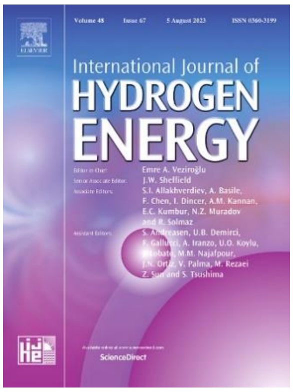
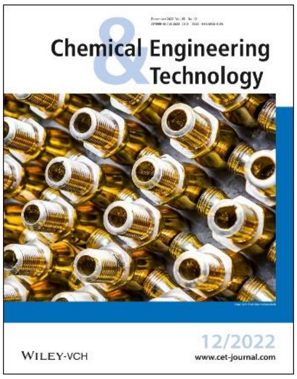
List of Publications

1.		Title: **Synthesis and characteristics of HAB-6FDA thermally rearranged polyimide nanocomposite membranes** **Harsh D. Patel,** Naveen K Acharya **Polymer Engineering and Science (I.F- 3.2),** Vol. 61, P.P 2782-91 **Available Online:** 20 August 2021 **DOI:** 10.1002/pen.25788
2.		Title: **Transport properties of polymer blends and composite membranes for selective permeation of hydrogen** **Harsh D. Patel,** Naveen K Acharya **International Journal of Hydrogen Energy (I.F- 7.2),** Vol. 48, Issue 96, P.P 37796-37810 **Available Online:** 12 December 2023 **DOI:** https://doi.org/10.1016/j.ijhydene.2022.11.304
3.		Title: **Transport, Spectroscopic, and Electrical Properties of Thermally Rearranged Nanocomposite Membranes** **Harsh D. Patel,** Naveen K Acharya **Chemical Engineering & Technology (I.F- 2.1),** Vol. 45, Issue 12, P.P 2223-2233 **Available Online:** 05, October 2022 **DOI:** 10.1002/ceat.202200281
4.	isbn **978-8196-2938-3-3** **RRRNA**	Title: **Absorption Coefficient of OHP Sheet by Using Mobile Sensor** **Harsh D. Patel,** Naveen K Acharya **International Conference Processing,** Vol. III, P.P 65-71 **Available:** 13, April 2023
5.	isbn **978-8196-2938-3-3** **RRRNA**	Title: **Experimental verification of Diffraction at Single Slit Using Advance Technique** **Harsh D. Patel,** Naveen K Acharya **International Conference Processing,** Vol. III, P.P 218-27 **Available:** 13, April 2023

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RESEARCH ARTICLE

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Synthesis and characteristics of HAB-6FDA thermally rearranged polyimide nanocomposite membranes

Harsh D. Patel | **Naveen K. Acharya**

Department of Applied Physics, Faculty of Technology and Engineering, The M.S. University of Baroda, Vadodara, India

Correspondence
Naveen K. Acharya, Department of Applied Physics, Faculty of Technology and Engineering, The M.S. University of Baroda, Vadodara 390 001, India.
Email: sarnavee@gmail.com

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Abstract

The thermal rearrangement of polyimides of ortho-positioned functional group membranes improves the gas permselectivity properties of the polyimide precursor. For this experiment, HAB-6FDA polyimide was synthesized from 3,3 dihydroxy-4,4-diamino-biphenyl (HAB) and 2,2-bis-(3,4-dicarboxyphenyl) hexafluoropropane dianhydride (6FDA) by chemical imidization. A sample was modified from a pure polymer to silica nanoparticle composition. Furthermore, a modification was carried out by thermal rearrangement reaction at temperatures of 350, 400, and 450°C. The thermal property of these membrane films was characterized by differential scanning calorimetry (DSC), FTIR, opacity experiment, and free volume analysis. Permeability decreases with an increase in the kinetic diameter of gasses, which is normal behavior for glassy polymers. The composition of silica nanoparticles slightly changes the permeability in the polyimide. The combined effect of silica nanoparticles and thermal rearrangement of the HAB-6FDA membrane has shown an excellent performance. The thermal rearrangement with nanocomposite shows a significant impact on a larger effect on permeation for lighter gases, that is, H_2, CO_2, and O_2, compared with N_2 and CH_4. Particularly for H_2/CH_4 gas pair, it lies over Robeson's 2008 upper bound limit, which fits the composition in the novel class for the gas separation membranes.

KEYWORDS

gas separation, glass transition temperature, nanocomposite membranes, permeability and selectivity, thermally rearranged polyimides

1 | INTRODUCTION

Polyimide materials overcome the most encouraging environment for developing the membrane gas separation area with high selectivities and low permeabilities. Gas separation by the membrane is an extensive research area for productive energy distribution with many favorable circumstances under the standard separation method.[1,2] Overall polymeric films have been restricted partially by a trade-off between selectivity and permeability of gases depending on a polymeric membrane and improving both the permeability and selectivity of parameters.[3–6] Most data reported on polymeric gas separation membranes have achieved a great area to improving gas permeability or selectivity. Usually, it is hard for glassy polymers to increase permeability without disturbing their excellent inherent selectivity, not the other way around. As of later, Guo et al.[7] observed another group of gas separation of membrane films and thermally rearranged (TR) polymers, obtained from the precursor polyimides of ortho-positioned hydroxyl groups. The dense membrane mixed with TR polymers gives high

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Transport properties of polymer blends and composite membranes for selective permeation of hydrogen

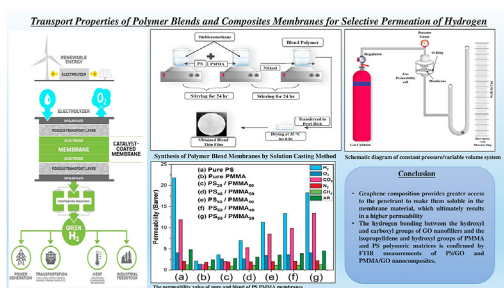
*Harsh D. Patel, Naveen K. Acharya**

Applied Physics Department, Faculty of Technology and Engineering, The M.S. University of Baroda, Vadodara 390 001, India

HIGHLIGHTS

- GO nanofillers in blends of PS/PMMA have shown relatively higher permeability for hydrogen.
- Selectivity for hydrogen in GO with PS/PMMA blend composite membranes is found to be higher.
- Better separation performance of nanocomposite membrane is found in separation technology.
- Porosimetry increases in different amount as GO content increases in polymers and in blends as well.

GRAPHICAL ABSTRACT



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ABSTRACT

Graphene Oxide (GO) dispersed in a polymer blend of Polystyrene (PS)/Poly (methyl methacrylate) (PMMA) nanocomposite membranes have been prepared by the solution cast method for hydrogen gas permeation application. This paper reports a study of blends of PMMA and PS that were prepared in different ratios of weight percentage for PMMA: PS (80:20, 50:50 and 60:40) composite with 1 wt% of GO and 2 wt% of GO. The structural and morphological properties of these prepared composite membranes have been characterized using gas permeation, Scanning Electron Microscopy (SEM) and Energy Dispersive Spectroscopy (EDS). UV Spectroscopy and FT-IR have carried out the optical absorbance measurement of the composite membranes. The permeability measurements indicate that the GO nanofillers in blends of PS/PMMA have shown higher permeability for hydrogen gas than that of pure polymers. The gases used for the permeation measurements were H_2, CO_2, N_2 and CH_4. Selectivity has been calculated for H_2/CO_2, H_2/N_2 and H_2/CH_4 gas pairs and plotted to show Robeson's 2008 upper bound and compared with reported data. The transport properties of these gases have been compared with that of a neat membrane. The permeability of all gases has increased to that of the unmodified polymer membrane. The selectivity measurements show that GO composite with PS/PMMA blend membranes is highly selective for hydrogen gas from different gas pairs, therefore, these composite

* Corresponding author.
E-mail address: sarnavee@gamil.com (N.K. Acharya).
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Harsh D. Patel
Naveen K. Acharya*

Transport, Spectroscopic, and Electrical Properties of Thermally Rearranged Nanocomposite Membranes

Nanocomposite membranes are a class of innovative filtering materials consisting of nanofillers embedded in a polymeric or inorganic oxide matrix that functionalizes the membrane. Thermally rearranged (TR) polymers have a good blend of selectivity and permeability. Nanocomposite membranes were tested after applying a TR process. The selectivity decreases with increasing permeability, showing a trade-off relationship between permeability and selectivity. TR polymer nanocomposite exhibits higher gas permeability than silica-doped and pure polymer. The selectivity for H_2/N_2 and H_2/CO_2 gas pairs exceeds the Robeson upper-bound limit, and in the case of the H_2/CH_4 gas pair. The selectivity for H_2/N_2 , H_2/CH_4 and H_2/CO_2 gas pairs exceeds the Robeson upper-bound limit.

Keywords: Gas Permeability, Membrane technology, Nanocomposite, Tauc plot

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1 Introduction

Membrane technology (MT) has evolved into a comprehensive separation technology. The key advantage of MT is that it operates without chemicals, uses extraordinarily little energy, and is a well-organized and straightforward process. The various applications of MT include air protection, water purification, pharmacy, medicine, food technology, soil protection, and agriculture. MT, with its high permeability and selectivity, helps to achieve good performance in purification and separation technology. The membrane functions as a highly selective filter, allowing gas to pass through while capturing suspended particles and other contaminants. There are several methods for allowing gases to pass through a membrane. Application of high pressure, maintaining a concentration gradient on each side of the membrane, and introducing an electric potential are examples of these approaches .

Polymer nanocomposites (PNCs) are becoming increasingly popular in materials science. These new materials can be used for water purification, gas separation, fuel cells, drug delivery, nano-electronics, and other multidisciplinary research applications. Gas separation with polymer nanocomposite membranes has received much attention in the literature. The unique properties of nanoparticles have resulted in a novel form of composite membrane materials. The structure of the host polymer is altered when inorganic nanoparticles are introduced into a polymer matrix, and this increases the separation of gases. This new technique for separating gases using membranes shows great promise in various industrial applications, including air purification, fuel cells, carbon capture, and natural gas upgrading [1, 2].

Since 1970, the global output of natural gas has more than doubled, making it the fastest-growing primary energy source today. Therefore, MT has emerged as one of the fastest-growing areas of the natural gas processing industry, notably for CO_2 removal sweetening [2–4]. It is common for MT to be used in remote or offshore sites, where minimum requirement for human attention, easy operation, low weight, and a small footprint are vital benefits. Since world energy consumption is expected to rise dramatically in the following years, new ways to generate environmentally friendly and cost-effective power must be found. Considering global warming and energy security, hydrogen fuel can provide clean and efficient energy requirements. Production, separation, and purification of hydrogen via MT uses less energy and allows for continuous operation while still producing ultrapure hydrogen gas for fuel cells and other power sources, which are only two of the many possible uses for MT-based hydrogen generation.

In MT, new hybrid materials are being developed to replace the existing ones in the gas transport process [1, 5]. To manufacture high-performance polymers for molecular-scale separation, Lee et al. introduced a new class of polymers, so-called thermally rearranged (TR) polymers, in their seminal paper published over a decade ago [1]. TR polymers have a tailored free-volume element architecture because of their high-free-

Harsh D. Patel, Dr. Naveen K. Acharya
https://orcid.org/0000-0002-9206-8891
(sarnavee@gmail.com)
Applied Physics Department, Faculty of Technology and Engineering, The M.S. University of Baroda, Vadodara 390 001, India.

Absorption Coefficient of OHP Sheet by Using Mobile Sensor

HARSH D. PATEL[1], AVANI PATEL[2], NAVEEN K. ACHARYA[3]

[1]PhD Research Scholar, Department of Applied Physics, Faculty of Technology & Engineering, The Maharaja Sayajirao University of Baroda, India – 390002
Email: harshpatel10996@gmail.com

[2]Temporary Assistant Professor, Department of Applied Physics, Faculty of Technology & Engineering, The Maharaja Sayajirao University of Baroda, India – 390002
Email: patelavani3@gmail.com

[3]Assistant Professor, Department of Applied Physics, Faculty of Technology & Engineering, The Maharaja Sayajirao University of Baroda, India – 390002
Email: sarnavee@gmail.com

Abstracts

According to the Beer-Lambert Law, the characteristics of the medium through which light is travelling affect how much light has attenuated. The law has often used to explain attenuation in physical optics as well as chemical analysis studies. In particular, if the material is strongly scattering, the rule tends to fail at extremely large concentrations. Nonlinear optical processes may potentially generate variations if the radiation is very strong. Although being undetectable to the naked eye, the sensor generates a beam of light that has reflected back. As you might anticipate, the ambient light sensor measures the amount of light in the space and adjusts the brightness of your screen accordingly. We measured the absorption coefficient using a variety of overhead projector sheets (OHP) sheets. First, put one sheet on the path of He-Ne laser light. After that measured how much intensity has reduced due to this OHP sheet. Note value of that intensity of light, and put second sheet and measured the reduced light intensity. We putting number of OHP sheets until maximum intensity of light has reduced and by using beer lambert law found the absorption coefficient.

Keywords: Physics Tool Box app., Absorption coefficient, Mobile Sensor, OHP sheet

1. Introduction

Similar to a mechanical wave or sound wave, light has an electromagnetic wave made up of time-varying electric and magnetic fields that oscillate in time and travel across space. Electromagnetic waves do not require a medium to move, unlike mechanical waves. A proximity sensor is a device that can identify adjacent objects without making physical touch. The proximity sensor, which often rests up top near the top speaker, uses an infrared LED and light detector to determine when the phone is in your ear so the screen may turned off. While it can not be seen by the human eye, the sensor generates a beam of light that is reflected back (Pandita et al., 2014). In the meanwhile, the ambient light sensor performs precisely as you would anticipate it to sensing the amount of light in the space and altering the brightness of your screen appropriately (if indeed it is set to auto-adjust). Reflected Light Meters (RLM) and Incident Light Meters (ILM) are two different kinds of light meters (Wall, 2004). They are

Experimental verification of Diffraction at Single Slit Using Advance Technique

HARSH D. PATEL[1], NAVEEN K. ACHARYA[2]

[1]PhD Research Scholar, Department of Applied Physics, Faculty of Technology & Engineering, The Maharaja Sayajirao University of Baroda, India – 390002

Email: harshpatel10996@gmail.com

[2]Assistant Professor, Department of Applied Physics, Faculty of Technology & Engineering, The Maharaja Sayajirao University of Baroda, India – 390002

Email: sarnavee@gmail.com

Abstract

We explain the single-slit diffraction of an optical beam carrying a phase singularity. The diffraction pattern of the single beam varies from that of a plane wave because of azimuthal phase dependency. Depending on the sign of the topological charge of the singular beam, the fringes in the diffraction pattern of the beam undergo continuous bending as they travel through the center of the pattern and show left to right or right to left shift. He-Ne laser light passes through a single slit and makes diffraction pattern. A diffraction pattern has observed on scale to measure distance between central maxima to 1st, 2^{ed} and orders of diffraction. The distance between source, slit and detector for batter diffraction pattern. The mobile sensor have used instead of photo-detector for measuring the intensity of diffracting light. The application of PHYSICS TOOL BOX measured the intensity of diffracting light. This intensity pattern was recoded in application of physics tool box in my mobile phone. This intensity measuring started from central maxima to the last observing order. By using a reading of this intensity we draw a graph to show that how intensity changed with orders and calculating amount of intensity for Red and Green laser light.

Keywords: Diffraction through single slit, Fraunhofer Diffraction, Mobile Sensor, Experimental Physics

1. Introduction

A sensor is a converter that changes a physical quantity into a signal that an observer or an instrument can read. What kind of sensors do we often use? When new, high-tech functions are added to our smartphones, customers sometimes get confused by the many technical names, and the various kinds of sensors are no exception: G-sensors, gyroscopes, proximity sensors, ambient light sensors, compass, etc. (Ponomarenko et al., 2002). In order to identify when you are holding the phone up to your ear so the screen may be turned off, the proximity sensor, which is often located up near the top speaker, combines an infrared LED and light detector. Although being undetectable to the naked eye, the sensor generates a beam of light that has reflected back. While this is going on, the ambient light sensor does exactly what you would expect it to do: it measures the amount of light present in the space and adjusts the brightness of your screen appropriately (if indeed it is set to auto-adjust) (Al-Saymari et al.,

List of Papers under Communication

1. Thermally Stable PET/PS-GO Polymer Blend Membranes with Enhanced Properties for Food Packing Applications
   H. D. Patel, N. K. Acharya
   Journal of Food Science and Technology, 07/2023
   (Under Review)
2. Energy Bandgap and Thermal Analysis of Polymer PC/GO Nanocomposites Membrane Films
   H. D. Patel, N. K. Acharya
   Journal of Applied Polymer Science, 08/2023
   (Under Review)
3. Study of Thermal Behavior of Various PMMA-PS/ GO Nanocomposite Blends Membrane
   H. D. Patel, N. K. Acharya
   Journal of Electronic Materials, 12/2023
   (Under Review)
4. Study Thermal Analysis Behaviour and Activation Energy of Various PMMA/PS Polymer Blends
   H. D. Patel, N. K. Acharya
   Journal of Electronic Materials, 12/2023
   (Under Review)
5. A Significant Permeability and Selectivity of PS/ PDMS Blends to Enrich the Upper Bound Visualization
   H. D. Patel, A. K. Patel, N. K. Acharya
   International Journal of Hydrogen Energy, 11/2023
   (Under Review)
6. CO_2 Removal from Natural Gas specifically for lighter gases N_2/CH_4 through PS/PDMS Blend Membranes composite with CNT nanofillers
   H. D. Patel, A. K. Patel, N. K. Acharya
   Journal of Membrane Science, 12/2023
   (Submitted)
7. Mechanically and thermally improved DES/GO doped PS/PDMS nanocomposite membranes to enhance the stability of CO_2/CH_4 separations for flue gas application
   H. D. Patel, A. K. Patel, N. K. Acharya,
   Manuscript Prepared

Paper Presented in Conferences:

1. A New Way to Determine the Melting Behaviour of Polymer Blends

   H. D. Patel, N. K. Acharya

   22nd Workshop and Symposium on Thermal Analysis THERMANS-2020, BARC, Mumbai.

   28th Jan - 01st Feb 2020
2. Gas permeation and thermal properties of Thermally Rearranged (TR) HAB-6FDA polymer nanocomposite membranes

   H. D. Patel, N. K. Acharya

   4th International Conference on Polymers for Energy conversion and storage, Jaipur.

   13th - 18th Dec, 2020
3. Synthesis & Characterization of Polyimides Nanocomposite Membranes

   H. D. Patel, N. K. Acharya

   International conference on Recent Advances in Material Science (ICRAMS- 2021), HNB, Uttrakhand.

   15th – 17th May, 2022
4. Spectroscopic and Transport Behavior of HAB - 6FDA Thermally Rearranged (TR) Nanocomposite Membranes

   H. D. Patel, N. K. Acharya

   Frontline Area in Chemical Science (FACS 2021), Pacific University, Udaipur.

   3rd - 4th Oct, 2021

   (**Best Poster Presentation**)
5. Thermal Analysis of various PMMA/PS polymer blends

   H. D. Patel, N. K. Acharya

   International Symposium on Applications of Thermal Analysis and Calorimetry (SATAC- 2021), Magadh University, Bodh Gaya.

   21th – 22 th Dec, 2021
6. Transport Properties of Polymer Blends and Composites Membranes for Selective Permeation of Hydrogen

   H. D. Patel, N. K. Acharya

   International Conference on Renewable Energy (ICRE 2022), Rajasthan University, Jaipur.

   25th– 27 th Feb, 2022

7. Thermally Stable PET/PS Polymer Blend Membranes with Enhanced Properties for Food Packing Applications

   H. D. Patel, N. K. Acharya

   International Seminar on Advanced Materials and Applications (ISAMA 2022), The M. S. Univeristy, Baroda.

   18^{th} July, 2022

8. Study of Gas Permeation of Polymer Nanocomposite Membranes for Hydrogen Separation

   H. D. Patel, N. K. Acharya

   International Conference on Recent Advances in (Applied) Sciences & Engineering (RAISE) organized by Faculty of Technology & Engineering, The Maharaja Sayajirao University Of Baroda

   12^{th} – 13^{th} April, 2023

   (**Best Paper Presentation**)

9. CO_2 Removal from Natural Gases specifically for lighter gases N_2 and CH_4 through CNT doped PS/PDMS nanocomposite blend Membranes

   H. D. Patel, N. K. Acharya

   International Online Conference on Nano Materials, Mahatma Gandhi University, Kottayam, Kerala, India

   12^{th} to 14^{th} August 2022

10. Mechanically and thermally improved DES/GO doped PS/PDMS nanocomposite membranes to enhance the stability of CO_2/CH_4 separations for flue gas application

    H. D. Patel, N. K. Acharya

    National Research Scholar's Meet on Condensed Matter Physics and Materials Science (CMPMS - 23), Gujarat University, Ahmedabad.

    4^{th} March, 2023

    (**Best Paper Presentation**)

11. Study of Thermal Behavior of Various PMMA-PS/GO Nanocomposite Blends Membrane

    H. D. Patel, N. K. Acharya

    28^{th} International Conference On Nuclear Tracks & Radiation Measurements, Gurugram University, Gurugram.

    06^{th} to 10^{th} November 2023

    (**Best Oral Presentation**)