Dr. MINJU N

PROFILE

The area of expertise revolves around material science particularly inorganic porous materials, CO_2 sequestration and storage, adsorption and absorption processes, industrial textile effluent treatment, crude oil spillage treatment, and Computational fluid dynamics (CFD) modeling studies of transport phenomena using the governing equations and chemical engineering unit operations using different modeling software.

CONTACT

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RESEARCH INTERESTS

Materials Science, Porous materials, Ceramics, Computational Fluid Dynamics, CO_2 capture and storage, Sorption processes.

EDUCATION

Ph.D. details
Doctor of Philosophy in Engineering Sciences from CSIR-National Institute for Interdisciplinary Science and Technology (NIIST), Trivandrum, India for the thesis entitled 'Surface engineered porous silicates and hybrid materials for sorption applications' awarded on 14-06-2021.

Degree/ Course	Institution	University / Board	Year of Passing	Marks
M.Tech (First class with Distinction) in Computer Aided Process Design (Chemical Engg.)	Govt. Engineering College, Kozhikode	University of Calicut, Kozhikode	2013	CGPA 8.08
B.Tech (First class with Honours) in Chemical Engg.	Govt. Engineering College, Kozhikode	University of Calicut, Kozhikode	2011	76.39 %
Higher Secondary	Medical College Campus Govt. HSS, Kozhikode	State Board of Public Examinations	2007	87.30 %
S.S.L.C.	Chinmaya Vidyalaya Higher Secondary School, Kozhikode	State Board of Public Examinations	2005	88.95 %

PROFESSIONAL EXPERIENCE

- Completed online certificate course on 'COMSOL Multiphysics® Intensive Online Training Course' conducted from 20-01-2020 to 31-01-2020 by COMSOL Multiphysics Pvt. Ltd., Bengaluru.
- Worked as Project Assistant Gr-II at CSIR- NIIST, Trivandrum from 12-02-2014 to 06-10-2015 for the project based on CO_2 capture and storage.

TECHNICAL EXPOSURE

- Apprenticeship training at Kochi Refineries Ltd. Ernakulam, Kerala.
- Industrial training at FACT, Ernakulam, Kerala.
- Industrial training at 'The Kerala Minerals and Metals Ltd.', Chavara, Kollam, Kerala.
- Visit to 'Hindustan Insecticides Ltd.', Ernakulam, Kerala.

EDUCATIONAL PROJECTS COMPLETED

- M. Tech Project: Project based on the 'Removal of fluoride ions from aqueous solution using Magnesium oxide coated magnetite nano adsorbent' done at National Institute of Technology (NIT) Calicut, India.
- B. Tech Mini Project: Study on the Separation of Water-Methanol System Sieve Plate Column at Constant Reflux done at GEC Kozhikode, India.
- B. Tech Main Project: Manufacture of 175 TPD NaOH done at 'The Travancore-Cochin Chemicals (TCC) Ltd.', Udyogamandal, Ernakulam, India.

AWARDS

- Best oral presentation award at the National Seminar on Advanced Materials (NSAM) held on 04-10-2017 at the University of Kerala, Trivandrum, India.
- Senior Research Fellowship (SRF) awarded by Council of Scientific and Innovative Research (CSIR), Government of India in 2015.

PUBLICATIONS

- **Minju, N**.; Swaroop, K. V.; Haribabu, K.; Sivasubramanian, V.; Kumar, P. S. Removal of Fluoride from Aqueous Media by Magnesium Oxide-Coated Nanoparticles. *Desalin. Water Treat.* **2013**, 1–10. https://doi.org/10.1080/19443994.2013.868837.
- **Minju, N**.; Abhilash, P.; Nair, B. N.; Mohamed, A. P.; Ananthakumar, S. Amine Impregnated Porous Silica Gel Sorbents Synthesized from Water – Glass Precursors for CO2 Capturing. *Chem. Eng. J.* **2015**, *269*, 335–342. https://doi.org/10.1016/j.cej.2015.01.069.
- **Minju, N**.; Nair, B. N.; Peer Mohamed, A.; Ananthakumar, S. Surface Engineered Silica Mesospheres – A Promising Adsorbent for CO2 Capture. *Sep. Purif. Technol.* **2017**, *181*, 192–200. https://doi.org/10.1016/j.seppur.2017.03.038.
- **Minju, N**.; Jobin, G.; Savithri, S.; Ananthakumar, S. Double-Silicate Derived Hybrid Foams for High-Capacity Adsorption of Textile Dye Effluent: Statistical Optimization and Adsorption Studies. *Langmuir* **2019**, *35*, 9382–9395. https://doi.org/10.1021/acs.langmuir.9b00898.
- **Minju, N**.; Ananthakumar, S.; Savithri, S. Superswelling Hybrid Sponge from Water Glass for Selective Absorption of Crude Oil and Organic Solvents. *ACS Omega* **2019**, *4*, 17990–18001. https://doi.org/10.1021/acsomega.9b01655.
- **N. Minju**, N. Balagopal N., S. Savithri*, Sodium silicate-derived aerogels : effect of processing parameters on their applications, *RSC Adv.* **2021**, *11*, 15301–15322. https://doi.org/10.1039/D0RA09793D.
- **Minju, N**.; Siyad Ubaid.; Ananthakumar, S.; Savithri, S.* Modeling and simulation of carbon dioxide adsorption on silica aerogel storage system (*to be communicated*).

CONFERENCES ATTENDED

- **Minju N**, Peer Mohamed A., Ananthakumar S, 'Adsorption studies on amine modified porous silica sorbents' International Conference on Ceramic & Advanced Materials for Energy and Environment (CAMEE 2015), held on December 15 – 17, 2015, Christ University, Bengaluru. (*Poster presentation*)
- **N. Minju**, S. Savithri, S. Ananthakumar, 'Sol-Gel Silica Matrix Clay-Polymer Hybrid Foams: A Novel Inter-Networked Solid Adsorbent for Textile Effluent Treatment', National Seminar on Advanced Materials (NSAM 2017) held on October 4, 2017, University of Kerala, Trivandrum. (***Best oral presentation***)
- **N. Minju**, S. Savithri, S. Ananthakumar, 'Super flexible hydrophobic silica foams for oil spill clean-up', International Conference on Recent Trends in Materials Science and Technology (ICMST), October 10 – 13, 2018, IIST Trivandrum. (*Poster presentation*)
- **N. Minju**, S. Savithri, S. Ananthakumar, 'Silica hybrid foams and sponges for environmental remediation', 3rd International Conference on Advanced Materials and Manufacturing Processes for Strategic Sectors (ICAMPS), October 25 - 27, 2018, IIM Trivandrum chapter. (*Poster presentation*)
- **Minju N** and S. Savithri, Carbon dioxide adsorption on silica aerogel storage system - Modeling & simulation, COMSOL Conference 2019, November 28-29, ITC Gardenia Bangalore. (*Oral presentation*)

RESEARCH DONE SO FAR

As a part of the Ph.D. research work entitled, "Surface engineered porous silicates and hybrid materials for sorption applications" we have synthesized porous silica aerogels, foams, and sponges out of water-glass and have utilized them for sorption applications. The multiphysics and kinetics associated with the sorption process were effectively studied employing CFD and statistical optimization.

Inorganic silica porous materials are rarely explored candidates for sorption applications due to their non-uniform porous nature. Since silica is hygroscopic, water is chemically bound in a non-stoichiometric amount ($SiO_2.xH_2O$). The basic knowledge about the surface structure helps in understanding the chemical reactivity and sorption of these classes of materials. The chemical nature of silica allows for its modification with different organic moieties forming fascinating products of technical importance. Materializing products of technological importance demand low-cost and abundant raw materials for mass production reducing the total cost. Abundant in nature and cheap sodium silicate has been considered as an alternative silica precursor for mass production.

Sodium silicate being a silica source is widely used by industries for high-tech engineering applications. This thesis unveils the potential of sodium silicate as a sorbent material. Hybrid sorbents like foams and sponges were processed out of multiphase constituents involving inorganic and organic species that offer superior performance to the conventional single-phase sorbents. For the treatment of textile dye effluent, a lightweight inorganic-organic hybrid foam adsorbent was processed out of double silicate precursors natural bentonite and water glass through facile cross-linking and polymerization technique. To reduce the time and resource consumption, Response Surface Methodology based on multivariate technique was used to optimize the whole dye adsorption process. Batch adsorption results revealed adsorption capacity as high as 99.9 %, 98.9 %, and 98.2 % for 200, 600, and 1000 µM concentrations of Methylene Blue (MB) in 120 min. respectively and 100 % adsorption for 200, 600, and 1000 µM concentration of Crystal Violet (CV) in 120 min. for 10 g L^{-1} of the adsorbent. The adsorbent also showed high efficiency in treating synthetic industrial effluent through column adsorption. Overall the hybrid foam adsorbent was cheap and can be repeatedly used making it attractive for dye industries.

For the synthesis of hybrid absorbent sponges for crude oil and organic solvents absorption, water-glass and polyvinyl alcohol were cross-linked and polymerized and surface functionalized with organic silanes to impart hydrophobicity. The tailoring from super hydrophilic to hydrophobic was confirmed from contact angle measurements. The sponges were found to be macroporous flaky nature from morphology analysis and were super flexible with an apparent density of 0.069 g cc^{-1} and ~ 97 % porosity. The octadecyltrimethoxy silane-modified hybrid sponge exhibited optimum performance with absorption capacity in the range 12-23 g g^{-1} for the test liquids light crude oil, engine oil, paraffin oil, chloroform, kerosene, and hexane. Absorption capacity by weight basis was directly proportional to the density and inversely proportional to the viscosity of test liquids. It was recorded that the long alkyl chain length of the silane and the surface functional groups could thrive the oleophilic and hydrophobic qualities of the absorbent sponge.

As a final attempt sodium silicate was used for the synthesis of silica aerogels and considered for Carbon Capture and Storage (CCS) application. Silica aerogels inherently have a very low affinity to adsorb CO_2 molecules. But their abundant surface hydroxyl groups facilitate surface functionalization with different amine molecules improving the adsorption capacity. The synthesis procedure used the sol-gel nano casting technique avoiding both supercritical drying and the use of organosilane precursors making the whole process highly affordable. The addition of amine APTMS increased the bond strength and helped in improving the adsorption capacity. The studies showed that CO_2 reacted more with primary amines than with secondary amines. Also, the samples at 75 ^{0}C had better adsorption capacity and kinetics than those at 50 ^{0}C. Aerogels modified with the combination of amines APTMS and TEPA gave the best adsorption capacity of 3.26 mmol g^{-1} at 75 ^{0}C.

The feasibility of CO_2 storage in the silica aerogel fixed-bed adsorption column was looked upon with the help of CFD. The commercial CFD software COMSOL Multiphysics ver. 5.4a was used for multiphysics modeling studies. A modified D-A model was used to define the isotherm. The pressure and temperature inside the tank rise rapidly with time during the adsorption process. It is perceived that the center of the tank was more prone to temperature rise compared to the region near the wall boundaries due to lower CO_2 flow along the radial direction and heat transfer from the wall to the surroundings. An increase in pressure favored an increase in adsorption whereas an increase in temperature lowered the adsorption capacity. An initial pressure value of 1400 MPa and 1200 s charging time was capable of delivering maximum adsorption capacity with porosity 0.75. Overall CFD was effectively used as a tool to simulate the transport phenomena involved with the gas storage process in fixed bed columns.

Thus the whole study reveals the potential of silica porous materials for sorption applications in an effective manner following simple and less expensive routes.

DECLARATION

I hereby declare that all the details mentioned above are in accordance with the truth and fact as per my knowledge and I hold the responsibility for the correctness of the above mentioned particulars.

Place: Kerala
Date: 05-08-2022
N

Signature
Minju