Curriculum Vitae

Sourish Bhattacharya
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Personal Details

Name: Sourish Bhattacharya

Date and Place of Birth: 4th August, 1985

Address at work: Lab 206, Division of Biotechnology and Phycology, Central Salt and Marine Chemicals Research Institute (Council of Scientific and Industrial Research), Bhavnagar-364002, Gujarat, India.

Position: Scientist, Division of Biotechnology and Phycology, Central Salt and Marine Chemicals Research Institute (Council of Scientific and Industrial Research), Bhavnagar-364002, Gujarat, India.

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Education

B. Tech. – Biotechnology - 2002-2006 – West Bengal University of Technology, Kolkata, West Bengal, India.

M.Tech. - Fermentation Technology – 2006-2008 – Institute of Chemical Technology, Mumbai, India.
Advisor: Prof. Rekha S. Singhal
Research Title: Utilization of glycerol for production of secondary metabolites.

PhD – Biological Sciences – 2013-2018 - Academy of Scientific and Innovative Research, Council of Scientific and Industrial Research
Advisor: Dr. Sandhya Mishra
Research Title:- Microbial production of ε-polylysine using cheap carbon source

Research Interests

- ❖ Mass cultivation of microalgae and extraction of microalgal oil at pilot scale for bio-diesel production
- ❖ ε-polylysine production from marine bacterial isolates.
- ❖ Optimization of upstream process parameters for improving polyhydroxyalkanoate production at bench scale
- ❖ Scaling up of developed process (bench scale) for poly-hydroxyalkanoate production at pilot scale.
- ❖ Microbial leaching of Potassium Feldspar for potassium recovery for its application as biofertilizers.
- ❖ Alcohol production from Lignocellulosic and microalgal biomass.

- ❖ Utilizing textile effluents for generation of microalgal biomass and high value products (PUFA).
- ❖ Bioreactor design

Professional Experience

2010 – Present	Junior Scientist, Process Design and Engineering Cell, Central Salt and Marine Chemicals Research Institute, Council of Scientific and Industrial Research, Gujarat, India.
2008-2010	R&D Executive, Innovative Creations Business Modules Pvt. Ltd., Mumbai, India.

Language Proficiency
English - fluent in speaking, reading, and writing.
Hindi - native in speaking, reading, and writing.

IELTS: 6.5 Band

Publications

1. Shrivastav, A., Mishra, S. K., Pancha, I., Jain, D., **Bhattacharya, S**., Patel, S., & Mishra, S. (2011). Biodegradability studies of polyhydroxyalkanoate (PHA) film produced by a marine bacteria using Jatropha biodiesel byproduct as a substrate. *World Journal of Microbiology and Biotechnology*, *27*(7), 1531-1541.

2. Das, P., **Bhattacharya, S**., Mishra, S., & Das, A. (2011). Zn (ii) and Cd (ii)-based complexes for probing the enzymatic hydrolysis of $Na_4P_2O_7$ by alkaline phosphatase in physiological conditions. *Chemical Communications*, *47*(28), 8118-8120.

3. Sahu, A., Pancha, I., Jain, D., Paliwal, C., Ghosh, T., Patidar, S., **Bhattacharya, S**., & Mishra, S. (2013). Fatty acids as biomarkers of microalgae. *Phytochemistry*, *89*, 53-58.

4. **Bhattacharya, S**., & Singh, P. (2013). Studies on various parameters involved in conjugation of starch with lysine for excellent emulsification properties using response surface methodology. World Academy of Science, Engineering and Technology, *International Journal of Biological, Biomolecular, Agricultural, Food and Biotechnological Engineering*, *7*(5), 357-360.

5. Patidar, S. K., Chokshi, K., George, B., **Bhattacharya, S**., & Mishra, S. (2015). Dominance of cyanobacterial and cryptophytic assemblage correlated to CDOM at heavy metal contamination sites of Gujarat, India. *Environmental monitoring and assessment*, *187*(1), 4118.

6. Patidar, S. K., Mishra, S. K., **Bhattacharya, S**., Ghosh, T., Paliwal, C., Goel, S., & Mishra, S. (2015). Naturally floating microalgal mat for in situ bioremediation and potential for biofuel production. *Algal Research*, *9*, 275-282.

7. **Bhattacharya, S**., Bachani, P., Jain, D., Patidar, S. K., & Mishra, S. (2016). Extraction of potassium from K-feldspar through potassium solubilization in the halophilic Acinetobacter soli (MTCC 5918) isolated from the experimental salt farm. *International Journal of Mineral Processing*, *152*, 53-57.

8. **Bhattacharya, S**., Maurya, R., Mishra, S. K., Ghosh, T., Patidar, S. K., Paliwal, C., Chokshi, K., Pancha, I., Maiti, S., & Mishra, S. (2016). Solar driven mass cultivation and the extraction of lipids from Chlorella variabilis: A case study. *Algal Research*, *14*, 137-142.

9. Pancha, I., Chokshi, K., Maurya, R., **Bhattacharya, S**., Bachani, P., & Mishra, S. (2016). Comparative evaluation of chemical and enzymatic saccharification of mixotrophically grown de-oiled microalgal biomass for reducing sugar production. *Bioresource Technology*, *204*, 9-16.

10. Bachani, P., **Bhattacharya, S**., Jain, D., Patidar, S. K., Soundarya, R., Tirkey, S. R., Ranawat, B., Bharadwaj, S.V., & Mishra, S. (2016). Bioprospecting of Halotolerant Bacterial Isolates for Potassium Recovery from K- Feldspar. *Chemical Engineering & Technology*, *39*(9), 1645-1652.

11. **Bhattacharya, S**., Soundarya, R., & Mishra, S. (2016). Ammonium Bicarbonate as Nutrient Substitute for Improving Biomass Productivity of *Chlorella variabilis*. *Chemical Engineering & Technology*, *39*(9), 1738-1742.

12. **Bhattacharya, S**., Dubey, S., Singh, P., Shrivastava, A., & Mishra, S. (2017). Biodegradable Polymeric Substances Produced by a Marine Bacterium from a Surplus Stream of the Biodiesel Industry. *Bioengineering*, 3(4), 34.

13. **Bhattacharya, S**., Dineshkumar, R., Dhanarajan, G., Sen, R., & Mishra, S. (2017) Improvement of ε-polylysine production by marine bacterium *Bacillus licheniformis* using artificial neural network modelling and particle swarm optimization technique. *Biochemical Engineering*, 126, 8-15.

14. **Bhattacharya, S.**, Pramanick, S.K., Gehlot, P.S., Patel, H., Gajaria, T., Mishra, S. & Kumar A. (2017) Process for preparing value added products from microalgae using textile effluent through biorefinery approach. *ACS Sustainable Chemistry and Engineering*, 5, 10019-10028.

15. **Bhattacharya, S.**, Bhayani, K., Ghosh, T., Bajaj, S., Trivedi, N. & Mishra, S. (2018) Stability of phycobiliproteins using Natural Preservative ε-polylysine (ε-PL). *Fermentation Technology*, 2018, 7, 149.

16. **Bhattacharya, S.**, Singh, P., Maity, N.C., Mishra, S. (2018) Distribution of antimicrobial

ε-polylysine producing marine microbe in sea Water along west coast of India. Biomaterials and Medical Applications. 2:1.

17. Sequeira, R.A., Singh, N., Pereira, M.M., Chudasama, N.A., **Bhattacharya, S.,** Sharma, M., Mondal, D., Prasad, K. (2018) High concentration solubility and stability of ε-poly-l-lysine in an ammonium-based ionic liquid: A suitable media for polypeptide packaging and biomaterial preparation. International Journal of Biological Macromolecules, 120, 378-384.

Book Chapter

1. Sevda, S., **Bhattacharya**, S., Abu Reesh, I.M., Bhuvanesh, S., & Sreekrishnan, T.R. (2016). Challenges in the Design and Operation of an Efficient Photobioreactor for Microalgae Cultivation and Hydrogen Production. In Biohydrogen Production: Sustainability of Current Technology and Future Perspective (ISBN: 978-81-322-3575-0).

2. **Bhattacharya S**., Bachani, P., Pachigar, K., Mishra, S. (2017) Waste Biomass Resource Utilization for Liquid Fuels, In *Handbook of Biotechnology for Renewable Fuels: Technology Assessments, Emerging Industrial Applications, and Future Outlooks (Proof submitted).*

Patents

Patent Published & Granted: Engine worthy fatty acid methyl ester (biodiesel) from naturally occurring marine microalgal mats and marine microalgae cultured in open salt pans together with value addition of co-products **(US 2014/0099681 A1; EU patent EP2475754 granted**).

Patent Filed: A process for the preparation of a potassic fertilizer from natural potassic ores using halophilic bacteria" filed at national phase **(1445DEL2015 filed on 22nd May' 2015)**.

Lead Projects as Principal investigator (PI)

- CSIR EMPOWER project on "Fermentative production of ε-polylysine utilizing the byproduct of biodiesel" (PI).

- In house project on "Process scale up for Polyhydroxyalkanoate (PHAs) production utilizing the biodiesel waste streams" (PI).

- Indo-Brazil project on "Integrated process development for maximizing production of bio-pigments and residual biomass as an energy feedstock from algae and its life cycle assessment (LCA)" funded by Department of Science of Technology (Co-PI).

- CSIR Network project on "To develop commercially viable process for recovery of K value from mineralogical resources through chemical/bio-chemical/electro-chemical means (K-TEN)" in work package "Recovery of K value from mineralogical resources through biochemical means" (Co-PI).

- CSIR Network project on "High purity salt and recovery of valuable metal ions from marine resources" (Co-PI).

- Ongoing CSIR Fast Track Project (FTT) project on "Generation of energy from microalgal feedstock through CO_2 capture from flue gases" in collaboration with Adani Power Limited, India (Co-PI).

Projects Completed

- Completed a project on "Utilization of glycerol for fermentative production of microbial metabolites" under the guidance of Prof. Rekha S. Singhal at Institute of chemical technology, University of Mumbai, Mumbai, Maharashtra (June 2007- July 2008).

- Completed a project on "Studies on isolation, Characteristics of the air micro flora of a niche in an industrial belt viz. BCET campus " under Mr. Sambhu Nath Banerjee at Bengal College of Engineering and Technology, Durgapur, West Bengal, India (September 2005 – May 2006).

- Completed a project on "Effect of ripening stage on the physiochemical attributes of packed black berry fruit under ambient condition" under P. Parihar at Jawaharlal Nehru Krishi Vishwavidyalaya, Jabalpur, Madhya Pradesh, India (June 2004 – July 2004).

- Worked as a team member on CSIR-NMITLI-MoES project "Biofuel from marine microalgae".

Paper Presentations in Conferences

- Presented a poster on "**Effect of Ripening Stage on the Physiochemical attributes of Packed Blackberry fruit under ambient condition**" at the 18th Indian Convention of Food Scientists & Technologists (ICFOST), held in Hyderabad on Nov., 2006.

- Presented a poster on "***Studies on isolation, Characteristics of the air microflora of a niche in an industrial belt viz. BCET campus***" at the 19th Indian Convention of Food Scientists & Technologists (ICFOST), held in IIT Kharagpur on Dec., 2007.

- Presented a poster entitled "**Fermentative Production of ε-Polylysine from a bacterial Isolate from the Garden Soil of CSIR-CSMCRI**" at the IX Convention of The Biotech Research Society, India in International Conference on Industrial Biotechnology (ICIB) 2012, held at Punjabi University, Patiala, Punjab, India.

- Oral presentation on "**Polymeric substances from crude glycerol through marine bacteria" at the International Conference on Advancements in Polymeric Materials'** 2016 held at CIPET, Ahmedabad during 12-14 February 2016.

- Oral presentation on "**Cost effective γ- linolenic acid from microalgae through biorefinery approach" at the International Conference on *Fermented Foods: Nutrition, Health status and Social well-being"*** which was held at National Research Centre, Giza, Egypt on 13 - 15 Nov 2017 as a part of the Society first International conference titled" ***Sciences for Women: Development and Innovation".***

- Presented a poster on **Natural preservatives for natural products: Bacterial ε-polylysine for microalgal pigments** at **XXXII-** Gujarat Science Congress 2018, Bhavnagar during 4-5 February' 2018.

Conferences Attended

- 5th Indo Korea joint workshop on Bioenergy at CSIR-NIIST at Trivandrum, India.
- 18th Indian Convention of Food Scientists & Technologists on *Innovations in Food Science and Technology* (***ICFOST 2006***), held in Hyderabad on November, 2006.
- National Symposium on ***Synbiotic Dairy and Food Products in Human Health and Nutrition*** (***SYNBIO* 2007**) held at Chennai on January 2007.
- 19th Indian Convention of Food Scientists & Technologists ***(ICFOST 2008***), held in IIT Kharagpur, West Bengal on December, 2007.
- **International Conference on *Fermented Foods: Nutrition, Health status and Social well-being"*** which was held at National Research Centre, Giza, Egypt on 13 - 15 Nov 2017.
- XXIV-Gujarat Science Congress 2010, Ahmedabad held at Gujarat University on 21st March 22, 2010.
- One day workshop on **"Solar Energy Utilization: Learning from the past"** at CSIR-CSMCRI on the 27th March, 2012.
- **International Conference on Industrial Biotechnology** (ICIB) 2012 conducted by the Biotech research Society, India during November 21-23' 2012 at Punjabi University, Patiala, Punjab, India.
- **International Conference on *Fermented Foods: Nutrition, Health status and Social well-being"*** held at National Research Centre, Giza, Egypt on 13 - 15 Nov 2017.
- **XXXII-** Gujarat Science Congress 2018, Bhavnagar during 4-5 February' 2018.
- Fifth International Conference on Nanomedicine and Tissue Engineering (ICNT 2018) 12-14 October 2018, Kottayam, Kerala, India.

Invited talks

- Delivered a expert talk at on "Microbial synthesis of biopolymers" at Parul University, Vadodara, Gujarat, India.
- Delivered an invited talk on "Bioprospecting of marine resources for biopolymer production for biomedical applications" at Fifth International Conference on Nanomedicine

and Tissue Engineering (ICNT 2018) during 12-14 October 2018 at Kottayam, Kerala, India.

- Delivered a talk on "Transforming wastelands for biofuels" at Consultative Workshop on Biofuel', to be held at Raipur (Chhattisgarh) on 25th and 26th May, 2016 conducted by Chhattisgarh biofuel development authority.
- Delivered a talk on "Brief Developments of CSMCRI's Marine Microbiology Group" at NIPE, University of Campinas on 10th May 2016.
- Delivered a talk on "Recent Developments on Microalgal Biofuel, Fermentative Production of ε-polylysine & Recovery of K value from mineralogical resources through bio-chemical means by CSIR-CSMCRI - An Overview" at IMMT, Bhubaneshwar during 11th July' 2014.
- Delivered a special talk in radio station (All India Akashwani, Rajkot) on Bioplastics and its microbial synthesis from biodiesel waste residue during November' 2012.

International visits

- Visit to University of Campinas, Sao Paulo, Brazil as a part of Indo-Brazil collaborative project.
- Visit to National Research Centre, Giza, Egypt on 13 - 15 Nov 2017.

Reviewer : Starch – Stärke Journal; Iranian Journal of Chemistry and Chemical Engineering (IJCCE); Journal of Research in Environmental Science and Toxicology; Journal of Advanced Research in Biotechnology.

Editorial Board Member, Biomaterials and Medical Applications, SciTechnol

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Date: 6th November' 2018

Synopsis of Research

Cultivation of microalgae in a cost effective manner for preparation of engine worthy biodiesel.

The main objective was to generate microalgal biomass in a cost-effective manner. In this regard, after extensive studies to optimize the growth conditions at lab scale as well as at bench scale, the focus was shifted to the study of growth under autotrophic conditions in open solar salt pans. The learning from laboratory studies was useful in identifying the most important inorganic nutrients for growth. Close observations in the laboratory also helped to decide on a practical harvesting protocol. The selected microalgae was grown in hypersaline environment in open solar salt pans even at high temperature for generation of sundried biomass at pilot scale. The mass cultivation was done in unused land of salt farm and the harvesting was done in a cost effective manner through drying the autosettled biomass. Extraction of oil was done at pilot scale through conventional solvent extraction for recovery of microalgal lipids. The fatty acid profile of the lipid extracted from *C. variabilis* showed its suitability for the biodiesel production. Thereafter, the extracted lipids were processes further for biodiesel preparation which was used for running an unmodified diesel motor vehicle successfully using the produced B100 biodiesel flagged off by late Shri Vilasrao Deshmukh, Minister S&T at CSIR Headquarters, New Delhi.

A floating microalgal mat present in the water in the eutrophic lagoon on the West Coast of India was explored for its bioaccumulation of lipids for sustainable utilization for biofuel production. The natural mat is widely spread and found to regenerate after a few weeks after it has been harvested. Considering harvesting of microalgae is energy intensive, taking advantage of the nature, the natural floating mat containing lipids was skimmed off and process further for sun drying and oil extraction at pilot scale. However, several optimizations have been done in the process for efficient oil extraction. The extracted oil was further processed for biodiesel preparation and an unmodified diesel vehicle ran using B20 microalgal biodiesel prepared from natural microalgal mats.

Process for Preparing Value-Added Products from Microalgae Using Textile Effluent through a Biorefinery Approach

A model was designed for effective utilization of textile effluent as the nutrient medium for the production of high-value products from Chlorella variabilis through a greener approach. Biomass productivity of 74.96 ± 2.62 g/m^2/d with lipid yield of 20.1 ± 2.2% (w.r.t. dry biomass) was obtained using textile effluent as the nutrient source. A novel integrated process is developed based on detergent (sodium dodecyl sulfate) hydrolysis to convert the carbohydrates present in microalgal biomass to reducing sugars for microbial fermentation, while making available lipids for downstream processing of γ-linolenic acid, leaving the protein rich fragment behind. Our experimental data showed that from 495 g of microalgal biomass, 109.4 g total lipids was extracted containing 34.65 g γ-linolenic acid, and 1.3 g pure ε-polylysine from 36.68 g of reducing sugars. A two-step efficient green process was developed for recovering ε-polylysine using ethyl ammonium nitrate having 74% recovery. In addition to value-added products, CSIR-CSMCRI's Chlorella variabilis (ATCC PTA 12198) can remediate 100% of aluminium, 82.72% boron, 45.66% calcium, 100% cobalt, 14.5% potassium, 0.1% magnesium, 42.18% sodium, 100% nickel, and 100% iron. A total decrease of 78.17% total phosphate and 25.22% total inorganic phosphate

with respect to total phosphate present in the effluent was observed.

Fermentative production of ε-polylysine utilizing by-product of biodiesel
ε-Polylysine (ε-PL) is a non-toxic biopolymer with antimicrobial properties. The production of ε-PL by a bacterial isolate from west coast of India was performed at shake-flask, followed by optimization of upstream process parameters for identifying the most significant medium components which affect ε-PL production through one factor at a time methodology and response surface methodology to determine the optimal concentrations of these components. Thereafter, Optimization of downstream process was carried for maximum recovery of ε-PL. Further improvements in media composition and culture conditions will be required to obtain better yields comparable to those obtained with current commercial strains such as *Streptomyces albulus*.

Stability of Phycobiliproteins Using Natural Preservative ε-Polylysine (ε-PL)
0.02% ε-polylysine (w/v) was found to be optimum for storage of C-PC and C-PE at 4 ± 2°C and lesser loss of CPC and C-PE content as compared to citric acid for its storage up to 8 days without any change in colour and pH. The amount of C-PC and C-PE left in the solution containing ε-polylysine was 90.5 and 95.24% respectively. Further, there is a need to replace chemical or synthetic preservatives with natural preservative ε-polylysine as prolonged consumption of these chemical or synthetic preservatives possess health hazard. The present work provides an effective option for replacing these chemical or synthetic preservatives with ε-polylysine as natural preservative.

Preparation of ε-polylysine based ionic gel for polypeptide packaging and biomaterial preparation in collaboration with Dr. Kamlesh Prasad, Natural Products and Green Chemistry Division. In this study, solubility, chemical and structural stability of ε-poly-L-lysine (ε-PL), in different ionic liquids (ILs) namely 2-hydroxyethyl ammonium formate (2-HEAF), 2-hydroxyethyl ammonium acetate (2-HEAA), choline formate (Ch-Formate) and choline acetate (Ch-Acetate) was studied. Maximum solubility (15% w/v) of the homopolypeptide was observed in 2-HEAF and lowest was found in Ch-Formate (2% w/v). After regeneration of the dissolved polypeptide in the IL, the IL could be recycled and reused in the dissolution process. Unlike in other ILs, 3–15% w/v of ε-PL in 2-HEAF gave formation of a thixotropic thermoreversible soft gel. Molecular docking studies established favourable interactions of $[2\text{-HEA}]^+$ cation over [Ch]+ with ε-PL indicating [2-HEA]+ as the most promising cation for the dissolution process. However, the role of the anions was also found to be important, which could lead to improvement in polypeptide solubility when combined to the selected cation. The findings demonstrate suitability of the ionic liquids for functionalization of polypeptides for biomaterial preparation.