

SUJAY D. BAGI

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PROFESSIONAL SYNOPSIS

Materials Scientist and Research Assistant in Mechanical Engineering at MIT with focus on developing high-throughput synthesis pathways for accelerated crystallization of Metal–Organic Frameworks (MOFs) and Zeolites. Previous experience of 5+ years in Diesel Aftertreatment System, Lubricants, and Tribology. Effective communicator with expertise in project management, product design & dev.

PROFESSIONAL CONTOUR

Jul'16 – Present	Massachusetts Institute of Technology (MIT)	Research Assistant
<ul style="list-style-type: none">• <u>Research thesis</u> focused on developing flow chemistry platform for energy- & cost-efficient synthesis of <i>MOFs</i> & <i>Zeolites</i>, used in atmospheric water harvesting, heat pumps, gas storage, carbon capture, drug delivery, and catalysis.• Developed <i>techno-economic framework</i> and <i>CFD</i> models to evaluate potential <i>scalability</i> & trade-off scenarios for manufacturing industrially relevant MOFs at <i>kg scale</i>, with an overall goal to reduce synthesis costs for widespread deployment.• Computed activation energies and rate constants for nucleation & growth of MOF-808 (Zr) via SAXS & reaction quenching in flow.• Evaluated sinter-resistant core-shell (Pt/Pd-TiWC) catalysts for gasoline engine using packed-bed down-flow reactor.• Performed engine bench-tests to simulate accelerated DPF aging to elucidate ash sintering, transport and effects on filter ΔP.		
Feb'13 – Jun'16	Paccar Inc	Sr. R&D Engineer - Powertrain Systems
<ul style="list-style-type: none">• Developed strategies for Diesel Engine Aftertreatment System: Understanding physical/chemical interactions of soot & ash that affect DPF filtration (ΔP) & catalyst performance, DPF maintenance intervals, and approach for NOx control.• Evaluated <i>failure modes and wear mechanisms</i> for MX powertrain components related to Engine oils, Fuels, Coolants, Greases & Driveline fluids using materials characterization techniques during vehicle design and production stages.• Served as a technical resource to monitor automotive industry trends, legislation, and participate in development of industry standards (PC-11 / NCDT / ASTM) related to Fluid systems & Emissions, of practical significance to Paccar products.		
Jan'11 – Dec'12	University of Texas at Arlington	Research Assistant
<ul style="list-style-type: none">• <u>Research thesis</u> focused on developing high performance EP grease additives & surface analysis to elucidate wear mechanisms.• Performed comprehensive studies on investigation of structural, oxidative and morphological aspects of diesel engine soot extracted from crankcase and exhaust stream.		
May'12 – Aug'12	Albemarle Corporation	Intern - Polymer Solutions R&D
<ul style="list-style-type: none">• Formulated aminic and phenolic antioxidant chemistries used in power-plant turbine oils for long-term durability. Investigation of oil degradation behaviour and varnish deposits using oxidation bench tests, analytical & statistical tools, and condition monitoring.		
Jul'09 – Jun'10	John Deere India Pvt Ltd	Engineer - Product Design and Analysis
<ul style="list-style-type: none">• Involved in the product development of hydraulic system control-valve for small tractors, including conceptualization, market segmentation, detailed design, prototype development, and reliability testing in adherence with the quality & cost standards.		

ACADEMIC CREDENTIALS

2021	Ph.D. Candidate in Mechanical Engineering	Massachusetts Institute of Technology (GPA 4.7/5.0)
2012	M.S. in Materials Science and Engineering	University of Texas at Arlington (GPA 3.6/4.0)
2009	B.E. in Mechanical Engineering	BMS College of Engineering, Bangalore, India (72.91%)

SCHOLARSHIPS & PROFESSIONAL MEMBERSHIP

- Awarded *Tata Trusts fellowship* (2017-19, MIT) for developing sorbents used in heavy-metal sequestration from industrial wastewater and hydrogen/methane storage for automotive applications.
- Materials Science Dept. scholarship (2011-12, UTA) & STLE North Texas Scholarship for Tribological Research (2012).
- *Memberships* in: *STLE* (Engine & Drivetrain Technical Committee: PS Chair), *EMA* (Truck & Engine Manuf. Association), *LC* (Lubricants Committee), *DFC* (Diesel Fuel Committee), & *PC-11 taskforce* (Volvo T-13, Daimler Scuffing, CAT Aeration Test). Contributed toward the development of next generation fuel-efficient diesel engine oil standard (*API CK-4* & *FA-4*, 2014-16).

INDUSTRIAL & ACADEMIC WORKSHOPS

- *Fuels, Biofuels, Engine Oils and Drivetrain Fluids* Workshop - Afton Chemicals R&D Centre (Richmond, VA - 06/2015)
- Engine and Drivetrain Components for *Trucks & Heavy Equipment* - Paccar Technical Centre (Mt Vernon, WA - 04/2014)
- *Lubrication and Fuels Conference* - Lubrizol R&D Centre (Wickliffe, OH - 09/2014)
- *GD&T* (Geometric Dimensioning & Tolerancing) Workshop & Manufacturing *Aluminium Hybrid Composites* (04/2010)

TECHNIQUES – Materials Characterization & Mechanical Modelling/Simulation

- **Electron Microscopy & Spectroscopy:** SEM, TEM, XPS, AES. **X-ray Analysis:** XRD, SAXS, XRF, EDS. **Molecular Vibrational Spectroscopy:** Raman, FTIR. **Surface Analysis:** WLI, GDS, AFM. **Thermal Analysis:** TGA, DSC.

- **Chemical Analysis:** ICP-OES, GC-MS, BET, DLS, TAN, TBN, Calorimetry, Flash/Pour/Cloud Point Tests.
- **Tribology & Lubricant Analysis:** 4-Ball, HFRR, SRV, BOCLE, Pin-On-Disk, HTHS, KV, RPVOT, TEOST, TFOUT.
- **Modelling & Analysis:** COMSOL, OriginLab, SolidWorks, ANSYS, Minitab, Design Expert (DOE), 3D Printing (SLA/FDM).

PUBLICATIONS (Updated August 2020)

- Bagi, S., Bowker, R., and Andrew, R., "Understanding Chemical Composition & Phase Transitions of Ash from Field Returned DPF Units and their Correlation with Filter Operating Conditions", *SAE Int. J. Fuels Lubr.* 9(1):2016, DOI: 10.4271/2016-01-0898
- Bagi S., Sharma V., Patel M., and Aswath P., "Effects of Diesel Soot Composition and Accumulated Vehicle Mileage on Soot Oxidation Characteristics", *Energy and Fuels*, 2016, 30(10), 8479-8490. DOI: 10.1021/acs.energyfuels.6b01304
- Bagi S., Sharma V., and Aswath P., "Role of Dispersant on Soot-Induced Wear in Cummins ISB Engine", *Carbon*, 2018, 136, 395-408. DOI: 10.1016/j.carbon.2018.04.066
- Bagi S., Kamp C. J., Sharma V., and Aswath P. B., "Multiscale Characterization of Exhaust and Crankcase Soot Extracted from Heavy-Duty Diesel Engine and Implications for DPF Ash", *Fuel* 282 (2020):118878. DOI: 10.1016/j.fuel.2020.118878
- Bagi, S., Singh, N., and Andrew, R., "Investigation into Ash from Field Returned DPF Units: Composition, Distribution, Cleaning Ability and DPF Performance Recovery", *SAE Technical Paper* 2016-01-0928, 2016. DOI: 10.4271/2016-01-0928
- Bagi S.D., Aswath, P.B. Mechanism of Friction and Wear in MoS₂ and ZDDP/F-PTFE Greases under Spectrum Loading Conditions. *Lubricants* 2015, 3(4), 687-711. DOI: 10.3390/lubricants3040687
- S. D. Bagi and P. B. Aswath "Role of MoS₂ Morphology on Wear & Friction Coefficient under Spectrum Loading Conditions", *Lubr. Sci.*, 27: 429-449. DOI: 10.1002/lvs.1296
- Bagi, S., Vyavhare, K., and Aswath, P., "Tribological characteristics of greases with and without metallo-organic friction-modifiers". *Tribology - Materials, Surfaces & Interfaces*, 12:4, 223-236, 2018. ISSN: 1751-5831. DOI: 10.1080/17515831.2018.1542790
- Kamp, C., Zhang, S., Bagi, S. et al., "Ash Permeability Determination in the Diesel Particulate Filter from Ultra-High Resolution 3D X-Ray Imaging and Image-Based Direct Numerical Simulations," *SAE Int. J. Fuels Lubr.* 10(2):2017. DOI: 10.4271/2017-01-0927
- Sharma V., Bagi S., Patel M., and Aswath P., "Influence of engine age on morphology and chemistry of diesel soot extracted from crankcase oil", *Energy and Fuels*, 2016, 30(3), 2276-2284. DOI: 10.1021/acs.energyfuels.5b02512
- Kamp, C. J., Bagi, S., & Wang, Y. (2019). Phenomenological Investigations of Mid-Channel Ash Deposit Formation and Characteristics in Diesel Particulate Filters. *SAE Technical Paper* 2019-01-0973. DOI: 10.4271/2019-01-0973
- Kamp, C. J., & Bagi, S., (2019). Advanced analytical methods for the study of lubricant-derived ash and associated impacts on engine aftertreatment components. *SAE Technical Paper* 2019-01-2293. DOI: 10.4271/2019-01-2293
- Sharma V., Bagi S., Patel M., Aderniran S., and Aswath P., "Structure and Chemistry of Soot and its Role in Wear of Diesel Engines", *Tribology Online*, 11, 5 (2016) 551-555. DOI: 10.2474/trol.11.551
- Shah, A., Bagi, S. and Aswath, P., 2017. Wear and Friction of Greases Containing Organic and Inorganic Sulfur Carriers. *Tribology Online*, 12(4), pp.162-170. DOI: 10.2474/trol.12.162
- Vyavhare, K., Bagi, S., Patel, M., and Aswath, P., "Impact of diesel engine oil additives-soot interactions on physiochemical, oxidation and wear characteristics of soot". *Energy and Fuels*, 2019, 33(5), 4515-4530, DOI: 10.1021/acs.energyfuels.8b03841
- S. D. Bagi., Effect of Additive Morphology & Chemistry on Wear & Friction of Greases under Spectrum Loading, *M.S. Thesis*, 2012. DOI: <https://uta-ir.tdl.org/uta-ir/handle/10106/25525>
- Bagi, S. et al., High Throughput Synthesis of Metal–Organic Frameworks for Atmospheric Fresh Water Capture, 2020, *Manuscript in preparation*.
- Bagi, S. et al., Continuous Flow Chemistry Approach for Ultrafast and Low-Cost Synthesis of MOF-808 and Techno-Economic Analysis, 2020, *Manuscript in preparation*.
- Vyavhare, K., Bagi, S., Pichumani, P., and Aswath, P., Chemical and Physical Properties of Tribofilms formed by the Interaction of Ashless Dithiophosphate Anti-wear Additives, 2020, *Manuscript in preparation*.
- Yuan, S. ... Bagi, S. et al., Conversion of Methane into Liquid Fuels – Bridging Thermal Catalysis with Electrocatalysis, 2020, *Advanced Energy Materials*, AENM 202000268.

PATENTS

- Aswath, P. B., Bagi, S., Shah, A., Shah, K., and Mordaunt, K. "Lubricant Compositions." U.S. Patent 20,170,066,990, *Issued March 9, 2017*. (Application Number - 15/259,608)
- Bagi, S. and Román-Leshkov, Y., High-throughput Flow Synthesis of Crystalline Microporous Materials On-demand. *US Provisional Patent Application*, 2019.

POSTER PRESENTATIONS

- Bagi, S. and Román-Leshkov, Y., On-demand Synthesis of Zeolites In-Flow for Water Purification, *Tata Center for Technology & Design, MIT*, 2018.
- Bagi, S. and Román-Leshkov, Y., High-throughput Synthesis of Metal–Organic Frameworks (MOFs) for Catalysis and Water Uptake, *Tata Center for Technology & Design, MIT*, 2019.
- P. Pitchumani, S. Bagi, V. Sharma, and P Aswath, "Wear and Tribofilm Formation with Zinc-Free Antiwear Additives "Fundamentals II, STLE 67th Annual Meeting, St. Louis. MO, May 6th -10th, 2012. p. 28. (*Tribology & Lubrication Technology* 2 (2013): 1.)
- Kamp, C. J., ... Bagi, S., et al., High-Resolution X-Ray Computed Tomography and Direct Numerical Simulation for the Measurement and Calculation of Decreased Permeability in the Wall-Flow Diesel Particulate Filter due to the Accumulation of Lubricant-Derived Ash, *Materials Research Society*, TC02.03.09, 2017.

REFeree FOR PEER-REVIEWED SCHOLARLY JOURNALS

- SAE International Journal of Fuels and Lubricants (*ISSN: 1946-3952*): 30+ papers reviewed
- Emission Control Science and Technology (*ISSN: 2199-3637*): 2+ papers reviewed

MAJOR PROJECTS EXECUTED

Description	Project Synopsis
Development of High-Throughput Flow Chemistry Platform for Material Synthesis On-demand (06'2017 - present)	<ul style="list-style-type: none">Designed & built a modular and scalable materials discovery platform, for ultrafast synthesis of porous materials (Zeolites & MOFs) on a <i>gram to kg scale</i>.Employed microfluidic reactions using biphasic liquid-liquid slug flow to perform continuous crystallization; miniaturized reactions (μL to mL) enable fast heat/mass transport accelerating synthesisSupervised machine learning modules coupled with rapid synthesis helps minimize time-consuming steps in screening large number of reaction space parameters and aids pilot-scale production.Employed a robust <i>techno-economic model</i> coupled with <i>CFD</i> simulations to analyse cost and energy savings achieved in flow compared to batch, and scalable configurations to synthesize at <i>kg scale</i>.
Harvesting Fresh Water from Air (07'2019 - 05'2020)	<ul style="list-style-type: none">Employed flow chemistry for accelerated crystallization of $\text{Ni}_2\text{Cl}_2\text{BTDD}$ MOF—adsorbs nearly its own weight of water from air, delivering unprecedented performance in water harvesters & heat pumps.Explored chemical synthesis space of solvents, residence time and temperature, using DoE to minimize synthesis costs <u>enabling widespread deployment</u> of sorbent-based devices.Atmosphere holds ~10% of global fresh water. Energy- & cost-efficient capture along with decentralized distribution in remote arid areas would be a major breakthrough to address water scarcity.
Evaluate Crystallization Kinetics for industrially attractive MOFs (07'2020 - present)	<ul style="list-style-type: none">Employed rapid sampling module developed in-house to quench crystallization reactions for <i>MOF-808</i> (Zr), an industrially attractive MOF with open metal sites, used in catalysis, heat pumps, separation etc.Determined activation energies and rate constants for nucleation and crystal growth using Gualtieri model for solution-mediated transformation.Explored the effects of coordination modulation, temperature, & linker concentration on particle sizes.
Modelling Scenarios for Carbon Neutral MIT (02'2018 – 06'2018)	<ul style="list-style-type: none">Developed two scenarios using renewable energy sources and nuclear power to achieve 100% decarbonisation by 2080, from the current GHG emissions of ~214K MT CO_2.Recommendations for PPAs, continuous infrastructure upgrades pertaining to energy-efficient lighting, heating/cooling and estimated CAPEX for scenarios were outlined.
MIT Consortium on Diesel Engine Lubricants & Emission Control System (06'2016 - 05'2017)	<ul style="list-style-type: none">Developed bench-tests to simulate accelerated lubricant ash loading in DPF and monitor ash transport, HC light-off performance, mid-channel ash deposits and filter backpressure (ΔP).Computed permeability of aged filters taking into account resistances of filter wall and ash morphology, using X-ray CT (Computed Tomography) and CFD models.Evaluation of hydrated ash species on filter durability & correlations with vehicle operating environment.
Tailoring Hardware Specific Engine Oils (CK-4) for Improved Vehicle Fuel Economy (10'2014 - 04'2016)	<ul style="list-style-type: none">Executed the collaborative project from conception to engine testing with a goal of establishing engine-oil performance standard for MX13/MX11 engines.Additive chemistry formulations with low-ash & low-P content were developed for enhanced MX engine durability and improved service life of DPF catalyst.Developed and evaluated low HTHS engine oils to understand effects on engine durability and achieved ~0.5% fuel-economy improvement on MX platform.
After-treatment Performance & Extension of DPF Service Intervals (06'2013 - 02'2015)	<ul style="list-style-type: none">Collaborated with Cummins for evaluation of efficient DPF ash cleaning protocols. Dry or wet methods that recovered catalyst performance while removing most of the ash (lose & sintered) were selected.Investigated the relationship between accumulated vehicle mileage, duty-cycles, ash morphology (chemical makeup & distribution) and DOC/DPF catalyst performance for extension of DPF cleaning intervals of on-highway vehicles.
Projects at University of Texas at Arlington (04'2011 - 02'2013)	<ul style="list-style-type: none">Research collaboration with Boeing for development of Low Friction Aerospace Greases under spectrum loading conditions for landing gear application.Studied chemical & structural characteristics of tribofilms from Ashless Anti-Wear additives.

Areas of Interest: Materials Development, Renewable Energy Technologies, Crystallization Science, MOFs, Automotive Emissions.

Research Portfolio: <https://sbagi.github.io> | **References** provided on request.