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Research Interest

Development of the next-generation, energy-efficient separation processes using two-dimensional nanoporous materials and membranes.

Education

Ph.D., Chemical Engineering, University of Minnesota, Minneapolis, MN, USA 2008-2013

Advisors: Prof. Michael Tsapatsis, Prof. Lorraine F. Francis

Thesis: Dispersible exfoliated zeolite nanosheets and their application in high performance zeolite membranes

B. Tech., Chemical Engineering, IIT Bombay, Mumbai, India 2001-2005

Professional Experience

Assistant Professor, GAZNAT Chair for Advanced Separations July 2016- Present
École Polytechnique Fédérale de Lausanne (EPFL), Switzerland

Postdoctoral Research Assistant July 2014 – June 2016
Department of Chemical Engineering, Massachusetts Institute of Technology (MIT), USA
Advisor: Prof. Michael S. Strano

Postdoctoral Research Assistant Nov 2013 - June 2014
Department of Chemical Engineering & Material Science, University of Minnesota, USA
Advisor: Prof. Michael Tsapatsis

Engineer Nov 2005 - May 2008
Global Hair Care R&D, Procter & Gamble, Kobe, Japan

Publications

Google Scholar: <https://scholar.google.com/citations?user=uBT9VEEAAA&hl=en&oi=ao>

1. L. F. Villalobos, S. Huang, M. Dakhchoune, G. He, W.-C. Lee, K. V. Agrawal, "Polybenzimidazole copolymer derived lacey carbon film for graphene transfer and contamination removal strategies for imaging graphene nanopores", Submitted.
2. Q. Liu, D. J. Babu, M. T. Vahdat, D. Campi, K. V. Agrawal, "Metal Soap Membranes for Gas Separation", Submitted.
3. W. Lee, L. Bondaz, S. Huang, G. He, M. Dakhchoune, K. V. Agrawal, "Centimeter-Scale Gas-Sieving Nanoporous Single-Layer Graphene Membrane", Submitted.
4. S. Huang, L. F. Villalobos, S. Li, D. J. Babu, M. T. Vahdat, E. Oveisi, K. V. Agrawal, "High-permeance single-layer graphene membrane with a molecular sieving resolution of 0.2 Å", Submitted.
5. M. Dakhchoune, L. F. Villalobos, R. Semino, M. Rezaei, M. Ceriotti, K. V. Agrawal, "Gas sieving zeolitic membrane by the condensation of precursor nanosheets", Submitted.

6. M. T. Vahdat, D. Campi, N. Colonna, L. F. Villalobos, N. Marzari, K. V. Agrawal, "Efficient Kr/Xe separation from triangular g-C₃N₄ nanopores", **Journal of Material Chemistry A**, 2020, Just Accepted.
7. M. Rezaei, S. Li, S. Huang, K. V. Agrawal, "Crystallographic and morphological optimization of catalytic copper foil for high-quality single-layer graphene membranes", **Journal of Membrane Science**, 612, 118406, 2020.
 - Editor's Choice article (June 2020).
8. G. He, S. Huang, L. F. Villalobos, M. T. Vahdat, M. D. Guiver, J. Zhao, W.-C. Lee, M. Mensi, K. V. Agrawal, "Synergistic CO₂-sieving from polymer with intrinsic microporosity masking nanoporous single-layer graphene", **Advanced Functional Materials**, 2003979, 1-10, 2020.
9. R. Castro-Muñoz, K. V. Agrawal, J. Coronas, "Ultrathin permselective membranes: The latent way for an efficient gas separation", **RSC Advances**, 10, 12653- 12670, 2020.
 - Review article.
10. J. Hao, D. J. Babu, Q. Liu, C. Lu, Y. Liu, and K. V. Agrawal, "Synthesis of high-performance polycrystalline metal-organic framework membranes at room temperature in a few minutes", **Journal of Material Chemistry A**, 8, 7633-7640, 2020.
 - Featured on the cover page (back).
11. L. F. Villalobos, M. T. Vahdat, M. Dakhchoune, Z. Nadizadeh; M. Mensi, E. Oveisi, D. Campi, N. Marzari, K.V. Agrawal, "Single-layer nanoporous poly(triazine imide) nanosheets and observation of helium and hydrogen sieving from their self-assembled films", **Science Advances**, 6, eaay9851, 2020.
12. G. He, S. Huang, L. F. Villalobos, J. Zhao, M. Mensi, E. Oveisi, M Rezaei, K. V. Agrawal, "High-permeance polymer-functionalized single-layer graphene membranes that surpass the postcombustion carbon capture target", **Energy & Environmental Sciences**, 12, 3305-3312, 2019.
 - Featured on the cover page (back).
13. M. H. Khan, M. Dakhchoune, M. Rezaei, S. Huang, J. Zhao, K. V. Agrawal, "Hydrogen sieving from intrinsic defects of benzene-derived single-layer graphene", **Carbon**, 153, 458-466, 2019.
14. A. Bananezhad, M. Jovic, L. F. Villalobos, K. V. Agrawal, M. R. Ganjali, H. H. Girault, "Large-scale fabrication of flexible solid-state reference electrodes", **Journal of Electroanalytical Chemistry** 847, 113241, 2019.
15. D. J. Babu, G. He, M. T. Vahdat, P. A. Schouwink, M. Mensi, K. V. Agrawal, "Restricting lattice flexibility in polycrystalline metal-organic framework membrane for carbon capture", **Advanced Materials**, 31, 1900855, 2019.
16. S. Huang, L. F. Villalobos, D. J. Babu, G. He, M. Li, A. Züttel, K. V. Agrawal, "Ultrathin and size-tunable carbon molecular sieve membrane for gas separation", **ACS Applied Materials & Interfaces**, 11, 16729-16736, 2019.
17. S. Dutta, M. Rezaei, K. V. Agrawal, "Crystallization of gas-selective nanoporous graphene by chemical vapor deposition: a modeling study by kinetic Monte Carlo simulation". **Scientific Reports**, 9, 5202, 2019.

18. J. Zhao, G. He, S. Huang, L. F. Villalobos, M. Dakhchoune, H. Bassas, E. Oveisi, K. V. Agrawal, "Etching nanopores in single-layer graphene with an angstrom precision for high-performance gas separation". **Science Advances**, 5, eaav1851, 2019.
19. D. Babu, G. He, L. F. Villalobos, K. V. Agrawal "Crystal engineering of metal organic thin films for gas separations", **ACS Sustainable Chemistry & Engineering**, 7,49, 2019.
 - Invited review article.
20. G. He., D. J. Babu, K. V. Agrawal, "Electrophoretic crystallization of ultrathin high-performance metal-organic framework membranes". **Journal of Visualized Experiments**, 138, e58301, doi:10.3791/58301 (2018).
21. S. Huang, M. Dakhchoune, W. Luo, E. Oveisi, G. He, M. Rezaei, J. Zhao, A. Züttel, M. S. Strano, K. V. Agrawal, "Single-layer graphene membranes by crack-free transfer for gas mixture separation". **Nature Communications**, 9, 2632, 2018.
22. K. V. Agrawal, "Towards the ultimate membranes: two-dimensional nanoporous materials and films", **Chimia**, 72, 313-321, 2018.
 - Invited perspective article.
23. G. He., M. Dakhchoune, J. Zhao, S. Huang, K. V. Agrawal, "Electrophoretic nuclei assembly for crystallization of high performance membranes on unmodified supports", **Advanced Functional Materials**, 28, 1707427, 2018.
24. D. O. Bellesario, A. T. Liu, D. Kozawa, R. Han, J. K. Harris, R. B. Zabala, Q. H. Wang, K. V. Agrawal, Y. Son, M. S. Strano, "Experimental Observation of Real Time Molecular Dynamics Using Electromigrated Tunnel Junctions", **The Journal of Physical Chemistry C**, 121, 22550–22558, 2017.
25. Z. Yuan, A. G. Rajan, L. W. Drahushuk, R. P. Mishra, K. V. Agrawal, M. S. Strano, D. Blankshtein, "Mechanism and Prediction of Gas Permeation through Sub-Nanometer Graphene Pores: Comparison of Theory and Simulation", **ACS Nano**, 11 (8), 7974–7987, 2017.
26. K. V. Agrawal, Jesse Benck, Zhe Yuan, Yannick Eatmon, Ananth Govind Rajan, Suneet Kale, Ximo S. Chu, Duo O. Li, Chuncheng Gong, Daniel Blankshtein, Jamie Warner, Qing Hua Wang, Michael S. Strano, "Fabrication, Pressure Testing and Nanopore Formation of Single Layer Graphene Membranes", **The Journal of Physical Chemistry C**, 121, 14312-14321, 2017.
27. M. H. Shete, M. Kumar, D. Kim, N. Rangnekar, B. Topuz, K.V. Agrawal, E. Karapetrova, B. Stottrup, S. Al-Thabaiti, S. Basahel, K. Narasimharao, J. D. Rimer, M. Tsapatsis, "Nanoscale Control of Homoepitaxial Growth on a Two-Dimensional Zeolite", **Angewandte Chemie International Edition**, 56, 2, 535, 2017.
28. K. V. Agrawal, S. Shimizu, L. W. Drahushuk, D. Kilcoyne, M. S. Strano, "Observation of Extreme Phase Transition Temperatures of Water Confined Inside Isolated Carbon Nanotube Nanopores", **Nature Nanotechnology**, 12, 267, 2017.
29. K. V. Agrawal, L. W. Drahushuk, D. Kilcoyne, M. S. Strano, "Observation and Analysis of the Coulter Effect Through Carbon Nanotube and Graphene Nanopores", **Philosophical Transactions of the Royal Society A** (Invited Article), 374, 20150357, 2016.
 - Invited review article.

30. S. Shimizu, K. V. Agrawal, M. O'Mahony, L. W. Drahushuk, N. Manohar, A. S. Myerson, M. S. Strano, "Understanding and Analyzing Freezing-Point Transitions of Confined Fluids within Nanopores", **Langmuir**, 31, 10113, 2015.
31. K. V. Agrawal*, B. Topuz*, N. Sauer, T. C. T. Pham, N. Rangnekar, H. Zhang, K. Narasimharao, S. Basahel, L. F. Francis, C. W. Macosko, S. Al-Thabaiti, K. B. Yoon, M. Tsapatsis, "Oriented MFI Membranes by Gel-less Secondary Growth of Sub-100 nm MFI-nanosheet Seed Layers", **Advanced Materials**, 21, 3243, 2015.
 - Featured on the cover page.
32. N. Rangnekar, M. Shete, K. V. Agrawal, B. Topuz, P. Kumar, K. Narasimharao, I. Ismail, A. Alyoubi, S. Basahel, L. F. Francis, C. W. Macosko, K. A. Mkhoyan, B. Stottrup, S. Al-Thabaiti, M. Tsapatsis, "Langmuir-trough Deposition of Zeolite Nanosheets", **Angewandte Chemie International Edition**, 54, 6571, 2015.
33. P. Kumar, K. V. Agrawal, M. Tsapatsis, A. Mkhoyan, "Quantification of Thickness and Wrinkling of Exfoliated Two-dimensional Zeolite Nanosheets", **Nature Communications**, 6, 7128, 2015.
34. P. Kumar, K. V. Agrawal, M. Tsapatsis, A. Mkhoyan, "Analytical Method for Thickness and Wrinkling Measurements of 2-D Zeolites", **Microscopy and Microanalysis**, 21, 2367–2368, 2015.
35. P. Kumar, K. V. Agrawal, M. Tsapatsis, A. Mkhoyan, "Crystallographic Structure Determination of MFI-Zeolite Nanosheets", **Microscopy and Microanalysis**, 20 (S3), 390–391, 2014.
36. K. V. Agrawal, B. Topuz, M. Navarro, Z. Jiang, K. Nguenkam, B. Elyassi, L. F. Francis, M. Tsapatsis, "Solution-processable Exfoliated Zeolite Nanosheets Purified by Density Gradient Centrifugation", **AIChE Journal**, 59, 3458, 2013.
 - Invited article in the special issue of AIChE J. Founders Tribute to Neal R. Amundson.
37. X. Zhang, D. Liu, D. Xu, S. Asahina, K. Cychosz, K. V. Agrawal, Y. Al Wahedi, A. Bhan, S. Al Hashimi, O. Terasaki, M. Thommes, M. Tsapatsis, "Synthesis of Self-Pillared Zeolite Nanosheets by Repetitive Branching", **Science**, 336, 1684, 2012.
38. H. Zhang, W. J. Suszynski, K. V. Agrawal, M. Tsapatsis, S. Al Hashimi, L. F. Francis, "Coating of Open Celled Foams", **Industrial & Engineering Chemistry Research**, 51, 9250, 2012.
39. J. A. Stoeger, M. Palomino, K. V. Agrawal, X. Zhang, G. N. Karanikolos, A. Corma, M. Tsapatsis, "Oriented CoSAPO-5 Membranes by Microwave-Enhanced Growth on TiO₂-Coated Porous Alumina", **Angewandte Chemie International Edition**, 51, 2470, 2012.
40. K. Varoon (Agrawal)*, X. Zhang*, B. Elyassi, D. D. Brewer, M. Gettel, S. Kumar, J. A. Lee, S. Maheshwari, A. Mittal, C. Y. Sung, M. Cococcioni, L. F. Francis, A. V. McCormick, K. A. Mkhoyan, M. Tsapatsis, "Dispersible Exfoliated Zeolite Nanosheets and Their Application as a Selective Membrane", **Science**, 334, 72, 2011.
 - Featured in runner-up in **breakthrough of the year, 2011** by the Science Magazine.
41. K. Kahali, K. Varoon (Agrawal), J. Bellare, "Preparation of Lacey Polymer Film as Efficient Specimen Supports for TEM and Cryo-Transmission Electron Microscope (Cryo-TEM)", Proceedings of XXVII Annual Meeting of EMSI and Conference on Electron Microscopy and Allied Fields, April 1-3, 2004, p150-151.

Patent and Patent Applications

1. K. V. Agrawal, D. J. Babu, L. F. Villalobos, "Method of preparation of porous polymeric support layer and uses thereof", Application EP20174809
2. K. V. Agrawal, S. Huang "New process for graphene membranes lattice engineering and uses thereof", Application EP20166877
3. K. V. Agrawal, L. F. Villalobos, "Crystalline poly(triazine imide) membranes and uses thereof", Application EP19203932.
4. K. V. Agrawal, G. He, "Hybrid graphene-polymer membranes for separations", WO2020/011892A1.
5. K. V. Agrawal, S. Huang, "Graphene membrane filter for gas separation", WO2019/175162 A1.
6. K. V. Agrawal, M. Dakachoune, S. Huang, G. He, N. Dudani, "Ultrahigh flux gas-selective nanoporous carbon membrane and manufacturing method thereof", WO2018/177533A1.
7. M. Tsapatsis, K. V. Agrawal, L. F. Francis, "Silica Support Structure for a Zeolite Membrane", US10005674B2.
8. M. Tsapatsis, K. V. Agrawal, "Zeolite Nanosheet Membrane", US10005077B2.
9. C. K. Yagnik, K. Varoon (Agrawal), "Method for Assessment of Friction Properties of Fibers or Substrates upon Mechanical Treatment", US8429963B2.
10. K. Varoon (Agrawal), "Method for Assessment of Electrostatic Properties of Fibers or Substrates", US8198901B2.

Invited Talks

1. 16th International Conference on Inorganic Membranes (ICIM 16), Taipei, Taiwan, 2021.
2. Young Faculty Meeting, Swiss Chemical Society, Bern, Switzerland, 2021.
3. KAUST Research Conference: Advanced materials for energy-efficient separations, Addressing Vision 2030 and beyond, Thuwal, Saudi Arabia, 2020.
4. Summer School by European Membrane Society, University of Edinburgh, Scotland, 2019.
5. Seminar, ExxonMobil Research and Engineering, Clinton, USA, 2019.
6. Seminar, Stockholm University, Sweden, 2019.
7. Seminar, Eidgenössische Materialprüfungs- und Forschungsanstalt (EMPA), Switzerland, 2019.
8. Seminar, Imperial College London, UK, 2018.
9. Seminar, Massachusetts Institute of Technology, Boston, USA, 2018.
10. Gordon Research Conference (GRC) on "Membranes: Materials and Processes", USA, 2018.
11. North American Membrane Society (NAMS), Lexington, USA, 2018.
12. GAZNAT Global gas conference, EPFL, Lausanne, 2018.
13. Seminar, Indian Institute of Technology, Bombay, India, 2018.
14. Seminar, Czech Academy of Sciences, Czech Republic, 2017.
15. Raman Microscopy Workshop, ETH Zurich, Switzerland, 2017.
16. Inorganic Chemistry Seminar, University of Bayreuth, Germany, 2017.
17. Chemical Engineering Seminar, Indian Institute of Science, Bangalore, India, 2016.
18. Chemical and Biological Engineering seminar, University of Wisconsin-Madison, Madison, USA, 2015.
19. Chemical & Biological Engineering seminar, Northwestern University, Evanston, USA, 2015.
20. Special Chemical Engineering Seminar, Purdue University, West Lafayette, USA, 2015.
21. Chemical & Biochemical Seminar, Rutgers University, New Jersey, USA, 2015.

22. Memento ISIC Seminar, École Polytechnique Fédérale de Lausanne, Lausanne, Switzerland, 2014.
23. Seminar, Massachusetts Institute of Technology, Boston, USA, 2014.
24. CEMS Advanced Doctoral Student Seminar, University of Minnesota, Minneapolis, USA, 2013.

Project Funding

- Advanced in situ TEM for atomic-scale material chemistry and engineering (2020).
- Graphene scale-up project (funded by GAZNAT; 2020-2025)
- Carbon capture demonstrator project (funded by Valais administration, Switzerland; 2020-2025).
- Shell carbon capture project (2020-2023)
- Swiss National Science Foundation Project (2020-2024).
- Swiss National Supercomputing Center (2019-2020).
- ABB research grant (2019).
- GAZNAT carbon capture project - Phase II (2019-2023).
- Swiss National Supercomputing Center (2018-2019).
- European Research Council (ERC) Starting grant (2018-2022).
- Cooperation and Development Center (CODEV) seed grant (2018).
- Swiss National Science Foundation Assistant Professor Energy grant (2017- 2020).
- GAZNAT carbon capture project (2017-2020).
- Swiss Competence Center of Energy Research – Efficiency in Industrial Processes (SCCER-EIP), Phase II (2017 – 2020).
- EPFL Valais funding on exfoliation chemistry (2017-2020).
- ETH-Board funding on collaborative energy research (2016-2017).

Awards and Honors

1. Young Membrane Scientist Award, North American Membrane Society (NAMS), 2018.
2. Best poster, Gordon Research Conference on Nanoporous Materials and Their Applications, 2015.
3. AIChE Separations Division Graduate Student Research Award, 2013.
4. Doctoral Dissertation Fellowship (2012-2013), University of Minnesota.
5. Sigma Xi Award for best student poster presentation during DDF showcase.
6. Best poster, Gordon Research Conference on Nanoporous Materials and Their Applications, 2011.
7. CEMS Outstanding Teaching Assistant Award (2009-2010), University of Minnesota.
8. Procter & Gamble R&D Vice President Power of You Gold Award.
9. Institute Silver Medal for securing 1st rank in Department of Chemical Engineering at IIT Bombay.
10. Manudhane Best Undergraduate Student Award for overall excellence at IIT Bombay.
11. IIT Bombay Merit Scholarship (2003-2005)

Professional Activities at EPFL

1. Member of the Doctoral School Committee (EDCH), Institute of Chemical and Engineering Sciences (ISIC, 2020 onwards).
2. Chair of the EPFL Valais faculty meetings (2018 onwards).
3. Member of the ISIC vision panel, 2019.
4. Member of the ISIC hiring committee for platform scientists, 2019.
5. Member of the teaching committee (2016-2017).

Organization of Conference

1. Chair, Synthesis and Application of Inorganic Materials II: Application/Separations, AIChE Annual Meeting, San Francisco, USA 2020.
2. Co-chair, Inorganic Materials Graduate student award session, AIChE Annual Meeting, San Francisco, USA 2020.
3. Co-chair, Two-Dimensional Materials and Thin Films, AIChE Annual Meeting, San Francisco, USA 2020.

4. Chair, Inorganic Materials, North American Membrane Society 2020 (online meeting).
5. Chair, Graduate student award session (area: MESD Inorganic Materials), AIChE Annual Meeting, Orlando, USA 2019
6. Chair (Inorganic Materials, Material Engineering and Sciences Division, MESD), AIChE Annual Meeting, Pittsburgh, USA, 2018
7. Chair, Graduate student award session (area: MESD Inorganic Materials), AIChE Annual Meeting, Pittsburgh, USA 2018
8. Chair, MOFs, COFs, and Porous Polymer Materials I: Synthesis, AIChE Annual Meeting, Minneapolis, USA, 2017
9. Chair, MOFs, COFs, and Porous Polymer Materials II: Applications, AIChE Annual Meeting, Minneapolis, USA, 2017
10. Chair, Nanostructured Thin Films, AIChE Annual Meeting, San Francisco, USA, 2016
11. Co-Chair, Advances in the Synthesis and Application of Porous Materials I, AIChE Annual Meeting, San Francisco, USA, 2016
12. Chair, Advances in the Synthesis and Application of Porous Materials II, AIChE Annual Meeting, Salt Lake City, USA, 2015
13. Participant, Department of Energy's Advance Manufacturing Office Workshop on Membrane Technology, Chicago, USA, 2012

Professional Affiliations

Swiss Chemical Society (SCS), Swiss Process & Chemical Engineers (SGVC), European Federation of Chemical Engineering (EFCE), American Institute of Chemical Engineers (AIChE), American Chemical Society (ACS), Material Research Society (MRS), European Membrane Society (EMS), North American Membrane Society (NAMS), American Association for The Advancement Of Science (AAAS)

Teaching Experience

Lecturer ChE 310: Fundamentals of Separation Processes, EPFL, 2018- Present

Lecturer ChE 402: Diffusion and Mass Transfer, EPFL, 2018 - Present

Project Coach, "ChE 413: Chemical Product Design", EPFL, 2016 – Present

Kaufman Teaching Certificate Program, MIT, 2016

Guest Lectures

Fall 2009 'Absorption, Adsorption and Extraction', CHEN 2001, University of Minnesota

Spring 2012 'Structure of Zeolites', CHEN 8501, University of Minnesota

Fall 2015 'Nanoporous Membranes: Zeolite and Graphene', 10.585, Massachusetts Institute of Technology

Reviewer of Journal Articles

Nature Materials, Nature Energy, Advanced Materials, Science Advances, Proceedings of National Academy of Sciences, Nature Communications, Journal of American Chemical Society, Angewandte Chemie, Advanced Functional Materials, Nano Letters, ACS Nano, ACS Applied Materials and Interfaces, Carbon, ACS Applied Nano Materials, ACS Applied Polymer Materials, Chemistry-A European Journal, Chemical Reviews, ACS Sensors, The Journal of Physical Chemistry Letters, Journal of Membrane Science, Journal of Materials Science, Nano Research, The Journal of Physical Chemistry-C, Microporous and Mesoporous Materials, ChemPhysChem, Journal of Chemical Technology & Biotechnology, AIChE Journal, Chemical Engineering Science.