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FINAL REPORT
of
MAJOR RESEARCH PROJECT

UNIVERSITY GRANTS COMMISSION, NEW DELHI

[F.N. 41-929/2012 (SR) dated 23 -07-2012]

Tenure of the Project : 03 1/2 Years
From 01-07-2012 to 31-12-2015

for

Subject of Physics Entitled

"Study of Dielectric properties of binary mixtures of Nitriles and Alcohols through concentration dependent dielectric analysis"

SUBMITTED BY:

Dr. Prajapati Ashvin Narottamdas

Principal Investigator

Assistant Professor

Department of Applied Physics,

Faculty of Technology and Engineering,

Maharaja Sayajirao University of Baroda

Vadodara-390 001, Gujarat, India

THE MAHARAJA SAYAJIRAO UNIVERSITY OF BARODA

सत्यं शिवं सुन्दरम्

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SUMMARY OF FINAL REPORT
of
Major Research Project of UGC, New Delhi
[F.N. 41-929/2012 (SR) dated 23 -07-2012]
In Physics entitled
"Study of Dielectric properties of binary mixtures of Nitriles and Alcohols through concentration dependent dielectric analysis"

In the proposed project concentration, dependent dielectric properties of mixtures of primary alcohol with some nitrile examined. Complex permittivity of these systems (mixtures) will be measured at different temperatures for different concentrations in the frequency domain. The observed complex permittivity will be used to evaluate different dielectric parameters, thermodynamical parameters, correlation parameters and excess parameters are determined. Variation of these parameters against mole/volume fractions of participating molecules discussed in light of molecular interactions. Apart from the dielectric measurements other physical parameters like density, viscosity and ultrasonic velocity of the liquid samples will also be measured to support the inference drawn from the dielectric studies. When binary mixtures are prepared the molecular environment changes, these results into change in physical and chemical properties.

In the proposed project, dielectric properties of binary mixtures ($0.0 \leq X \leq 1.0$) of (1-Propanol + Benzonitrile, 1-Propanol + Fluorobenzene, 1-Butanol + Benzonitrile, 1-Butanol + Fluorobenzene, 1-Hexanol + Benzonitrile, 1-Propanol + Valeronitrile, 1-Butanol + Valeronitrile, 1-Octanol + Valeronitrile, Methanol + Acetophenone, 1-Propanol + N, N- Dimethylformamide, 1-Propanol + Acetophenone, 1-Hexanol + Acetophenone) were studied at different temperatures. Complex permittivity spectra for 1-Propanol, 1-Butanol with Benzonitrile/Fluorobenzene systems were obtained in the frequency range (0.3 MHz to 3.0 GHz and 9.1 GHz). Static dielectric constant (ε_0) of binary liquid mixtures were measured using precision LCR meter (20 Hz to 200 KHz). The liquid dielectric cell (cylindrical type) for the measurement of static dielectric constant (ε_0) was fabricated and tested. Refractive index (n) of liquid mixtures were measured abbe's refractometer. Kirkwood parameters (g^{eff} and g_F), Bruggemann parameter (f_B) and its numerical fitting parameter (a). In liquid binary mixtures, there is a wide range of possible interactions between the constituents such as hydrogen bonding, molecular associations, dipole–dipole, and dipole-induced dipole interactions.

As a consequence of these interactions, deviations occur from ideal behaviour of static dielectric constant (ε_0), relaxation time (τ_0), refractive index (n) with concentration variation of the mixture constituents. Several excess parameters were determined, excess static dielectric constant $(\varepsilon_0)^E$ provide valuable information regarding interaction between the solute–solvent (polar–polar) liquid mixtures. In the studied binary mixtures excess static dielectric constant $(\varepsilon_0)^E$ show negative deviation from their ideal behaviour which indicate that both molecular species interact so as to reduce the total effective dipoles due to orientation of some of the neighbouring dipoles in opposite direction in these systems. These suggest that the molecular species may form multimers leading to less effective dipoles. The different strength of H-bond interactions and net dipolar alignments is responsible for the divergent magnitude of $(\varepsilon_0)^E$ values in these mixtures. The magnitudes of $(\varepsilon_0)^E$ values can be ordered depending on the carbon chain length of the alcohols.

Kirkwood correlation parameters of polar-polar liquid mixtures provides valuable information about the solute-solvent interactions, i.e. about the ordering of the molecules in the liquid phase. The Values of g^{eff} describes the orientation of electric dipoles in the mixture. $g^{eff} > 1$ indicates the parallel orientation of the dipoles in the liquid. $g^{eff} < 1$ describes the antiparallel orientation of the dipoles. It is observed that the value of g^{eff} is concentration dependent. For the mixtures of alcohols (Methanol, 1-Propanol, 1-Butanol, 1-Hexanol, 1-Octanol) with niltile (Benzonitrile, Valeronitrile, Acetonitrile) derivatives the values of g^{eff} decreases as the concentration of alcohol decreases in the mixture. Similar trend is also obtained for the system Acetophenone and N, N Dimethylformamide also. This trend suggests reorientation of neighbourhood molecules of the constituent polar liquids forming a tendency towards antiparallel alignment of dipoles. This conclusion is similar to that arrived from the variation of dielectric parameters with concentration. The static dielectric data fitted with the modified Bruggeman model to understand the dipole interaction of the two constituent polar liquids of the binary mixture. The values of '*a*' are determined by the least squares fit method. This fitting parameter '*a*' signifies change in volume, that is, the change in the orientation of the constituent molecules and thus measures the extent of the dipole interaction of the constituent polar liquids of the binary mixture in terms of size of molecules and their occupation of volume. Deviation from unity in the value of '*a*' indicates the molecular interaction between the constituent polar molecules. The '*a*' values show systematic change with respect to different binary mixture systems. The thermodynamical quantities viz., free energy of activation, enthalpy and entropy of activation will

be obtained by determining the relaxation time at different temperatures using Eyring's rate equation. Relaxation time (τ_0) for binary liquid mixtures will be determined by Cole-Cole method.

The outcome of the research work presented at various state/national/International level conferences/symposia/seminars etc. Part of the work were published in journal and communicated for publications.

Acknowledgement

Principal Investigator of the Major Research Project is thankful to the University Grants Commission, New Delhi, for the award of project and financial assistance to pursue the research work on "Study of Dielectric properties of binary mixtures of Nitriles and Alcohols through concentration dependent dielectric analysis". Principal Investigator also conveys his sincere thanks to the authorities of the M S University of Baroda for providing basic infrastructure facilities in the department throughout the tenure of the project. Principal Investigator is also indebted to the services of project fellow, Shri Chaitanya L Limberkar, for his sincere support in carrying out the project work. Principal Investigator thanks to the collaborators: Prof. V. A. Rana (Department of Physics, Gujarat University, Ahmedabad), Prof. S. P. Bhatanagar (Head, Department of Physics, M. K. University, Bhavnagar) for their kind support.

Principal Investigator
UGC Major Research Project
Department of Applied Physics
Faculty of Technology & Engineering
The M. S. University of Baroda

Annexure - III

UNIVERSITY GRANTS COMMISSION
BAHADUR SHAH ZAFAR MARG
NEW DELHI – 110 002

STATEMENT OF EXPENDITURE IN RESPECT OF MAJOR RESEARCH PROJECT

1. Name of Principal Investigator: Dr. Prajapati Ashvin Narottamdas

2. Dept. of Principal Investigator: Department of Applied Physics

University/College: The M.S. University of Baroda, Vadodara.

3. UGC approval Letter No. and Date: F. No. 41-929/2012 (SR) dated 23 -07-2012

4. Title of the Research Project: **Study of Dielectric properties of binary mixtures of Nitriles and Alcohols through concentration dependent dielectric analysis**

5. Effective date of starting the project: 01-07-2012 (as mentioned in UGC letter)

6. a. Period of Expenditure: From 01-07-2012 to 31-12-2015

b. Details of Expenditure

S. NO.	Item	Amount Approved (Rs.)	Expenditure Incurred (Rs)
i.	Books & Journals	Nil	Nil
ii.	Equipment	3,00,000/-	294432.50/-
iii.	Contingency	30,000/-	24308.75/-
iv.	Field work/Travel (Give details in the proforma at Annexure iv)	15,000/-	8163/-
v.	Hiring Services	Nil	Nil
vi.	Chemicals & Glassware	45,000/-	39,991/-
vii.	Overhead	60,300/-	60,240/-
viii.	Any other item (Please Specify)	Nil	Nil

c. Staff.

Date of appointment: 01-11-2012

S.No.	Items	From	To	Amount Approved (Rs.)	Expenditure Incurred (Rs)
1.	Honorarium to PI (Retired Teachers) @ 18,000/-p.m	------	-------	Nil	Nil
2.	**Project Fellow:**				
	(i) NET/GATE qualified-Rs. 16,000/- p.m. for intial 2 years and Rs. 18,000/-p.m. for third year.	------	------	Nil	Nil
	(ii) Non-GATE/Non-NET-Rs. 14,000/- p.m. for intial 2 years and Rs. 16,000/-p.m. for third year.	01-11-12	31-03-15	4,64,000/-	4,16,000/-

1. It is certified that the appointment(s) have been made in accordance with the terms and conditions laid down by the Commission.

2. If as a result of check or audit objection some irregularly is noticed at later date, action will be taken to refund, adjust or regularize the objected amounts.

3. Payment @ revised rates shall be made with arrears on the availability of additional funds.

4. It is certified that the Total grant of **Rs. 8,58,900** (Rupees Eight Lacs Fifty-Eight Thousand Nine hundred only) received from the University Grants Commission under the scheme of support for Major Research Project entitled "**Study of Dielectric properties of binary mixtures of Nitriles and Alcohols through concentration dependent dielectric analysis**" vide UGC letter No. F. 41-929/2012 (SR) dated **23-07-2012 (as 1st Installment) & 23-06-2015 (2nd Installment)** has been received and the amount of **Rs. 8,43,135.25/-** (Rupees Eight Lacs Forty-Three Thousand One Hundred Thirty-Five and Twenty-Five Paisa only) has been utilized for the purpose for which it was sanctioned and in accordance with the terms and conditions laid down by the University Grants Commission.

PRINCIPAL INVESTIGATOR

Principal Investigator
UGC Major Research Project
Department of Applied Physics
Faculty of Technology & Engineering
The M. S. University of Baroda

HEAD OF DEPTT.

Applied Physics Department
Faculty of Technology & Engineering
The M. S. University of Baroda
Vadodara-390001, Gujarat, INDIA.

DEAN

Dean
Faculty of Tech. & Engg.
The M. S. University of Baroda.
Vadodara.

AUDITOR

FOR SANJAY C. SHAH & CO.
CHARTERED ACCOUNTANTS
SANJAY SHAH
(PARTNER)
MEM. NO.: 042331

CHIEF ACCOUNT OFFICER

Chief Accounts Officer
The M.S. University of Baroda

REGISTRAR

8/7/17
(Signature with seal)
Registrar (Officer On Special Duty)
The Maharaja Sayajirao University of Baroda
Fatehgunj ,
Vadodara - 390002

Annexure - IV

UNIVERSITY GRANTS COMMISSION
BAHADUR SHAH ZAFAR MARG
NEW DELHI – 110 002

STATEMENT OF EXPENDITURE INCURRED ON FIELD WORK

Name of the Principal Investigator: Dr. Ashvin Narottamdas Prajapati

Name of the Place visited	Duration of the Visit		Mode of Journey	Expenditure Incurred (Rs)
	From	To		
Applied Physics Dept., MSU Prof. S. P. Bhatanagar, M. K. Uni., Bhavnagar	16-10-12	16-10-12	Bus	784/-
Department of Physics, Gujarat uni, Ahmedabad	22-05-13	23-05-13	Bus	1996/-
Department of Physics, Gujarat uni, Ahmedabad	27-12-13	27-12-13	Bus	226/-
UGC, New Delhi	07-02-14	09-02-14	Train	5157/-
			Total	**8163/-**

Certified that the above expenditure is in accordance with the UGC norms for Major Research Projects.

PRINCIPAL INVESTIGATOR
Principal Investigator
UGC Major Research Project
Department of Applied Physics
Faculty of Technology & Engineering
The M. S. University of Baroda

HEAD OF DEPTT.
Head
Applied Physics Department
Faculty of Technology & Engineering
The M. S. University of Baroda
Vadodara-390001, Gujarat, INDIA.

DEAN
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Vadodara.

AUDITOR

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MEM. NO.: 042331

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REGISTRAR
8/7/17
(Signature with seal)
Registrar (Officer On Special Duty)
The Maharaja Sayajirao University of Baroda
Fatehgunj ,
Vadodara - 390002

Annexure - V

UNIVERSITY GRANTS COMMISSION
BAHADUR SHAH ZAFAR MARG
NEW DELHI – 110 002

UTILIZATION CERTIFICATE

Certified that the total grant of ₹ **8,58,900** (**Rupees Eight Lacs Fifty Eight Thousand Nine Hundred only**) from the University Grants Commission under the scheme of support for Major Research Project entitled **Study of Dielectric properties of binary mixtures of Nitriles and Alcohols through concentration dependent dielectric analysis** vide UGC letter No. F. No. 41-929/2012 (SR) dated 23 -07-2012, has been received and the amount of ₹ **8,43,135.25** (**Rupees Eight Lacs Forty Three thousand One Hundred Thirty Five and Twenty Five Paisa only**) has been utilized for the purpose for which it was sanctioned and in accordance with the terms and conditions laid down by the University Grants Commission. The balance amount of ₹ **15,764.75** (**Rupees Fifteen Thousand Seven Hundred Sixty-Four and Seventy-Five Paisa only**) has been refunded vide demand draft no: _____ dated _____ to "The Secretary, University Grants Commission, New Delhi".

PRINCIPAL INVESTIGATOR

Principal Investigator
UGC Major Research Project
Department of Applied Physics
Faculty of Technology & Engineering
The M. S. University of Baroda

HEAD OF DEPTT.

Head
Applied Physics Department
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Vadodara.

AUDITOR

FOR SANJAY C. SHAH & CO.
CHARTERED ACCOUNTANTS

SANJAY C. SHAH & CO. VADODARA

SANJAY SHAH
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MEM. NO.: 042331

CHIEF ACCOUNT OFFICER

Chief Accounts Officer
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REGISTRAR

8/7/17

(Signature with seal)

Registrar(Officer On Special Duty)
The Maharaja Sayajirao University of Baroda
Fatehgunj ,
Vadodara - 390002

Annexure – IX

UNIVERSITY GRANTS COMMISSION
BAHADUR SHAH ZAFAR MARG
NEW DELHI – 110 002

PROFORMA FOR SUBMISSION OF INFORMATION AT THE TIME OF SENDING THE FINAL REPORT OF THE WORK DONE ON THE PROJECT

1. Title of the Project **Study of Dielectric properties of binary mixtures of Nitriles and Alcohols through concentration dependent dielectric analysis**.
2. NAME AND ADDRESS OF THE PRINCIPAL INVESTIGATOR
   Dr. Ashvin N. Prajapati, A-23 Amardeep Greens, Ajwa Road, Vadodara.
3. NAME AND ADDRESS OF THE INSTITUTION
   Applied Physics Department, Faculty of Technology & Engineering,
   The M. S. University of Baroda, Vadodara.
4. UGC APPROVAL LETTER NO. AND DATE: 41-929/2012 (SR) dated 23 -07-2012
5. DATE OF IMPLEMENTATION: 01-07-2012
6. TENURE OF THE PROJECT:
   FROM 01-07-2012 TO 30-06-2015, EXTENDED UPTO 31-12-15
7. TOTAL GRANT ALLOCATED: ₹ 9,14,300 .
8. TOTAL GRANT RECEIVED: ₹ 8,58,900
   ₹ 6,69,300 (1st installment) + ₹ 1,89,600 (2nd installment) = ₹ 8,58,900
9. FINAL EXPENDITURE: ₹ 8,43,135.25
10. TITLE OF THE PROJECT: "STUDY OF DIELECTRIC PROPERTIES OF BINARY MIXTURES OF NITRILES AND ALCOHOLS THROUGH CONCENTRATION DEPENDENT DIELECTRIC ANALYSIS**"**
11. OBJECTIVES OF THE PROJECT:

In the proposed project concentration dependent dielectric properties of mixtures of primary alcohol with some nitrile examined. Complex permittivity of these systems (mixtures) will be measured at different temperatures for different concentrations in the frequency domain. The observed complex permittivity will be used to evaluate different dielectric parameters, thermodynamical parameters, correlation parameters and excess parameters are determined.

Variation of these parameters against mole/volume fractions of participating molecules discussed in light of molecular interactions.

Apart from the dielectric measurements other physical parameters like density, viscosity and ultrasonic velocity of the liquid samples will also be measured to support the inference drawn from the dielectric studies.

12. WHETHER OBJECTIVES WERE ACHIEVED: YES
    (GIVE DETAILS)

In the proposed project, dielectric properties of binary mixtures of varying concentrations ($0.0 \leq X \leq 1.0$) of 1-Propanol, 1-Butanol, 1-Hexanol, 1-Octanol with Benzonitrile and Valeronitrile are studied at different temperatures. Complex permittivity spectra for 1-Propanol, 1-Butanol with Benzonitrile systems were obtained in the frequency range (0.3 MHz to 3.0 GHz and 9.1 GHz). Static dielectric constant (ε_0) and refractive index (n) were measured using precision LCR meter (20 Hz to 200 KHz) and abbe's refractometer respectively. Kirkwood parameters (g^{eff} and g_F), modified Bruggemann parameter (f_B), Thermodynamic energy parameters and excess parameters are evaluated from the measured values of Static dielectric constant (ε_0) and refractive index (n). From the variations of these parameters against mole/volume fraction of one component, hetero molecular interactions between participating molecules are predicted.

Furthermore, we also studied some other binary mixture systems Methanol, 1-Propanol, 1-Hexanol with Acetophenone, N-N Dimethylformamide and Fluorobenzene. For all these systems molecular interaction and validation of various mixing rules have been tested for static dielectric constant (ε_0), refractive index (n) and ultrasonic speed (u).

13. ACHIEVEMENTS FROM THE PROJECT

In the proposed project dielectric properties of binary mixtures of varying concentrations ($0.0 \leq X \leq 1.0$) of normal alcohols with nitriles are studied at different temperatures. Complex permittivity spectra for 1-Propanol, 1-Butanol with Benzonitrile systems were obtained in the radio and lower microwave frequency range (0.3 MHz to 3.0 GHz and 9.1 GHz). For all studied systems single Debye type dispersion observed. Static dielectric constant (ε_0) and refractive index (n) were determined using precision LCR meter and abbe's refractometer respectively. The liquid dielectric cell (cylindrical type) for the static dielectric constant measurements was fabricated and tested. The non rectilinear behaviour of Static dielectric constant (ε_0) and refractive index (n) against mole/volume fraction of alcohols suggests heteromolecular interaction between the participating molecular species.

From the measured values of Static dielectric constant (ε_0), optical dielectric constant ($\varepsilon_\infty = n^2$) for all binary liquid mixtures effective Kirkwood correlation parameter (g^{eff}) and corrective Kirkwood correlation parameter (g_F) are evaluated. The excess of static dielectric constant for binary are determined and fitted with R. K. polynomials. Variation of $(\varepsilon_0)^E$, (g^{eff}) and (g_F) against volume/mole fraction indicates heteromolecular interaction between the molecular species in the binary mixtures, which may produce structural change in the system. All the studied binary systems show deviation in Bruggeman parameter (f_B) from linearity indicating deviation in the static dielectric constant (ε_0) value at different concentrations from normal mixture values resulting molecular interaction between dissimilar molecular species.

The results obtained from the present investigation indicate that the molecules of studied binary mixtures may be joined, by a network of interactions such as dipolar and hydrogen bonds, to form stable intermolecular complexes between the molecular species.

14. SUMMARY OF THE FINDINGS (IN 500 WORDS)

When binary mixtures are prepared the molecular dynamics (environment) changes these result into change in physical and chemical properties. In the proposed project dielectric properties of binary mixtures ($0.0 \leq X \leq 1.0$) of (1-Propanol + Benzonitrile, 1-Butanol + Benzonitrile, 1-Hexanol + Benzonitrile, 1-Propanol + Valeronitrile, 1-Butanol + Valeronitrile, 1-Octanol + Valeronitrile, Methanol + Acetonitrile) are studied at different temperatures. Complex permittivity spectra for 1-Propanol, 1-Butanol with Benzonitrile systems were obtained in the frequency range (0.3 MHz to 3.0 GHz and 9.1 GHz). Static dielectric constant (ε_0) and refractive index (n) were measured using precision LCR meter (20 Hz to 200 KHz) and abbe's refractometer for these binary systems at different temperature. Kirkwood parameters (g^{eff} and g_F), Bruggemann parameter (f_B) and its fitting parameter (a), excess parameters are determined. In liquid binary mixtures there is a wide range of possible interactions between the constituents such as hydrogen bonding, molecular associations, dipole–dipole, and dipole-induced dipole interactions.

As a consequence of these interactions, deviations occur from ideal behaviour of dielectric constant with concentration variation of the mixture constituents. Several excess parameters were determined, excess static dielectric constant $(\varepsilon_0)^E$ provide valuable information regarding interaction between the solute–solvent (polar–polar) liquid mixtures. In the studied binary mixtures (1-Propanol + Benzonitrile, 1-Butanol + Benzonitrile, 1-Hexanol + Benzonitrile, 1-Propanol + Valeronitrile, 1-Butanol + Valeronitrile, 1-Octanol + Valeronitrile, Methanol + Acetonitrile) excess static dielectric constant $(\varepsilon_0)^E$ show negative deviation from their ideal behaviour which indicate that both molecular species interact so as to reduce the total effective dipoles due to orientation of some of the neighbouring dipoles in opposite direction in these systems. These suggest that the molecular species may form multimers leading to less effective dipoles. The different strength of H-bond interactions and net dipolar alignments is responsible for the divergent magnitude of $(\varepsilon_0)^E$ values in these mixtures. The magnitudes of $(\varepsilon_0)^E$ values can be ordered depending on the carbon chain length of the other ingredient i.e. alcohol.

Kirkwood correlation parameters of polar-polar liquid mixtures provides valuable information about the solute-solvent interactions, i.e. about the ordering of the molecules in the liquid phase. The Values of g^{eff} describes the orientation of electric dipoles in the mixture. $g^{eff} > 1$ indicates the parallel orientation of the dipoles in the liquid. $g^{eff} < 1$ describes the antiparallel orientation of the dipoles. It is observed that the value of g^{eff} is concentration dependent. For the mixtures of alcohols with niltile derivatives the values of g^{eff} decreases as the concentration of alcohol decreases in the mixture. This trend suggests reorientation of neighbourhood molecules of the constituent polar liquids forming a tendency towards antiparallel alignment of dipoles. This conclusion is similar to that arrived from the variation of dielectric parameters with concentration. The static dielectric data will be fitted with the modified Bruggeman model to understand the dipole interaction of the two constituent polar liquids of the binary mixture. The values of '*a*' are determined by the least squares fit method. This fitting parameter '*a*' signifies change in volume, that is, the change in the orientation of the constituent molecules and thus measures the extent of the dipole interaction of the

constituent polar liquids of the binary mixture in terms of size of molecules and their occupation of volume. Deviation from unity in the value of '*a*' indicates the molecular interaction between the constituent polar molecules. The '*a*' values show systematic change with respect to different binary mixture systems. The thermodynamical quantities viz., free energy of activation, enthalpy and entropy of activation will be obtained by determining the relaxation time at different temperatures using Eyring's rate equation. Relaxation time (τ_0) for binary liquid mixtures will be determined by Cole-Cole method.

The outcome of the research work presented at various state/national/International level conferences/symposia/seminars etc. Part of the work were published in journal and communicated for publications.

15. CONTRIBUTION TO THE SOCIETY .....

In the present work dielectric properties of binary mixtures of nitriles and alcohols through concentration dependent dielectric analysis, we carried out systematic measurements (ε', ε'', ε_0, ε_∞) of various binary mixture systems. A project fellow, Shri. Limberkar Chaitanya Sushil appointed under this research project and has been trained during the project work. During the tenure of the project ten (10) student have been completed their M. Sc. Dissertation. Funds utilised to set up dielectric lab at the Applied Physics Department.

16. WHETHER ANY PH.D. ENROLLED/PRODUCED OUT OF THE PROJECT ..Nil.....

17. NO. OF PUBLICATIONS OUT OF THE PROJECT (List is enclosed)

Journal : 7 Conference : 11

(PRINCIPAL INVESTIGATOR)
Dr. A. N. Prajapati

HEAD
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DEAN

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M. S. University of Baroda,
Baroda.

(REGISTRAR/PRINCIPAL)

(Seal)

8/12/17
Registrar(Officer On Special Duty)
The Maharaja Sayajirao University of Baroda
Fatehgunj ,
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List of Publications.

Journal Paper:

[1] Study of concentration dependent Physico-chemical properties of 1–Propanol, Benzonitrile and their binary mixtures, International Journal of advancement in electronics and computer engineering (IJAECE), Volume 3 (1) 2014, pp.297-301.

A. N. Prajapati, C. S. Limberkar

[2] Dielectric studies of binary mixtures of 1-Propanol and Fluorobenzene, Solid State Phenomena, Vol. 209 (2013) pp 203-206.

Ashvin N. Prajapati, Vipinchandra A. Rana, A. D. Vyas, S. P. Bhatanagar, D. H. Gadani

[3] Study of Physical Properties of Binary Mixtures (N, N- DIMETHYLFORMAMIDE with 1-PROPANOL) at Atmospheric Pressure, International Journal of Science and Research (IJSR) (2015) pp. 10-13.

A. N. Prajapati

[4] Ultrasonic, Optical and Volumetric Studies of Binary Mixtures of 1-Propanol With Benzonitrile, International Journal of Science and Research (IJSR) (2015) pp. 388-390.

A. N. Prajapati, C. S. Limberkar

[5] Study of Molecular Interaction in Binary Mixtures (1-Propanol + Acetophenone) Advanced Materials Research, Vol. 1141 (2016) pp 125-130.

A. N. Prajapati

[6] Prediction of Static Dielectric Constant (ε_0) and Refractive Index (n) Using Various Models for Binary Mixtures (Acetophenone with n-Hexanol) Advanced Materials Research, Vol. 1141 (2016) pp 131-135.

A. N. Prajapati

[7] Acoustic and refractometric study of binary mixtures of 1-Propanol + Benzonitrile at 313 K, Indian Journal of pure and applied Physics. Indian Journal of Pure and Applied Physics, Vol. 55 (2017) pp 297-303.

A. N. Prajapati

Conference Proceedings & Presentations

[1] **Measurements of refractive index and density for binary mixtures {(x) l-Propanol + (1-x) (Fluorobenzene or Benzonitrile)}**, One Day Seminar on Current Trends in Research and Applications of Physical Sciences in Gujarat (CTRAPSG-12), 29, December 2012 at Department of Physics, S. P. University, V. V. Nagar (Gujarat).

[2] **Dielectric Studies of Polar Liquids and their mixture at microwave and lower microwave frequencies**, National Symposium on High Power RF & Microwave (HPRFM-2013), 4-6, September 2013 at Institute for Plasma Research, Bhat, G'Nagar, (Gujarat).

[3] **Study of hetero-molecular interaction in binary mixtures of Benzonitrile with n-Hexanol**, UGC Sponsored National Conference on Microwave Techniques and Applications (NCMTA-2013), 29-30, November 2013 at Department of Physics and Electronics, Maulana Azad college of Arts, Commerce & Science, Aurangabad, (Maharastra).

[4] **Microwave dielectric relaxation and dispersion studies of 1-Butanol, Fluorobenzene and their mixtures**, 9th International Conference on Microwaves, Antenna, Propagation and Remote Sensing ICMARS-2013, 11-14, December 2013 at International Centre for Radio Science, Jodhpur (Rajasthan).

[5] **Microwave Dielectric Characterization of binary mixtures (1-Propanol with Fluorobenzene)**, National Conference on Recent Advances in Materials Science and Technology, 22-23, December 2014 at Sh. M. L. V. Govt. College, Bhilwara (Rajasthan).

[6] **Secondary Dielectric dispersion binary liquid mixtures from VNA data**, 9th National Level Science Symposium, February 14, 2016, at Crist College, Rajkot (Gujarat).

[7] **Bruggeman factor - a probe to investigate molecular interaction and volume change in binary mixtures**, 9th National Level Science Symposium, February 14, 2016, at Crist College, Rajkot (Gujarat).

[8] **Estimation of static dielectric constant and refractive index using various models for binary data**, Recent Scenario in Science & Technology (RSST-2016), February 27. 2016 at Faculty of Tech. & Engg., The M. S. University of Baroda, Vadodara (Gujarat).

[9] **Study of hetero molecular interactions in binary Liquid mixtures**, Recent Scenario in Science & Technology (RSST-2016), February 27. 2016 at Faculty of Tech. & Engg., The M. S. University of Baroda, Vadodara (Gujarat).

[10] **Study of molecular interactions in binary liquid mixtures using dielectric data**, National conference on material characterization (NCMC-16), 18-19, March, 2016 at Department of Physics, The M. S. University of Baroda, Vadodara (Gujarat).

[11] **Bruggeman factor – an indicator of hetero-molecular interaction and volume change in binary mixtures**, National conference on material characterization (NCMC-16), 18-19, March, 2016 at Department of Physics, The M. S. University of Baroda, Vadodara (Gujarat).