CONTACT DETAILS

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EDUCATIONAL QUALIFICATIONS

PhD Chemistry (Studies on Preparation and characterization of composite ionomer membranes for electro-driven separations**)**, Central Salt and Marine Chemicals Research Institute Bhavnagar, Gujarat, India; Year- 2006

M.Sc. Inorganic Chemistry, Karnatak University Dharwad- 580 003 Karnataka, India; Year-1999.

B.Sc. Karnatak University Dharwad- 580 003 Karnataka, India; Year-1997.

AWARDS

- **Ramanujan Fellow**, Department of science and technology, India
- **Senior research fellow** from Council of Scientific & Industrial Research (CSIR), India.
- **Prof. G. K. Narayana Reddy Gold Medal** from Karnatak University Dharwad for standing first among the successful students in Inorganic chemistry in 1999.

SELECTED PUBLICATIONS

- **R.K.Nagarale**, Udo Hoss, and Aadam Heller, "Mixed Valence Metal Oxide Nanoparticles as Electrochemical Half-Cells: Substituting the Ag/AgCl of Reference Electrodes by CeO2-x Nanoparticles" **Journal of the American Chemical Society** (**2012**) Accepted **DOI: 10.1021/ja3103549**
- Yong-Mao Lin, **R.K. Nagarale**, Kyle C. Klavetter, C. Buddie Mullins and Adam Heller, "A Fast and Stable TiO_2-Supported SnO_2-Nanocomposite Lithium Ion Battery Anode"; **Journal of Materials Chemistry**; 22 (**2012**) 1134-1139.
- Woonsup Shin, Jong Myung Lee, **R.K. Nagarale**, Samuel Jaeho Shin, and Adam Heller, "An Efficient 0.5 V Electroosmotic Pump"; **Journal of the American Chemical Society** 133 (**2011**) 2374-2377**.**
- **R.K. Nagarale***, Woonsup Shin, and Pramod K. Singh; "Progress in Ionic Organic-Inorganic Composite Membranes for Fuel Cell Applications"; **Polymer Chemistry** 1 (**2010**) 388-408.

- **R.K. Nagarale**, Jong Myung Lee, and Woonsup Shin; "Electrochemical Properties of Ferrocene Modified Polysiloxane/Chitosan Nanocomposite and Its Application to Glucose Sensor"; **Electrochimica Acta** 54 (**2009**) 6508–6514.
- **R.K. Nagarale**, G.S. Gohil, Vinod K. Shahi, and R. Rangarajan; "Organic-Inorganic Hybrid Membrane: Thermally Stable Cation-Exchange Membrane by Sol-Gel Method"; **Macromolecules** 37(26) (**2004**) 10023-10030.

RESEARCH INTEREST:

Charged membranes have been studied over century, but their inherent efficiency remains unchanged due to non existence of periodicity in conducting path. My research involves the design and synthesis of charged porous membranes with periodicity in conducting path. The basic approach will be the sintering of charged polymeric micro and nano spheres. The development of non-gassing electrode materials for arguably simplest Electro-osmotic pump (EOP) based subcutaneous drug delivery systems is also interested. Because most electro-osmotic pumps reported in the literature uses platinum electrodes and operate at high voltages, electrolyzing water with evolution of gases and bocks the steady flow. The electrode materials with excellent electron as well as mass transport capability has interesting applicability in biosensor, while tuned porosity charged polymeric membranes in fuel cell, secondary polymeric battery and separation/purification technologies.

POSITIONS HELD

- **Visiting Research Scholar from July 2009 to February 2012** with Prof. Adam Heller, Department of Chemical Engineering, University of Texas at Austin, Texas, USA.
- **Research Professor from July 2008 to June 2009** with Prof. Shin Woonsup, Dept of Chemistry and Interdisciplinary program of integrated Biotechnology, Sogang University, Seoul, Korea.
- **Researcher from September 2006 to June 2008** with Prof. Shin Woonsup, Dept of Chemistry and Interdisciplinary program of integrated Biotechnology, Sogang University, Seoul, Korea.
- **CSIR-Senior research fellow** in central salt and marine chemicals research institute Bhavnagar, Gujarat-364002 India. BHAVNAGAR -364 002.

LIST OF PUBLICATIONS

List of Patents:

1. **PCT Patent:** Ceria, Alizarin and Related Dye Containing Electrodes for Glucose Monitors **Rajaram K. Nagarale,** Adam Heller, Attorney's Docket: 24266768.001000-2012-in process

2. **PCT Patent:** An efficient non-gassing low voltage electro-osmotic pump; Woonsup Shin, Adam Heller, **Rajaram K. Nagarale**; Attorney Docket No.:15967.105003; PCT Int. Appl. (2011), WO 2011112723 A2.

3. **Repub. Korean Patent**: Nanocomposite of ferrocene-substituted polysiloxane and chitosan and its manufacture method; Shin, Woonsup Shin, **Rajaram K. Nagarale**, Jong Myeong Lee; Repub. Korean Kongkae Taeho Kongbo (2011), KR 2011012463 A 20110209. Registration No. 10-1108243

Research articles in peer reviewed journals:

37. **R.K.Nagarale**, Udo Hoss, and Aadam Heller, "Mixed Valence Metal Oxide Nanoparticles as Electrochemical Half-Cells: Substituting the Ag/AgCl of Reference Electrodes by CeO2-x Nanoparticles" **Journal of the American Chemical Society** (**2012**) Accepted **DOI: 10.1021/ja3103549**

36. H.D. Jiremali, **R.K. Nagarale,** D. Sarawankumar, J.M. Lee and W. Shin, "Hydroquinone Modified Chitosan/Carbon film Electrode for the Selective Detection of Ascorbic acid"; **Carbohydrate Polymers**; 92 (**2013**) 641-644.

35. Yong-Mao Lin, **R.K. Nagarale**, Kyle C. Klavetter, C. Buddie Mullins and Adam Heller, "A Fast and Stable TiO_2-Supported SnO_2-Nanocomposite Lithium Ion Battery Anode"; **Journal of Materials Chemistry**; 22 (**2012**) 1134-1139.

34. **R.K. Nagarale*** , Adam Heller, Woonsup Shin, "Micro-porosity of the Phosphosilicate-on-Silica Membrane Stabilizes the Flow the $Ag/SiO_2/Ag_2O$ Electroosmotic Pump"; **Journal of The Electrochemical Society**; 159(1) (**2012**) P14-P17.

33. Jieun Song, Zhenyu Hong, **R. K. Nagarale**, and Woonsup Shin, "Simple Preparation of Diaphorase/Polysiloxane Viologen Polymer-Modified Electrode for Sensing NAD and NADH"; **Journal of Electrochemical Science and Technology**; 2(3) (**2011**) 163-167.

32. H.D. Jiremali, **R.K. Nagarale,** J.M. Lee, D. Sarawankumar, and W. Shin; "Synthesis and Electrochemical Characterization of Well Ordered PEG Tethered Ferrocene Functionalized Polyacylic Acid and Its Applications to Enzyme Based biosensor"; **Electroanalysis**, 23(9) (**2011**) 2109-2115.

31. **R.K. Nagarale*** , Bhaskar Bhattacharya, Nitin Jadhav, Pramod K. Singh; "Synthesis and Electrochemical Study of Functional Ionic Polymer"**; Macromolecular Chemistry and Physics,** 212 (**2011**) 1751-1757.

30. Woonsup Shin, Enhua Zhu, **R.K. Nagarale**, Chang Hwan Kim, Jong Myung Lee, Samuel Jaeho Shin, Adam Heller "Stabilization of the Flow of the Ag/Ag_2O-Ceramic

Membrane Ag/Ag_2O Electroosmotic Pump for Programmable Quantitative Drug Infusion", **Analytical Chemistry,**. 83 (**2011**) 5023–5025.

29. Pramod K. Singh, **R. K. Nagarale** and Bhaskar Bhattacharya, "Present status of solid state photoelectrochemical solar cell and dye sensitized solar cell using PEO-based polymer electrolytes", **Advances in Natural Sciences: Noanoscience and Nanotechnology**, 2 (**2011**) 023002 (13PP).

28. Woonsup Shin, Samuel Jaeho Shin, Jong Myung Lee, **R.K. Nagarale**, Adam Heller, "A Miniature, Single Use, Skin-Adhered, Low-Voltage, Electroosmotic Pumping-Based Subcutaneous Infusion System", **Drug Delivery and Translational Research** 1 (**2011**) 342–347.

27. Woonsup Shin, Jong Myung Lee, **R.K. Nagarale**, Samuel Jaeho Shin, and Adam Heller, "An Efficient 0.5 V Electroosmotic Pump"; **Journal of the American Chemical Society** 133 (**2011**) 2374-2377**.**

26. Pramod K. Singh, B. Bhattacharya, and **R.K. Nagarale*; "**Effect of nano-TiO_2 dispersion on PEO polymer electrolyte property"; **Journal of Applied Polymer Science** 118 (**2010**) 2976–2980.

25. D. Quan, **R.K. Nagarale**, and Woonsup Shin; "A Nitrite Biosensor Based on Entrapped Siloxane-Viologen Polymer and Nitrite Reductase"; **Electroanalysis** 22 (**2010**) 2389-2398.

24. B. Bhattacharya, **R.K. Nagarale,** and Pramod K. Singh; "Effect of Sodium-mixed Anion Doping in PEO-based Polymer Electrolytes"; **High Performance Polymers** 22 (**2010**) 498-512.

23. **R.K. Nagarale***, Woonsup Shin, and Pramod K. Singh; "Progress in Ionic Organic-Inorganic Composite Membranes for Fuel Cell Applications"; **Polymer Chemistry** 1 (**2010**) 388-408.

22. Pramod K. Singh, B. Bhattacharya, **R.K. Nagarale**, S.P. Pandey and Hee-Woo Rhee; "Ionic liquid doped Poly (N-methyl 4-vinylpyridine iodide) Solid Polymer Electrolyte for Dye sensitized solar cell"; **Synthetic Metals** 160 (**2010**) 950-954.

21. Pramod K. Singh, S.K. Tomar, **R.K. Nagarale**, and Hee -Woo Rhee; "Ternary Semiconductor Nanoparticles Embedded in PEO-Polymer Electrolyte Matrix"; **Journal of Thermoplastic Composite Materials** 23 (**2010)** 227-237.

20. Pramod K. Singh, B. Bhattacharya, **R.K. Nagarale**, Kang-Wook Kim, and Hee-Woo Rhee; "Synthesis, characterization and application of biopolymer-ionic liquid composite membranes"; **Synthetic Metals** 160 (**2010**) 139-142.

19. **R.K. Nagarale**, Jong Myung Lee, and Woonsup Shin; "Electrochemical Properties of Ferrocene Modified Polysiloxane/Chitosan Nanocomposite and Its Application to Glucose Sensor"; **Electrochimica Acta** 54 (**2009**) 6508–6514.

18. Pramod K Singh, Kang-Wook Kim, **RK Nagarale**, and Hee-Woo Rhee; "Preparation, Characterization and Application of Ionic Liquid Doped Solid Polymer Electrolyte Membranes"; **Journal of Physics D: Applied Physics** 42 (**2009**) 125101.

17. M.Y. Kariduraganavar, **R.K. Nagarale,** A.A. Kittur, and S.S. Kulkarni; "Ion-Exchange Membranes: Preparative Methods for Electrodialysis and Fuel Cell Applications"; **Desalination** 197 (**2006**) 225–246.

16. V.V. Binsu**,** **R.K. Nagarale,** Vinod K. Shahi, and P.K. Ghosh; " Studies On N-methylene Phosphonic acid Chitosan/Poly(Vinylalcohol) Composite Proton-Exchange Membranes"; **Reactive and Functional Polymer** 66 (**2006**) 1619-1629**.**

15. **R.K. Nagarale**, G.S. Gohil, Vinod K. Shahi, and R. Rangarajan; "Sulfonated Poly(ether ether ketone)/Polyaniline Composite Proton Exchange Membrane"; **Journal of Membrane Science** 280 (**2006**) 389-396.

14. G.S. Gohil, **R.K. Nagarale**, V.V. Binsu, and Vinod K. Shahi; "Preparation and Characterization of Mono-valent Cation Selective Sulfonated Poly(ether ether ketone) and Poly(ether sulfone) Composite Membranes"; **Journal of Colloid and Interface Science** 298 (**2006**) 845-853.

13. M.Y. Kariduraganavar, **R.K. Nagarale**, and S.S. Kulkarni; "Electrodialytic Transport Properties of Heterogeneous Cation-Exchange Membranes Prepared by Gelation and Solvent Evaporation Methods"; **Journal of Applied Polymer Science** 100 (**2006**) 198-207.

12. **R.K. Nagarale**, G.S. Gohil, and Vinod K. Shahi; "Recent Developments on Ion-exchange Membranes and Electro-membrane Processes"; **Advances in Colloid and Interface Science** 119 (**2006**) 97-130**.**

11. V.V. Binsu, **R.K. Nagarale** and Vinod K. Shahi; "Phosphonic Acid Functionalzed Aminopropyl Triethoxysilane-PVA Composite Material: Organic-Inorganic Hybrid Proton-Exchange Membranes in Aqueous Media"; **Journal of Materials Chemistry** 15(45) (**2005**) 4823-4831.

10.G.S. Gohil, **R.K. Nagarale**, Vinod K. Shahi, and R. Rangarajan; "Micellar-Enhanced Electrodialysis: Influence of Surfactants on the Transport Properties of Ion-Exchange Membranes"; **Separation and Purification Technology** 47 (**2005**) 1-9.

9. **R.K. Nagarale,** G.S. Gohil, Vinod K. Shahi, and R. Rangarajan; "Preparation and Characterization of Organic-Inorganic Composite Anion-Exchange Membranes via Aqueous Dispersion Polymerization and Their Characterization"; **Journal of Colloid and Interface Science** 287 (**2005**) 198–206

8. **R.K. Nagarale,** G.S. Gohil, Vinod K. Shahi, and R. Rangarajan; "Preparation and Electrochemical Characterization of Sulfonated Polysulfone Cation-Exchange Membranes: Effect of Solvents on Degree of Sulfonation"; **Journal of Applied Polymer Science** 96 (**2005**) 2344-2351.

7. **R.K. Nagarale**, Vinod K. Shahi, and R. Rangarajan; "Preparation of Polyvinyl Alcohol-Silica Hybrid Heterogeneous Anion-Exchange Membranes by Sol-Gel Method and Their Characterization"; **Journal of Membrane Science** 248 (**2005**) 37–44

6. **R.K. Nagarale**, G.S. Gohil, Vinod K. Shahi, G.S. Trivedi, S.K. Thampy and R. Rangarajan; "Studies on Transport Properties of Short Chain Aliphatic Carboxylic Acids in Electro-Dialytic Separation"; **Desalination** 171 (**2005**) 195-204**.**

5. **R.K. Nagarale**, G.S. Gohil, Vinod K. Shahi, and R. Rangarajan; "Organic-Inorganic Hybrid Membrane: Thermally Stable Cation-Exchange Membrane by Sol-Gel Method"; **Macromolecules** 37(26) (**2004**) 10023-10030.

4. **R.K. Nagarale,** G.S. Gohil, Vinod K. Shahi, and R. Rangarajan; "Preparation and Electrochemical Characterizations of Cation-Exchange Membranes With Different Functional Groups", **Colloids and Surfaces A: Physicochemical and Engineering aspects** 251 (**2004**) 133-140**.**

3. **R.K. Nagarale**, Vinod K. Shahi, S.K. Thampy, and R. Rangarajan; "Studies on Electrochemical Characterization of Polycarbonate and Polysulfone Based Heterogeneous Cation-Exchange Membranes"; **Reactive and Functional Polymer 61**(**2004**) 131-138**.**

2. **R.K. Nagarale,** G. S. Gohil, Vinod K. Shahi, G.S. Trivedi, and R. Rangarajan; "Preparation and Electrochemical Characterization of Cation- and Anion-Exchange/Polyaniline Composite Membranes"; **Journal of Colloid and Interface Science** 277(**2004**) 162-171**.**

1. **R.K. Nagarale**, Vinod K. Shahi, Rolf Schubert, R. Rangarajan, and R. Mehnert; "Development of Urethane Acrylate Composite Ion-Exchange Membranes and Their Electrochemical Characterization"; **Journal of Colloid and Interface Science** 270 (**2004**) 446–454.

Papers presented in the International conferences

1. **R.K. Nagarale,** Junghyun Lee, Jong Myung Lee, Woonsup Shin, "Preparation and Electrochemical Properties of Organic/Inorganic Composite Redox Material" The 99th National meeting of the Korean chemical society, April 19-20 **2007.**
2. Jong Myung Lee, **R.K. Nagarale,** Junghyun Lee, Woonsup Shin, "Studies of Alternative Polymers to Nafion for Continuous Discharge of Zn Anode in Physiological Conditions, The 99th National meeting of the Korean chemical society, April 19-20 **2007.**
3. **R.K. Nagarale,** Jong Myung Lee, Durai Saravanakumar, Woonsup Shin, "Electron Transport in Ferrocene Functionalized Polysiloxane/Chitosan Composite Material for Enzyme Based Glucose Sensor" The 9th Asian conference on analytical sciences and The 39th convention of the Korean society of analytical science, November 4-8 **2007**, Ramada plaza Jeju, Jeju Island Korea.
4. Youngjin Park, Jong Myung Lee, Junghyun Lee, **R.K. Nagarale,** Woonsup Shin, "The Effect of Anions on Zn Anode Discharge and Thickness Limit of Nafion in Continuous Discharge of Zn Anode in Physiological Conditions" The 9th Asian conference on analytical sciences and The 39th convention of the Korean society of analytical science, November 4-8 **2007**, Ramada plaza Jeju, Jeju Island Korea.

Papers presented in the National conferences

1. Kariduraganavar, M.Y.; U.S. Toti; **R.K. Nagarale** and T.M. Aminabhavi; " Electrodialysis-A Method to Produce Drinking Water- A Water Testinasurvey of Dharwad District Villages," Bharat Ratna Sir M. Vishveshvaraya Memorial National Seminar On Environment Pollution and Management, November 24-25, **2000**, at University of Agricultural Science, Dharwad.
2. **R.K. Nagarale,** S.P. Maradur, T.M. Aminabhavi and M.Y. Kariduraganavar; " Synthesis and Characterization of Anion Exchange Membranes for the Development of Electrodialysis for Purification of Brackish Water" Advanced Polymeric Materials and Environmental Protection for the New Millennium during July 26-27, **2001** at the A. C. College of Technology Building Guindy Chennai.
3. **R.K. Nagarale**, G.S. Gohil, Vinod K. Shahi, R. Rangarajan and P.K. Ghosh; "Sol-gel" a novel method for the preparation of heterogeneous anion-exchange membranes"

Presented in National Seminar on MEMBRANE SCIENCE & TECHNOLOGY: CHALLENGES AND OPPORTUNITIES February 12-13, **2004** *at* Regional Research Laboratory, Jorhat.

4. Vinod K. Shahi*, **R.K. Nagarale**, G.S. Gohil, S.K. Thampy and R. Rangarajan, "Concentration of short chain aliphatic carboxylic acids solution by electrodialysis", Presented in National Seminar on MEMBRANE SCIENCE & TECHNOLOGY: CHALLENGES AND OPPORTUNITIES February 12-13, **2004** *at* Regional Research Laboratory, Jorhat.

5. Vinod K. Shahi, **R.K. Nagarale**, G.S. Gohil, R. Rangarajan, " Preparation, Characterization and applications of polyaniline Composite Ion-exchange Membranes for Electro-driven Separations", Presented in National conference on CHEMISTRY IN THE DEVELOPMENT OF NEWER MATERIALS (CDNM-2004) February 23-24, **2004** at Department of chemistry Faculty of science Banaras Hindu University Varanasi-221 005.

6. **R.K. Nagarale,** G.S. Gohil, V.K. Shahi, S.K. Thampy, R. Rangarajan and P.K. Ghosh; "Development of Ion-exchange membranes at CSMCRI for Electrodialysis and related processes", Paper presented in AIChE-IIChE-Indo-US Joint Conference 04, held at Mumbai during Dec. **2004**.

7. **R.K. Nagarale**, G.S. Gohil, Vinod K. Shahi, R. Rangarajan, "Sol-Gel: A Novel Method for the preparation of Organic-Inorganic Hybrid Cation- Exchange Membrane in Aqueous Medium", presentation at the international conference on advances in polymer blends, composites, ipns and gels: macro to nano scale held at School of Chemical Sciences, Mahatma Gandhi University, Kerala, during March **2005**.

8. **R.K. Nagarale,** Junghyun Lee, Jong Myung Lee, Woonsup Shin, "Preparation and Electrochemical Properties of Ferrocene Modified Polysiloxane" Presented at international conference on electroanalytical chemistry and allied topics, Toshali royal view resort shion bang, Simla, March 10-15, **2007.**