International Journal of Management, IT & Engineering
Vol. 7 Issue 11, November 2017,
ISSN: 2249-0558 Impact Factor: 7.119
Journal Homepage: http://www.ijmra.us, Email: editorijmie@gmail.com
Double-Blind Peer Reviewed Refereed Open Access International Journal - Included in the International Serial Directories Indexed & Listed at: Ulrich's Periodicals Directory ©, U.S.A., Open J-Gage as well as in Cabell's Directories of Publishing Opportunities, U.S.A

UNIFORM U-SHAPED GLASS ROD BASED FIBER OPTIC REFRACTOMETER: INFLUENCE OF TEMPERATURE ON REFRACTIVE INDEX OF LIQUIDS

Dr. S. Venkateswara Rao & S. Srinivasulu*

Abstract: The influence of temperature on the refractive index of liquids using a uniform U – Shaped glass probe based fiber optic evanescent wave absorption sensor is investigated experimentally. The extrinsic optical fiber sensor having high sensitivity and a linear dynamic range is proposed in the present paper. The U-Shaped uniform glass probe is used to achieve high sensitivity and while the linear dynamic response is obtained by preventing the surface reactivity of the solute molecules of the absorbing fluid with the silica glass rod. Two PCS fibers are connected to both ends of the U shaped glass rod. The other end of the input fiber is connected a light source of 630nm wavelength and output fiber is connected to a power detector. Light from the source is launched into the input fiber and the power reaching the detector is recorded. The changes in the power levels are noted from the variations in intensity reaching the detector due to the influence of the temperature on the refractive index of active medium surrounding the sensing probe. The sensor can be easily constructed and a great deal of repeatability and reproducibility has been obtained in the experimentation.

Keywords: *Absorbing fluid, Evanescent wave absorption, Sensing Probe, Sensitivity, Temperature, U-shaped uniform glass probe*

I. Introduction

Fiber optic sensors based on evanescent wave absorption have been under intensive investigation for the applications of chemicals and biological sensors in the past few years. The dominant features of these sensors offers high sensitivity, small in size, light in weight, no cross-talk of the signal. Fiber optic sensors have dominant features because of excellent properties such as cheaper in cost, offers low loss, large bandwidth, light in weight, etc [1–4]. Among the various sensing schemes, refractive index sensing is very crucial, since it is important in many chemical, biological, food industries, etc., [5–10]. In this paper, an evanescent wave absorption based fiber optic sensor is developed, which is capable in the detecting of small change in the refractive index of chemical mixtures (methanol mixed in benzene) at various temperatures (303°K, 308°K, 313°K, 318°K, 323°K, 328°K & 333°K) by

* *Department of Physics, JNTUH College of Engineering Hyderabad – 500085, Telangana State, India.*

using a uniform U-shaped borosilicate glass rod with specific dimensions and at the operating wavelength of 630nm.

II. Experimental Details

A uniform U-shaped borosilicate glass rod is used as sensing probe for investigating the effect of temperature on the variation of refractive index of chemical mixtures whose dynamic range from 1.323n_D to 1.497n_D at temperature variations between 303K and 333K, and at the operating wavelength of 630nm. Geometrical parameters of the U-shaped glass rod are, total height (H):4cm, depth of the glass rod immersed(h):3cm, diameter(d):0.5mm, width between two prongs(Z):2cm, depth of curvature(Y):1cm and radius of the curvature(X):1cm.

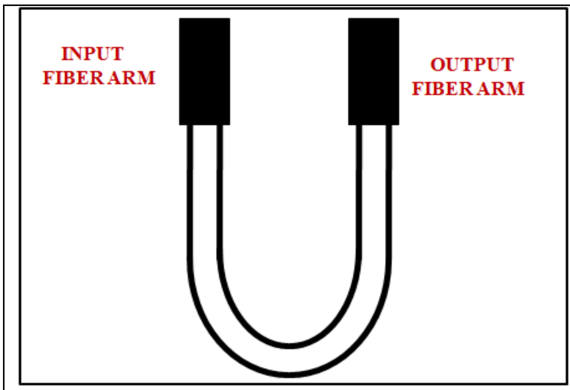

Fig.1: U-shaped Borosilicate Glass Probe

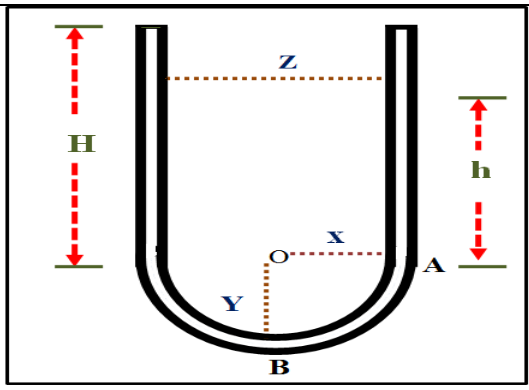

Fig.2: Geometrical parameters of U-shaped Glass Probe

Initially one end of the U-shaped glass rod is connected to input PCS (200/230µm) fiber arm and other end of the U-shaped glass rod is connected to output PCS (200/230µm) fiber arm by using proper connectors and index matching gel available in the local market. Then the other end of the input fiber arm is connected to a light source operating at the wavelength of 630nm and other end of the output fiber arm is connected to a bench mark optical power detector with SMA connectors. The light source is switched on and the light transmitted through active medium (chemical mixture) around the U-shaped glass element and output power is recorded from the power detector. Then slowly increasing the temperature in the glass container containing methanol is raised in steps of 5K up to its boiling point and each time the power values were recorded. Next 1ml of methanol + 9ml of benzene is taken and again experiment procedure is repeated and corresponding output powers were recorded. Output power values in the similar manner also noted for other methanol mixed in benzene mixtures. Refractive index of all the chemical mixtures were determined by using Abbe's refractometer. This forms a standard relationship between the output powers obtained from U-shaped glass sensor and the refractive indices obtained from Abbe's refractometer at different temparatures.

III. Results And Discussion

From the tabulated values of refractive index and output power at the room temperature (303K) a relationship is formed between refractive index and output power as shown graphically [Fig.3].

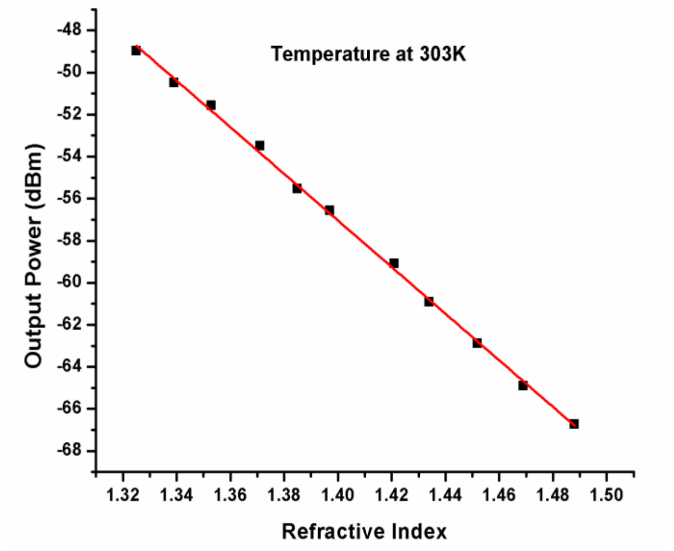

Fig.3: Relation between Refractive index and Output power (dBm) of Methanol + Benzene mixtures at the temperature of 303°K

In the similar manner relationship between refractive indices and output powers for all the methanol mixed in benzene mixtures were drawn graphically at the temperatures of 308K, 313K, 318K, 323K, 328K and 333K [Fig.4–9].

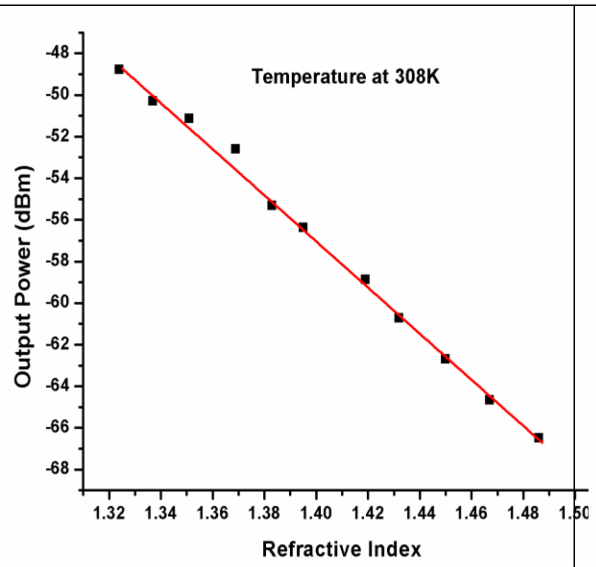

Fig.4: Relation between Refractive index and Output power (dBm) of Methanol + Benzene mixtures at the temperature of 308°K

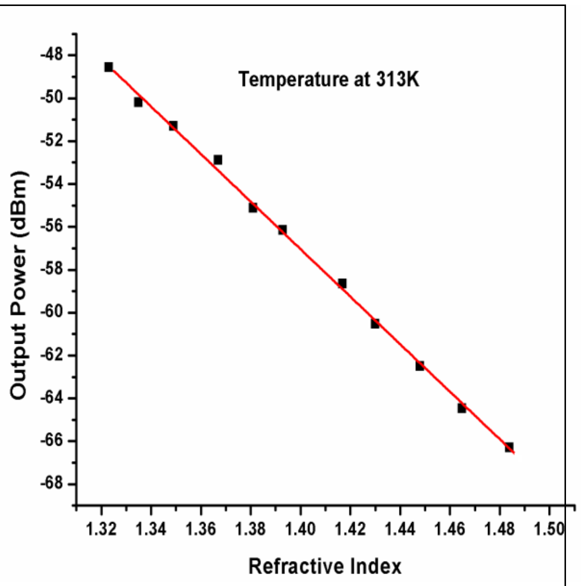

Fig.5: Relation between Refractive index and Output power (dBm) of Methanol + Benzene mixtures at the temperature of 313°K

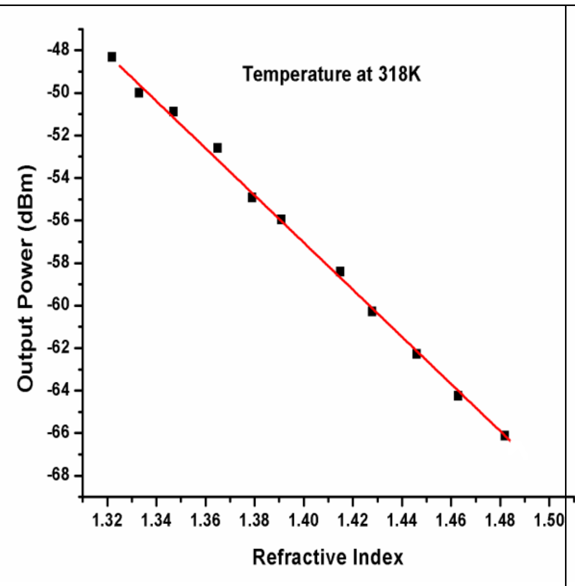

Fig.6: Relation between Refractive index and Output power (dBm) of Methanol + Benzene mixtures at the temperature of 318°K

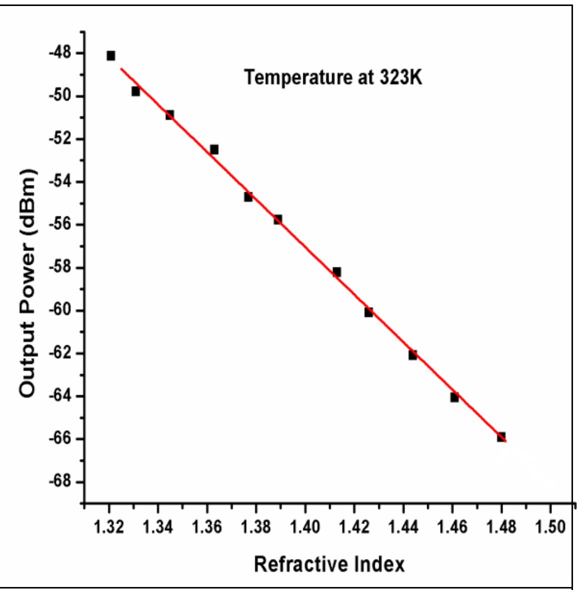

Fig.7: Relation between Refractive index and Output power (dBm) of Methanol + Benzene mixtures at the temperature of 323°K

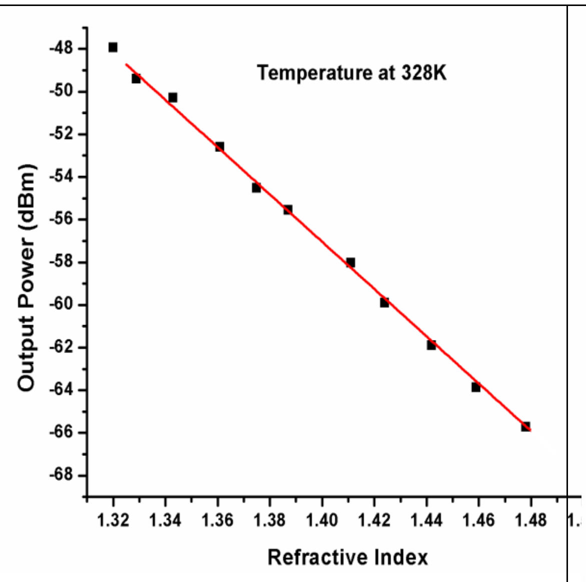

Fig.8: Relation between Refractive index and Output power (dBm) of Methanol + Benzene mixtures at the temperature of 328°K

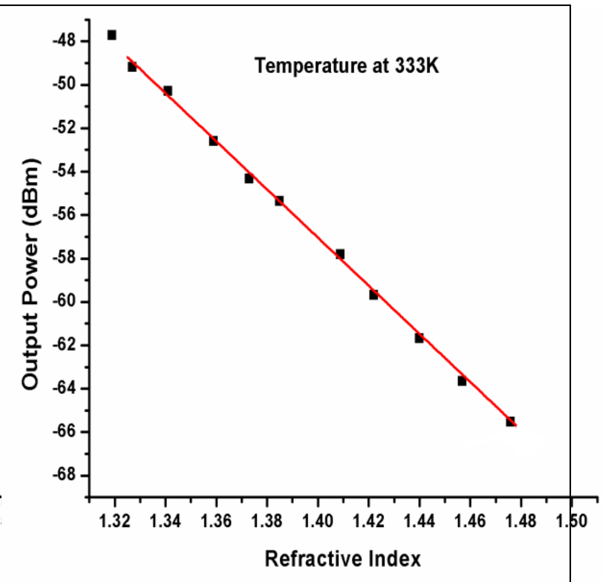

Fig.9: Relation between Refractive index and Output power (dBm) of Methanol + Benzene mixtures at the temperature of 333°K

Finally the change in the refractive index and output powers with respect to the different temperatures for different ratios of binary mixtures (methanol mixed in benzene) are shown Fig.[10–11]. As expected, the refractive index values are linearly changing with variation of the temperature which is in good agreement with the theoretical predictions.

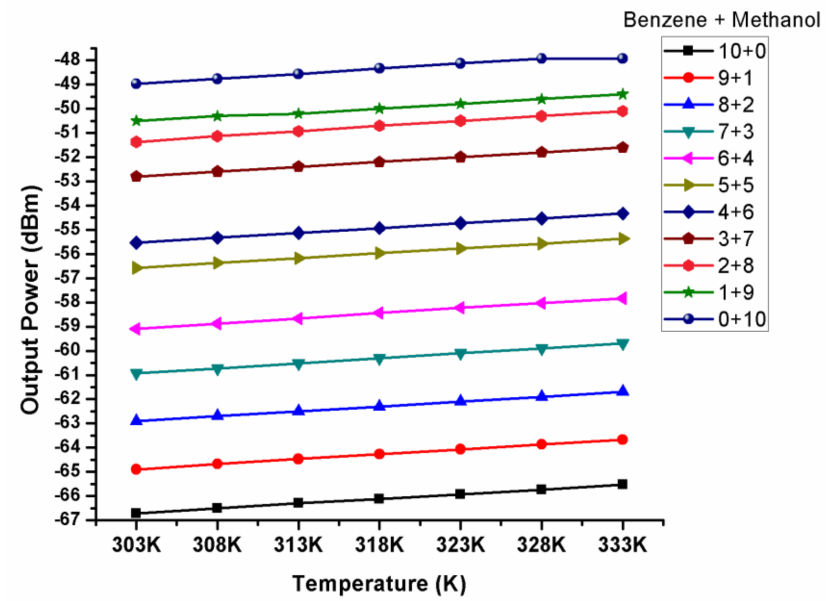

Fig.10: Relation between Output power (dBm) and Temperature (303°K, 308°K, 313°K, 318°K, 323°K, 328°K & 333°K) of Methanol + Benzene mixtures

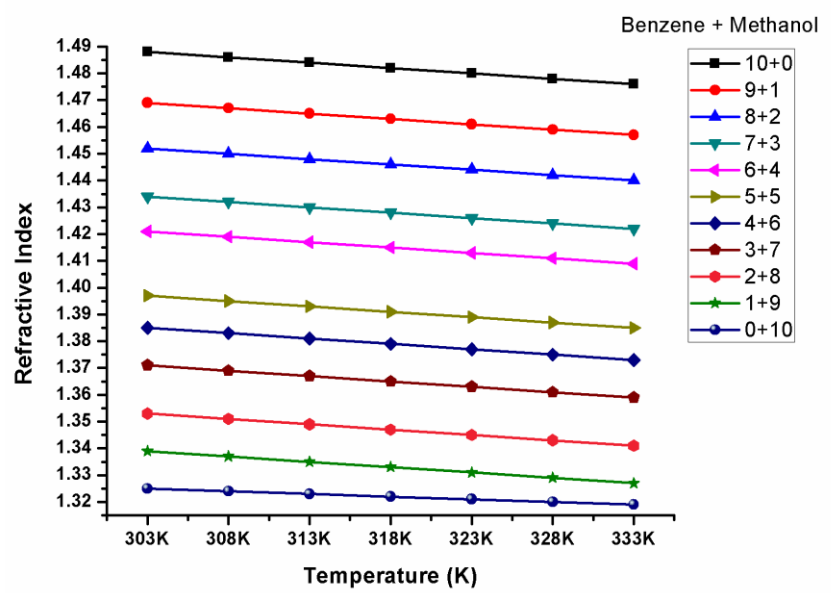

Fig.11: Relation between Refractive Index and Temperature (303°K, 308°K, 313°K, 318°K, 323°K, 328°K & 333°K) of Methanol + Benzene mixtures

IV. Conclusion

A simple optical fiber sensor has been designed and developed for measuring the variation of refractive index at several temperatures ranging from 303K to 333K. The advantage of the sensor reported here are high sensitivity, easy to fabrication, compact in size, robust and rugged, etc.. Therefore this sensor can be applied to many fields including food, chemical, bio-chemical, fragrance analysis, environmental monitoring and also in pharmaceuticals, etc.

References

[1] G. Brambilla, V. Finazzi, and D. J. Richardson, Ultra-low-loss optical fiber nanotapers, Opt. Express, Vol.12, No. 10, pp. 2258–2263, 2004.

[2] Min Li and Yulin Li, Fiber-optic temperature sensor based on interaction of temperature-dependent refractive index and absorption of germanium film, Appl. Opt., Vol. 50, pp. 231–236, 2011.

[3] L. M. R. R. Tong, J. B. Gattass, S. L. Ashcom, J. Y. He, M. Y. Lou, I. Shen, Maxwell, and E. Mazur, Subwavelength – diameter silica wires for low-loss optical wave guiding, Nature, vol. 426, No. 6968, pp. 816–819, 2003.

[4] S. G. Leon-Saval, T. A. Birks, W. J. Wadsworth, P. S. J. Russell, and M. W. Mason, Supercontinum generation in submicron fibre waveguides, Opt. Express, Vol. 12, No. 13, pp. 2864-2869, 2004.

[5] Lars Hoffmann, Mathias, S. Muller, Sebastian Kramer, Matthias Giebel, Gunther Schwotzer and Torsten Wieduwilt, Applications of fibre optic temperature Measurement, Proc. Estonian Acad. Sci. Eng., Vol. 13, No. 4, pp. 363–378, 2007.

[6] Yonghao Xu, Xianfeng Chen and YuZhu, High Sensitive Temperature Sensor Using a Liquid-core Optical, Sensors, Vol. 8, pp. 1872–1878, 2008.

[7] S. Yalthayar. Aydin Experimental Investigation of Temperature Effect on the Refractive Index of Dye Laser Liquids Turkish, J. Phys., Vol. 26, pp. 41-47, 2002.

[8] Arunava Mukherjee, Debanjan Munsi, Vishal Saxena, Ramaswarup Rajput, Paramhans Tewari, Vandana Singh, Anjan Kumar Ghosh, Joseph John, Harshwardhan Wanare and Pinaki Gupta-Bhaya, Characterization of a fiber optic liquid refractive index sensor, Sensors and Actuators, Chemical Volume, Vol. 145, No. 1, pp. 265–271, 2010.

[9] M. Li, Y. Li., Fiber-optic temperature sensor based on interaction of temperature-dependent refractive index and absorption of germanium film, Appl. Opt., Vol. 50, No. 2, pp. 231–236.

[10] 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.