study of refractive index of medicinal oils is carried out by using an extrinsic fiber optic U-shaped glass probe, one end of which is connected to a light source of 660nm and other end to a power detector. To calibrate the sensor, few chemicals i.e., Methanol, Propanol, Butanol, Cyclo-hexane and Benzene having a dynamic range of refractive index between $1.323n_D$ to $1.497n_D$ at room temparature. The calibrated curve is drawn between the power output noted from output power detector and refractive index recorded by using Abbe's refractometer. The calibrated curve can be used to determine the refractive index of any unknown liquid whose dynamic range lies between $1.323n_D$ to $1.497n_D$ at room temperature at the operating wavelength of 660nm. Few medicinal oils were selected to determine the refractive index with the help of calibrated curve and the results obtained were in good agreement with literature values.

Keywords: *Abbe's Refractometer, Calibrated Curve, Dynamic Range, Medicinal Oils, Refractive Index, Operating Wavelength.*

I. INTRODUCTION

Study of refractive index of medicinal oils is very important in various applications. The conventional method to determine the refractive index is by using Abbe's refractometer, but it has its own limitations i.e., useful only for transparent liquids, degree of accuracy is less, bulk in size and heavy in weight. Determinations of refractive index by using several methods have been reported in the literature. In view of the above, development of an alternative refractive index sensor based on optical fibers have been reported [1-4]. An optical fiber based refractive index sensor is smaller in size, light in weight, immune to RFI and EMI, immune to chemical reactions, electric shocks and sparks, it can be used as a chemical sensor, etc. Silica glass fiber has also been used as a absorption sensor [5-8]. By changing the intensity of the light which is propagating through the sensor, we can study the refractive index of the liquids [9-10]. In this paper, we discussed the study of refractive index of certain medicinal oils by using optical fiber based refractometer.

II. EXPERIMENTAL DETAILS

In the first stage of experimentation chemical mixtures were prepared by mixing methonal in benzene with different ratios and make the total volume as 10ml. Refractive index of all the mixtures were determined by using Abbe's

refractometer. By maintain chemical mixtures around the U-shaped glass probe, light launched from the source and output power was recorded by using power detector for each chemical mixtures. Similar procedure repeated for propanol mixed in benzene, butanol mixed in benzene and cyclo-hexane mixed in benzene. The calibrated curve has been drawn between refractive index Vs output power having dynamic range between $1.323n_D$ to $1.497n_D$.

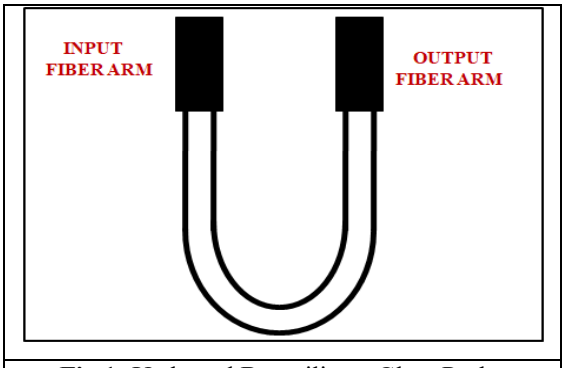

Fig.1: U-shaped Borosilicate Glass Probe

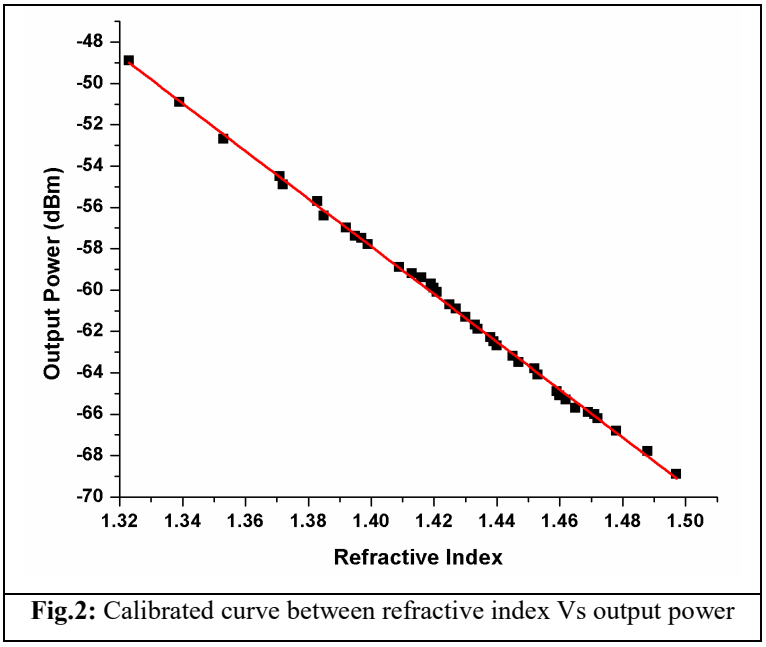

Fig.2: Calibrated curve between refractive index Vs output power

In the second stage of experimentation medicinal oils maintained around the U-shaped glass probe and output powers were noted down by using power detector, and also refractive index noted by using Abbe's refracatometer one after the other and values are tabulated.

III. RESULTS AND DISCUSSION

To determine the refractive index of medicinal oils by using intensity modulated fiber optic refractometer, the experiment has been carried out by maintaining the different oils around the U-shaped glass probe

which act as a liquid cladding. By launching the light from the source, the output powers reaching the detector were recorded and the refractive indices measured by using Abbe's refractometer and fiber optic refractometer were also recorded and tabulated [Table-1].

Table-1

S. No.	Name of the Medicinal Oil	Output Power (dBm)	R. I. from U-Shaped glass rod Fiber Optic Sensor	R. I. From Abbe's Refractometer	Error Percentage in R.I.	Standard Values of R. I.
1	Coconut oil	-64.2	1.452	1.453	0.0688	1.488–1.449
2	Rogan-e-gul oil	-64.3	1.453	1.454	0.0687	1.449–1.455
3	Levender oil	-64.8	1.458	1.459	0.0685	1.459–1.464
4	Rose mary oil	-65.2	1.462	1.463	0.0684	1.466-1.470
5	Bone oil	-65.3	1.463	1.464	0.0683	1.460-1.464
6	Moha oil	-65.6	1.466	1.467	0.0682	1.463–1.468
7	Almond oil	-65.7	1.467	1.468	0.0681	1.462–1.466
8	Menthol oil	-65.7	1.467	1.468	0.0681	1.462–1.469
9	Groundnut oil	-65.8	1.468	1.469	0.0680	1.462–1.464
10	Nilgiri oil	-65.8	1.468	1.469	0.0680	1.458–1.470
11	Olive oil	-65.9	1.469	1.470	0.0680	1.468–1.471
12	Pistha oil	-65.9	1.469	1.470	0.0680	1.464–1.464
13	Mandara oil	-65.9	1.469	1.470	0.0680	1.465–1.471
14	Citronela oil	-65.9	1.469	1.470	0.0680	1.480–1.492
15	Til oil	-66.0	1.470	1.471	0.0679	1.465–1.468
16	Cajeput oil	-66.0	1.470	1.471	0.0679	1.464–1.482
17	Kalonji oil	-66.0	1.470	1.471	0.0679	1.460–1.470
18	Ankola oil	-66.0	1.470	1.471	0.0679	1.465–1.472
19	Malkangni oil	-66.0	1.470	1.471	0.0679	1.466–1.473
20	Mustard oil	-66.1	1.471	1.472	0.0679	1.527–1.529
21	Chemeli oil	-66.1	1.471	1.472	0.0679	1.468–1.475
22	Amla oil	-66.1	1.471	1.472	0.0679	1.466–1.470
23	Bawanchi oil	-66.1	1.471	1.472	0.0679	1.468–1.475
24	Astamulica oil	-66.3	1.473	1.474	0.0678	1.468–1.474
25	Akrot oil	-66.3	1.473	1.474	0.0678	1.475–1.478
26	Kaddu oil	-66.3	1.473	1.474	0.0678	1.472–1.474
27	Lemon oil	-66.3	1.473	1.474	0.0678	1.473–1.476

28	Soyabeam oil	-66.3	1.473	1.474	0.0678	1.465–1.469
29	Khushus oil	-66.4	1.474	1.475	0.0677	1.469–1.473
30	Turpent oil	-66.4	1.474	1.475	0.0677	1.469–1.474
31	Orange oil	-66.4	1.474	1.475	0.0677	1.470–1.474
32	Sunflower oil	-66.4	1.474	1.475	0.0677	1.465–1.469
33	Eucaliptus oil	-66.5	1.475	1.476	0.0677	1.458–1.470
34	Karad oil	-66.5	1.475	1.476	0.0677	1.458–1.470
35	Neem oil	-66.6	1.476	1.477	0.0677	1.462–1.471
36	Caster oil	-66.7	1.477	1.478	0.0676	1.477–1.481
37	Alsi oil	-66.8	1.478	1.479	0.0676	1.475–1.479
38	Karanja oil	-66.8	1.478	1.479	0.0676	1.473–1.479
39	Nutmeg oil	-67.0	1.480	1.481	0.0675	1.469–1.472
40	Lemon grass oil	-67.1	1.481	1.482	0.0674	1.486–1.490
41	Rosa oil	-67.5	1.485	1.486	0.0672	1.474–1.486
42	Cederwood oil	-68.7	1.495	1.496	0.0668	1.495–1.510

Relationship between output power Vs refractive index determined by U-shaped glass probe based fiber optic sensor and refractive index measured from Abbe's refractometer were shown graphically [Fig.3 & 4].

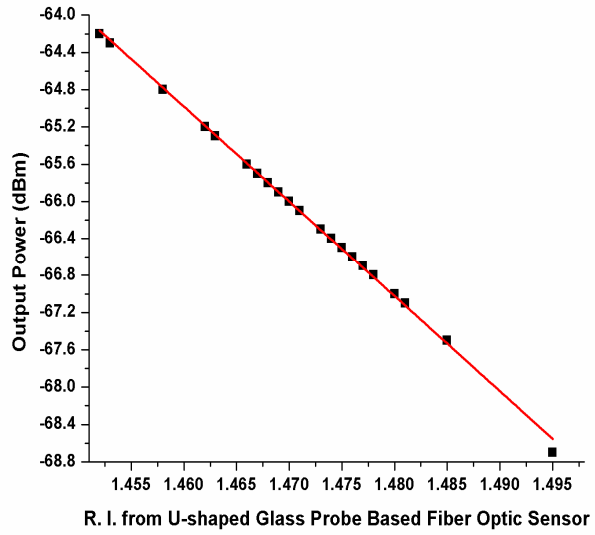

Fig.3: Relation between R. I. from U-shaped glass probe based fiber optic sensor Vs output power (dBm)

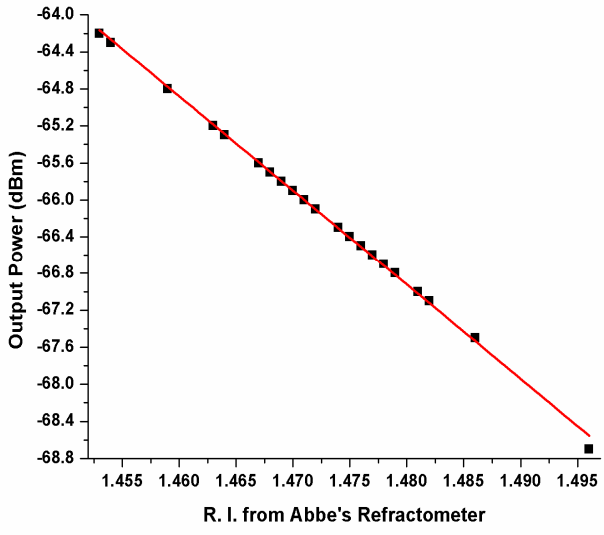

Fig.4: Relation between R. I. from Abbe's refractometer Vs output power (dBm)

Comparison between refractive indices obtained from U-shaped glass rod based fiber optic sensor and refractive indices measured from Abbe's refractometer with respect to output power was shown graphically [fig.5].

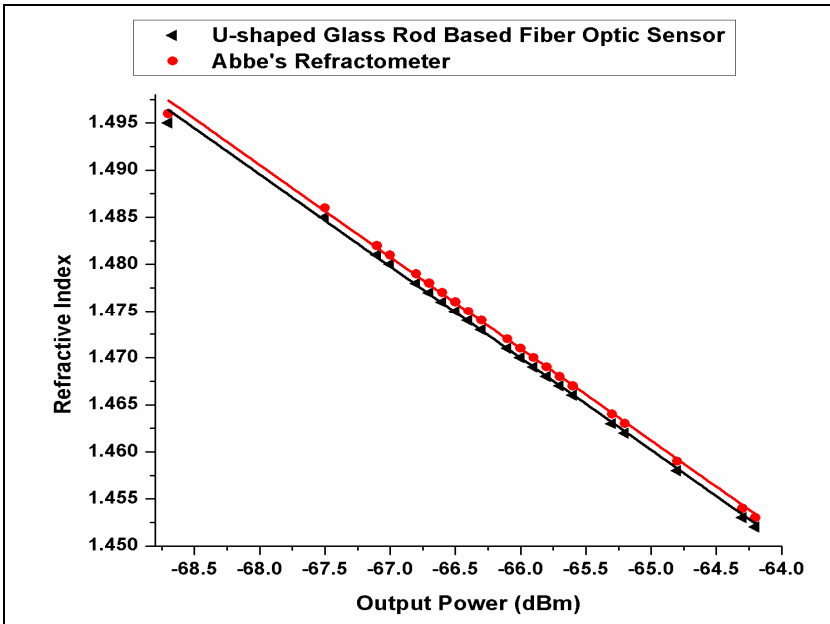

Fig.5: Comparison between refractive index from U-shaped glass rod based fiber optic sensor and Abbe's refractometer Vs refractive index

IV. CONCLUSION

In the present work the variation of output power with the refractive indices of the chemical mixtures whose dynamic range lies between $1.323n_D$ to $1.497n_D$ at room temperature at the operating wavelength of 660nm were investigated and the calibrated graph was plotted between refractive index and output power. With the help of calibrated graph the refractive indices of unknown medicinal oils were determined and compared with refractive index measured from Abbe's refractometer. Refractive indices determined by using U-shaped glass rod based fiber optic sensor were is good agreement with Abbe's refractometer values and the literature values.

REFERENCES

[1] W. Heller, The determination of refractive indices of colloidal particles by means of a new mixtyre rule or from measurement of light scattering, Phys. Rev. Vol. 68, pp. 5-10, 1945.

[2] G.H. Meetem, in: G. H. Meeten (Ed.), Optical Properties of Polymers, Elsevier, London, 1986.

[3] G.F. Stanley, Refractometers: Basic Principles, Bellingham & Stanley Ltd., 1989.

[4] S. Venkateswara Rao, S. Srinivasulu, "Calibration and development of a Novel Multi-mode Fiber optic U-Shaped Solid Glass Rod Based Sensing Probe to Measure Refractive Index of Various

Transparent Liquids", International Journal of Advance Research in Science and Engineering, Vol. No.06, Issue No.09, pp.132-135, Sep.-2017.

[5] B. D. Gupta, C. D. Singh, A. Sharma, Fiber Optic Evanescent Field Absorption Sensor, effect of launching condition and the geometry of the sensing region, Opt. Eng. 33, pp. 1864-1868, 1994

[6] V. Ruddy, B. D. MacCraith, J. A. Murphy, Evanescent Wave Absorption Spectroscopy using Multimode Fibers, J. Appl. Phys. 67, pp/ 6070-6074, 1990.

[7] V. Ruddy, An Effective Attenuation Coefficient for Evanescent Wave Spectroscopy using Multimode Fiber, Fiber Integr. Opt. 9, pp. 142-150, 1990.

[8] P. H. Paul, G. Kychakoff, Fiber Optic Evanescent Field Absorption Sensor, Appl. Phys. Lett., Vol. 51, pp. 12-14, 1987.

[9] A. Suhadolnik, A. Balnik, H. Mozina, Optical Fiber Reflection Refractometer, Sens. Actuators, B Chem. Switzerland. Vol. 29, pp. 428-432, 1995.

[10] R. D. H. Brown, D. Hardy, B. Thomas and E. Thomas, The Effect of Variation in Refractive Index on Transmission in Fiber Optic Sensors, J. Phys. E, Vol. 19, pp. 298, 1986