Curriculum Vitae

1. Personal details and the date of the CV

- KUNDU
- PATIT PABAN
- Researcher ID: patit.kundu@ch.iitr.ac.in (Web of science ID:AAU-5364-2020); ORCID ID: https://orcid.org/0000-0003-1776-6427

- Date of the CV: 02.03.2024

2. Address

- **Correspondence Address**: 207/1 Saraswati Kunj, Indian Institute of Technology, Roorkee, Uttarakhand-247667.
- **Permanent Address**: 1-A-113, Akshara Whispering Willows, Salua, Rajarhat Road, Kolkata-700136 (West Bengal).

3. Degrees

S. No.	Qualification	University	Year	Subjects/Topics	% Achieved	Distinctions etc
1.	Ph.D.	Indian Institute of Technology, Kharagpur, India	1997	Polymer	-	
2.	M. Tech.	University of Calcutta, India	1992	Plastics & Rubber Tech	75%	2nd in university
3.	B. Tech	University of Calcutta, India	1989	Plastics & Rubber Tech	72%	5th in university
4.	B. Sc (Hons)	University of Calcutta, India	1986	Hons in Chemistry	53% in Hons	-

4. Other education and expertise

International academic exposure (if any)

Sl. No.	Post/assignment	University	Area of assignment	Duration		
				From	To	In years &months
1.	Post doctoral fellow	Inha University (S. Korea)	Polymer Sc & Technology	1.6.2001	15.5.2002	1 year

2.	Post doctoral research associate	Iowa State University (USA)	Polymer Sc & Technology	17.6.2003	29.6.2004	1 year
3.	Post Doctoral Fellow	Yonsei University (S. Korea)	Polymer Sc & Technology	1.6.2006	31.8.2006	3 months

5. Language skills

- Bengali, Hindi and English
- German course work during Ph.D.

6. Current employment

a.	Designation	Professor (full time, Permanent)
b.	Organization	Indian Institute of Technology, Roorkee, India
c.	Pay Scale	Matrix 14 A (Rs 1,58,000- 2,20,200) present scale of pay: 2,20,200 plus allowance (Total pay around 3500 USD)
d.	Date of appointment to the post	03.05.2016
e.	Total experience (in years and months)	Seven years and ten months

- Secondary occupations: No

7. Previous work experience

S. No.	Post	Organization /University	Duration		Experience (in years and months)
			From	To	
1.	Professor	IIT Roorkee	3.5.2016	Till date	7 years 10 months
2	Professor	University of Calcutta	29.9.2008	2.5.2016	7 years 7 months
3	Professor	SLIET, Longwal	5.3.2007	28.9.2008	1 year 6 months
4	Assistant professor (Reader)	SLIET, Longwal	5.3.1999	4.3.2007	8 years
5	Lecturer	SLIET, Longwal	1.10.1996	4.3.1999	2 years 5 months

6.a. Administrative Experience/Posts & responsibilities held

S. No.	Post	Organization /University	Duration		Experience (in years and months)
			From	To	
1.	Head of Department, Department of Polymer Sc & Technology	University of Calcutta	2.11.2010	1.11.2012	2 years
2	Professor-in-charge, Training & Placement	University of Calcutta	1.4.2009	31.12.2009	09 months
3	Head of Department	SLIET, Longowal	1.4.2005	31.03.2008	3 years
4	Coordinator /Head of the Department, Department of Disability Studies	SLIET, Longwal	1.09.2004	30.11.2005	1 year 2 months
5.	Chairman, Board of Studies	SLIET, Longowal	1.4.2005	31.03.2008	3 years
6	Chairman, Board of Studies	University of Calcutta	2.11.2010	1.11.2012	2 years
7	Member, Board of studies	Punjab Technical University	1.4.2000	31.03.2003	3 years
8.	Member of academic council (SENATE)	SLIET, Longowal	1.4.2007	28.09.2008	1 year 5 months
9	Member of academic council (SENATE)	SLIET, Longowal	29.03.2017	28.03.2019	Two years
10	Member of academic council (SENATE)	University of Calcutta	02.02.2012	1.11.2012	10 months
11	Member of executive council (BOG)	SLIET, Longowal	01.01.2007	31.12.2007	1 year
12	Others (specify) Member, Regional Advisory Council for CIPET, Uttarakhand	Ministry of Chemicals & Petrochemicals, Shastri Bhawan, New Delhi	1.10.2018	Till date	3 years 11 Months

6.b. Participation and contribution in relevant areas in higher education

	Organization	Area of specialization
Visiting Professor during the period of 7th May to 31 st May, 2018	Tripura University, Agartala, India	Polymer & Chemical Engineering
Resource person during 18-20- th July, 2012 at UGC-Network program in Materials	IISc, Bangalore, India	Summer STC Materials Engg UGC NET work
Others (if any) ***Expert delegate for Indo Italy joint meet on 17-19 Sept, 2018***	***University of camerino, Italy***	Indo-Italy joint meet on "Renewable Energy Technologies at crossroad of glocal energy grids"
Three week Training on Leadership by MHRD, GOI as "LEADERSHIP FOR ACADEMICIAN PROGRAMME"	Two weeks at IIT BHU and one week at Judges Business School, University of Cambridge	Leadership

6.c. Involvement with formulation of academic programme:

Details about teaching in Teaching Portfolio

Sl. No.	Nomenclature of innovative academic programme	Date of approval of academic council	Year of introduction
1.	B. Tech (Polymer Sc & Technology), CU	31.03.2011	2011 (new syllabus)
2.	M. Tech (Polymer Sc & Technology), CU	31.03.2011	2011 (new syllabus)
3.	M. Tech (Polymer Technology), SLIET	31.03.2007	2007

8. Career breaks

- No career break

9. Research funding and grants (All funded in India)

Sl No	Project Title	Agency	Period (mm/yyyy - mm/yyyy)	Amount (Rs. in lakhs)
1	Development of Anti microbial Polymeric Nanocomposite Film from PET waste for Packaging of Milk and Milk Product	Ministry of Food Processing Industries, GOI	02/2013-11/2015	48.29
2	Microbial Synthesis of Copolymers of Polyhydroxybutyroate from Waste Cooked Oil for Biomedical Applications	CSIR, New Delhi	01/2012-12/2014	15.0
3	Synthesis of Derivatives of Chitosan and Their IPNs for oral insulin Delivery	DST, Govt. of West Bengal	12/2012-11/2015	13.5
4	Modernization of Polymer Characterization Laboratory in the area of Polymer Biodegradation	AICTE, New Delhi	04/2013-03/2015	6.5
5	Development of High Performance Direct Methanol Fuel Cell	Ministry of New and Renewable Energy (MNRE), GOI	10/2010-09/2014	59.03
6	DST-FIST	DST, New Delhi	04/2012-03/2017	117
7	UGC-SAP; Polymer Nanotechnology: PET nanocomposite	UGC, New Delhi	10/2012-03/2017	48.1
8	Production of Bioelectricity from Sludge and Domestic wastewater using Microbial Fuel Cell	Ministry of Environment and Forests (GOI)	11/2009-03/2015	49.5
9	Development of Elastomers from Vegetable Oils and Vibration damping Characterization through a fabricated machine	UGC, New Delhi	04/2009-03/2012	10.1
10	Modified Chitosan as Nonviral vector in Gene therapy	AICTE, New Delhi	04/2010-03/2012	11.6
11	Design and Development of Bridge Bearing based on Metal Reinforced Rubbers	CSIR, New Delhi	11/1997-10/1999	2.0
12	Development of PET waste based Polyurethanes and its modeling studies	MHRD, New Delhi	07/1997-12/2000	10.0
13	Development of Novel Microporous Polyolefin Films for Disposable Diaper	CSIR, New Delhi	04/2005-03/2008	7.5
14	Modernization of Polymer Characterization Laboratory in the area of Polymer Biodegradation	AICTE, New Delhi	04/2011-03/2013	15.0

15	Delivery of Antisense oligonucleotides (ASO) to the androgen receptor of prostate cancer cells by nanoparticles: a prospective antitumoral strategy	Nanoscience and Nanotechnology Center, University of Calcutta	2010-2013	Rs 2 lakhs and a senior Research Fellow
16	Modified Chitosan as nonviral vector in gene therapy	Nanoscience and Nanotechnology Center, University of Calcutta	2009-2012	Rs 2 lakhs and a senior Research Fellow
17	Polymeric nanocomposites as Membrane for application in Microbial Fuel Cell	FIG Grant, IIT Roorkee	2016 -2018	10.0
18.	Proposal for the Development of Biodegradable woven PP/HDPE bags for packaging of 50 Kg of Cement	JSW cement, Mumbai	2020-2024	70,0 Lakhs

In addition, two consultancy projects were undertaken from the Industry during the stay at University of Calcutta.

10. Research output: **Details about Research in Research Portfolio**

- **Total of publications in peer reviewed journals: 232 (List as Annexure 1)**
- **Total No of Books/Book Chapters: 1 (edited)/12 (chapters)**
- **Patents: One US patent and one EP patent, Two Indian Patents and one applied for Indian patent.**

- Methods, software, infrastructures, materials, guides and tools developed: Details of materials and processes developed are given in research portfolio (past research experience).

(1) Biopolymers and Biomaterials:

(a) Oral Insulin Delivery

i. Mukhopadhyay, Piyasi; Maity, Subhajit; Mondal, Sudipta; Chkarborty, Abhay Sankar; Prajapati, A. K.; Kundu, P. P.(2018): Preparation, characterization and in vivo evaluation of pH sensitive, safe quercetin-succinylated chitosan-alginate core-shell-corona nanoparticle for diabetes treatment, Carbohydrate Polymers (Elsevier Science, Impact Factor 7.2), 2018 182, 42-51.

ii. Chitosan-graft-PAMAM/alginate core-shell nanoparticles: a safe and promising oral insulin carrier in Animal model, RSC advances, 5,93995-94007.

iii. Preparation, characterization and in vivo evaluation of pH sensitive, safe quercetin-succinylated chitosan-alginate core-shell-corona nanoparticle for diabetes treatment, Carbohydrate Polymers (Elsevier Science) 2018 182, 42-51.

(b) Bone tissue Engineering:

i. TiO_2 doped chitosan/poly (vinyl alcohol) nanocomposite film with enhanced mechanical properties for application in bone tissue regeneration, International Journal of Biological Macromolecules (Elsevier Sc, UK, IF 5.16), 2020, 143, Pages 285-296.

ii. Arundhati Bhowmick et al, Multifunctional zirconium oxide doped chitosan based hybrid nanocomposites as bone tissue engineering materials, Carbohydrate Polymers (Elsevier Sc, UK, IF 7.2), Volume 151, 20 October 2016, Pages 879-888,

iii. Development of biomimetic nanocomposites as bone extracellular matrix for human osteoblastic cells, Carbohydrate Polymers (Elsevier Sc, UK, IF 7.2), Volume 141, 5 May 2016, Pages 82-91.

(2) Environmental Biotechnology (Microbial Fuel Cell):

i. Utilization of proteinaceous materials for power generation in a mediatorless Microbial Fuel Cell by a new electrogenic bacteria Lysinibacillus sphaericus VA5. Enzyme and Microbial Technology (Impact Factor 3.5), Elsevier Publications**,** vol. 53 issue 5 October 10, 2013. p. 339-344.

ii. Effect of electric impulse for improved energy generation in mediatorless dual chamber microbial fuel cell through electroevolution of Escherichia coli, Biosensor and bioelectronics (Elsevier Sc, UK; I.F. 10.2), 79, 796-801. DOI: 10.1016/j.bios.2016.01.023:

iii. Performance Assessment of Partially Sulphonated PVDF-co-HFP as Polymeric Electrolyte Membrane in Single Chambered Microbial Fuel Cell, *Applied Energy*, Elsevier Publications (Impact Factor 8.8)**,** Volume 137, Pages 310–321:

iv. Graphite oxide incorporated crosslinked polyvinyl alcohol and sulfonated styrene nanocomposite membrane as separating barrier in single chambered microbial fuel cell, Journal of Power Sources (Elsevier Sc., UK; IF-8.2)**,** 341, 285-293:

(3) Industrial Biotechnology:

(a) Microbial Synthesis of Polymers

i. Modified bacterial cellulose based self-healable polyeloctrolyte film for wound dressing application. Carbohydrate Polymers. 2017;174:580-590

ii. A sustainable production method of mycelium biomass using an isolated fungal strain *Phanerochaete chrysosporium* (accession no: KY593186): Its exploitation in wound healing patch formation. Biocatalysis and Agricultural Biotechnology. 2018;16:548-557

iii. Curcumin entrapped gelatin/ionically modified bacterial cellulose based self-healable hydrogel film: An eco-friendly sustainable synthesis method of wound healing patch. International Journal of Biological Macromolecules (Elsevier Sc). 2019;122:940-953.

iv. A Mussel Mimetic, Bioadhesive, Antimicrobial Patch Based on Dopamine-Modified Bacterial Cellulose/rGO/Ag NPs: A Green Approach toward Wound-Healing Applications. ACS Sustainable Chemistry & Engineering. 2019, 7, 12083−12097.

v. Microbial Degradation of Linseed Oil-Based Elastomer and Subsequent Accumulation of Poly(3-Hydroxybutyrate-co-3-Hydroxyvalerate) Copolymer. Applied Biochemistry and Biotechnology, 2014, volume 174, pages1613–1630.

vi. Aromatic π-Conjugated Curcumin on Surface Modified Polyaniline/Polyhydroxyalkanoate Based 3D Porous Scaffolds for Tissue Engineering Applications, *ACS Biomater. Sci. Eng.* 2016, 2, 12, 2365–2377.

(b) Microbial Biodegradation of Polyethylene to valuable Products:

i. Biodegradation of polyethylene via complete solubilization by the action of Pseudomonas fluorescens, biosurfactant produced by Bacillus licheniformis and anionic surfactant. Journal of Chemical Technology & Biotechnology 93 (5), 1300-1311

ii. Anionic surfactant induced oxidation of low density polyethylene followed by its microbial bio-degradation, International Biodeterioration & Biodegradation**,** Volume 117, February 2017, Pages 255-268.

(4) PET Polymer Waste Management- Glycolization of PET waste

i. Synthesis and Characterization of Saturated Polyester and nanocomposites derived from Glycolyzed PET waste with varied compositions for food packaging applications. *Bulletin of Materials Science* (*Springer and Indian Academy, Bangalore*, Impact Factor:1.39). Vol. 36, No. 2, April 2013, pp. 277–286.

ii. Thermal and Mechanical Behavior of Unsaturated Polyester (Derived from PET Waste) and Montmorillonite filled nanocomposites synthesized by IN-SITU polymerization. *Journal of Applied Polymer Science ISSN: 1097-4628* (*John Wiley, USA,* Impact Factor: 2.25), 122/4, 2731-2740.

iii. Bhattacharyya, Aditi; Mukhopadhyay, Piyasi; Kundu, P. P. (2014): Synthesis of a Novel pH – sesitive Polyurethane-Alginate Blend with Polyethylene Terephthatlate waste for Oral Delivery of Protein, *Journal of Applied Polymer Science ISSN: 1097-4628* (*John Wiley, USA*). (Impact Factor: 2.25), *131*, 40650-40655.

iv. Bhattacharyya, Aditi; Mukherjee, Debarati; Mishra, Roshnara; Kundu, P. P. (2017): Preparation of polyurethane –alginate/chitosan core shell nanoparticles for the purpose of oral insulin delivery, European Polymer Journal (Elsevier Science, Impact Factor 3.76). 92, 294-313.

v. Fabrication of calcium hydroxyapatite incorporated Polyurethane-Graphene oxide Nanocomposite porous Scaffolds from Poly(ethyleneterephthalate) Waste: A Green Route toward Bone Tissue Engineering, Polymer (Elsevier Sc, UK, IF 4.23). 195, 122436-50**.** https://doi.org/10.1016/j.polymer.2020.122436.

(5) Alternate Energy (Direct methanol fuel cell):

i. Partial sulfonation of PVdF-co-HFP: A preliminary study and characterization for application in direct methanol fuel cell**. Applied Energy, Elsevier Publications (Impact Factor 8.848)**, 113, 169-177.
ii. Polymer electrolyte membrane with high selectivity ratio for direct methanol fuel cells: A preliminary study based on blends of partially sulfonated polymers polyaniline and PVdF-co-HFP, ***Applied Energy*, Elsevier Publications (Impact Factor 8.848)**, 2014; 118:183-191.
iii. Membrane prepared by incorporation of crosslinked sulfonated polystyrene in the blend of PVdF-*co*-HFP/Nafion: A preliminary evaluation for application in DMFC, ***Applied Energy*, Elsevier Publications (Impact Factor 8.848)**, 2014; 123:66-74.
iv. Nickel nanocatalysts supported on sulfonated polyaniline: potential toward methanol oxidation and as anode materials for DMFCs, **Journal of Material Chemistry A** (**Royal Chemical Society, UK, I.F 10.4**), 3 (21), 11349-11357; **DOI:** 10.1039/C5TA01837D.
v. Partially sulfonated polyaniline induced high ion-exchange capacity and selectivity of Nafion membrane for application in direct methanol fuel cells. ***Journal of Membrane Science*** (**Elsevier Science, I.F. 7.2**), Volume 473, Pages 94–101.
vi. Reduction of methanol crossover and improved electrical efficiency in Direct Methanol Fuel Cell by the formation of a thin layer on Nafion 117 membrane: Effect of dip-coating of a blend of Sulphonated PVdF-co-HFP and PBI, ***Journal of Membrane Sci.*, Elsevier Publications (Impact Factor 7.2),** Volume 474, Pages 140–147.

11. Research supervision and leadership experience

- **Guided six Post- Doctoral students and currently guiding one Post-Doctoral student.**

List of Post- Doctoral Fellows

Sl. No.	Name of Post Doctoral Fellow	Topic of Research	Area
1.	Dr. Vinay Sharma	Development of Vegetable oil based Polymers	Biopolymers and Biomaterials
2.	Dr. Tapas Mitra	Extraction of Collagen from Fish Scale and its use in Biomedical Applications	Biopolymers and Biomaterials
3.	Dr. Tanmoy Rath	Development of Polymer based Super-capacitor	Alternate Energy
4.	Dr. Piyush Kumar	Development of power efficient microbial fuel cell	Environmental Biotechnology
5.	Dr. Deepak Kumar	Development of core-shell polymeric carriers for treatment of colon cancer	Biopolymers and Biomaterials
6.	Dr. Geetanjali Ranjan	Efficient Microbial Fuel Cell	Microbial Fuel cell
7.	Dr, Dipankar Saha*	Development of Plastic oil as alternative to diesel by pyrolysis of waste polyethylene	Alternate Energy

*This Post Doc is still continuing

List of Ph.Ds. Awarded (23 Nos)

Sr. No.	Name of the student	Year	Title of the thesis	Singly/ Jointly
1.	Kamlesh Kumari (SLIET, Longowal)	2007	Chitosan Hydrogels for Modulated Drug Delivery and its modeling	Single
2.	Vinay Sharma (SLIET, Longowal)	2009	Synthesis of Linseed oil based Polymers and their Nanocomposites	Jointly
3.	Himadri Roy Ghatak (SLIET, Longowal)	2010	Study and Evaluation of Electrolysis as a treatment option for non-sulphur black liquor	Jointly
4.	Ratan Pal Singh Randwawa (SLIET, Longowal)	2010	Mesoporous Methylcellulose for controlled Hormone and Fertilizer Release	Jointly
5.	Sunain Katoch (SLIET, Longowal)	2010	Nanocomposite from Depolymerized PET Waste for Food Packaging Application	Jointly
6.	Kishor Sarkar (Calcutta University)	2013	Modified Chitosan as non-viral vector in Gene Therapy	Single
7.	Piyasi Mukhopadhyay (Calcutta University)	2015	Oral Delivery of Encapsulated Insulin with Modified Chitosan	Jointly
8.	Rakesh Das (Calcutta University)	2016	Development of Elastomers From Linseed oil And Vibration Damping Character-ization Through a Fabricated Machine.	Jointly
9.	Vikhas Kumar (Calcutta University)	2016	Analysis of system parameters and process optimization for bioelectricity production from microbial fuel cell using municipal sludge and industrial waste water	Single
10.	Piyush Kumar (Calcutta University)	2016	Development of polymeric electrolyte membranes and analysis of different operating parameters to improve the efficiency of DMFC.	Single
11.	Kingshuk Dutta (Calcutta University)	2016	Synthesis of Polyaniline and Sulfonated Polyaniline, and Their Application in Direct Methanol Fuel Cell	Single
12.	Arpita Nandy (Calcutta University)	2017	Approaches to improve the performance of pure culture driven Microbial Fuel Cell through genetic modification of microorganisms.	Single
13.	Arundhuti Bhowmick (Calcutta University)	2017	Development of Bioactive Polymer/ Hydroxyapatite Nanocomposites for Bone Tissue Engineering	Jointly
14.	Nilkamal Pramanick (Calcutta University)	2017	Microbial Synthesis of Polyhydroxy-alkanoates from waste carbon sources for biomedical applications	Jointly
15.	Aditi Bhattacharya (Calcutta University)	2017	Synthesis of Polyurethane from PET waste and its application in controlled protein delivery	Jointly
16.	Shritama Mukherjee (Calcutta University)	2017	Microbial degradation of Polyethylene	Jointly
17.	Suparna Das (Calcutta University)	2018	Development of low cost MEA for DMFC: Studies on PVdF, its copolymers and blends as PEM; and transition metal based alloys as catalyst.	Single
18.	Prasanta Pattanayak (Calcutta University)	2019	Development of cost effective catalyst for DMFC: studies on transition metal based alloy supported on conducting polymer as anode catalyst	Jointly (officiating co-guide)
19.	Moumita Khamrai (Calcutta University)	2020	Microbial synthesis of cellulose and their derivatives for biomedical application	Jointly (officiating

				co-guide)
20.	**Farhan Papiya Calcutta University)**	**2021**	**Development of novel membrane electrode assembly: synthesis of modified polybenzimidazole composites and transition metal based alloy as catalyst**	**Jointly (officiating co-guide)**
21.	**Amit Chaturvedi (IIT Roorkee)**	**2022**	**Development of Efficient Transition Metallic Cathode Electrocatalyst for Application in Single Chambered Microbial Fuel Cell**	**Single**
22.	**Amandeep Singh (Calcutta University)**	**2023**	**Development of antimicrobial polymeric nanocomposite film from PET waste for packaging of food products**	**Jointly (officiating co-guide)**
23.	**Simran Kaur Dhillon (IIT Roorkee)**	**2023**	**Development of Transition metal-nitrogen-carbon nano-composites as Electrocatalysts for application in Single Chamber Microbial Fuel Cell**	**Single**

List of M. Tech/M. Pharm. Theses

Sl.No	**Name of the Student**	**Title of Thesis**	**Degree Awarded**	**Year of Award**	**Name of University/Institute Awarding the Degree**	**Co-Supervisor (if any)**
1	Miss Rupali Sharma	Modelling of Crosslinked Chlorphenramine Maleate Drug Delivery from Carrier System of Chotosan and L-alanine	M. Tech.	2006	Punjab Technical University	-
2	Miss Ambika Sharma	Synthesis and Characterization of Polyethylene Terephthalate (PET) from Depolymerized PET and its Nanocomposite	M. Tech.	2006	Punjab Technical University	Dr. Kamlesh Kumari
3	Miss Hardeep Kaur	Synthesis and Characterization of Lignin-Phenol-Formaldehyde Resin Using Black Liquior (Industrial Waste)	M. Tech.	2006	Punjab Technical University	-
4	Reena Shrama	Synthesis and Characterization of Divinyl benzene Nanofibers/ PMMA- composite films	M. Tech.	2006	Punjab Technical University	-
5	Harpreet Kaur	In-vitro Drug Release Studies Through beads and tablets made	M. Tech.	2007	Punjab Technical University	-
6	Manoj Kumar Misra	Correlation between free sulphur contents and properties of rubber vulcanizates used for mount application	M. Tech.	2007	Punjab Technical University	Dr. K. C. Guriya

7	Michael Vinrald Samuel	Studies on modulated release of ascorbic acid (vitamin C) through various polymeric carriers	M. Tech.	2007	Punjab Technical University	Dr. Kamlesh Prasad
8	Charu Sharma	In –vitro drug release studies through beads made of Chitosan-methyl cellulose	M. Tech.	2008	Punjab Technical University	-
9	Rituparana Kakati	Study of the performances of various super plasticizers with the help of their slump and compressive strength tests	M. Tech.	2008	Punjab Technical University	Mr. Puneet Arora, Mr. H. R. GHatak
10	Nilutpal Phukon	Study of Silicone resin Emulsion for Architectural Exterior Coating	M. Tech.	2008	Punjab Technical University	Mr. Sanatan Hazra, Miss Subita Bhagat
11	Rishi Sehgal	Effect of Various Ingredients used during synthesis of Acrylic based Impact modifier in Polyvinyl chloride formulation	M. Tech.	2008	Punjab Technical University	Mr. Puneet Arora
12	Rajkumar Singh	Effect of Various Surfactants used during synthesis of acrylic based binder for development of latex paint	M. Tech.	2008	Punjab Technical University	Mr. Puneet Arora
13	Rahul Kumar Singh	Synthesis and Characterization of Nanocomposite Materials from Recycled PET	M. Tech.	2008	Punjab Technical University	Dr. Kamlesh Kumari
14	Rishi Srivastava	Transfection of Hela cells through Self aggregates Nano Particle of Chitosan with DNA	M. Tech.	2008	Punjab Technical University	Prof. D.J. Chattopadhyay
15	Pritha Mitra	Modification of Caly For awste water treatment by Efficient cation dye removal	M. Tech.	2013	University of Calcutta	-
16	Moumita Saha	Isolation and modification of different Biocompatible Polymers and their applications in Drug Delivery	M. Tech.	2014	University of Calcutta	-
17	Sovan Lal Banerjee	Stabilization of Chitosan-grafted Polyacrylamide/Silver Nanoparticles through Pegylation for efficient Antimicrobial Activity	M. Tech.	2014	University of Calcutta	-

18	Souma Chakraborty	Development of Glucosamine Polymeric formulation from waste exoskeleton of shrimp and its application on Arthritic model	M. Pharm.	2014	Sikkim University	Dr. Manash Bhowmik
19	Sarthik Samanta	Development of novel carriers for controlled drug delivery	M. Tech.	2015	University of Calcutta	-
20.	Ruchira Rudra	Crosslinked PVA based Polymeric Membranes for application in Microbial Fuel Cell	M. Tech.	2016	University of Calcutta	
21	Priya Das	Polymeric Membranes for Microbial Fuel Cell	M. Tech.	2018	IIT Roorkee	
22.	Sarim Khan	Development of polymeric nanocomposites and hydrogels for application in bone tissue engineering and advanced magnified analysis of proteome	Int. B.Tech and M.Tech. (5 yrs)	2020	IIT Roorkee	
23	**Rinki**	Nickel-Cobalt oxides coated on polypyrrole nanotubes as bifunctional electrode catalyst for enhancing the performance of the Microbial fuel cells (MFCs)	M.Tech	**2022**	**IIT Roorkee**	

List of M. Phil. Thesis

Sl.No	Name of the Student	Title of Thesis	Degree Awarded	Year of Award	Name of University/Institute Awarding the Degree	Co-Supervisor (if any)
1.	Sunain Katoch	Electrical and Optical Properties of Polyurethane Liquid Crystal Display made from Glycolyzed PET	M. Phil	2007	Periyar University, Salem	-

12. Teaching merits

The followings are short overview of my teaching merits. Details of teaching merits is demonstrated with a separate teaching portfolio.

- Taught a course on Polymer Blends
- Taught Polymerization kinetics and mechanism, Plastic Technology, Advanced Polymer Science (including polymer chemistry), Introduction to Polymer Engineering.
- Taught Novel Separation Techniques, Fluid and particle mechanics

13. Other key academic merits, such as:

- Acting as pre-examiner or opponent of a doctoral dissertation; memberships in doctoral dissertation committees or boards: Yes, 10 times.
- Acting as expert evaluator in recruitment and in evaluation of applications for the Title of Docent, for example: Yes, four times.
- Peer review of funding applications: Yes, several times.
- Memberships and positions of trust in scientific communities: NA
- Memberships in national or international expert, evaluation or steering groups and other expert roles (such as evaluation activities in the researcher's own scientific discipline) : Yes
- Memberships in editorial committees for scientific and professional publication series and journals or position as editor or editor-in-chief: No
- Referee for scientific publications: yes, several times.
- Administrative or working group positions in institutes of higher education and research organisations, higher education community roles, and national and international positions of trust in science and research administration (for example on ethics committees)
- Significant invited National/ international lectures:

National Talk (In India):

1. Delivered one invited talk on the topic "Polymeric Nanocomposites" during the period of 12th Nov, 2005 for the A. I. C. T. E. sponsored staff development programme, organized by Department of Physics, SLIET, Longowal.
2. Delivered one invited talk on the topic "Polymer Blends & Composites Used in Fuel Cell" during National Conference organized by the School of Physics & Material Science, Thapar University, Patiala on 2nd Feb 2007.
3. Delivered one invited talk on the topic "Response Surface Methodology as Optimization Tool in Rubber Compounding" at the national seminar organized by Department of Mathematics, SLIET, Longowal on Jan 20, 2007.
4. Delivered one invited talk on Linseed oil based polymers during international conference organized by Rubber Technology Center, IIT Kharagpur on 30.11.2011.
5. Delivered one invited talk on Polymeric vectors for gene delivery during national conference on Polymer at IISER, Kolkata on 11 th Dec, 2011.
6. Delivered one invited talk in the area of Direct methanol fuel cell in AICTE sponsored short tern course, organized by Material Science Center, IIT Kharagpur on 12 Nov, 2012.
7. Delivered one invited talk in the area of Linseed oil based polymers from cationic polymerizations at the UGC-NRC-M programme organized by the Department of Materials Engineering, IISc, Bangalore on 19 th July, 2012.
8. Delivered one invited talk in the area of Polymers in drug delivery at the International Polymer Conference organized by Kottayam University, Kerala on 28th Nov, 2014.

9. Invited talk on chitosan based polymeric carrier for drug delivery in the International Conference on "Harnessing Engineering, Technology, and Innovation for Sustainable Growth (HETIS-2016)" on 1st October 2016 organizedby DR SSB University Institute of Chemical Engineering and Technology, Panjab University, Chandigarh [formerly DCET, PU Chandigarh].
10. Invited talk on Development of Cathode catalyst for Microbial Fuel Cell delivered at IIT Kanpur on 6 th April, 2019 during the national conference organized in honour to Prof. Anil K Bhowmick on his retirement from the service from IIT Kharapur.
11. Delivered one invited talk in the SPARC funded workshop titled "Upscaling and field scale application of bio-electrochemical systems for wastewater treatment and bioenergy recovery" on February 27, 2020 at Indian Institute of Technology Kharagpur in the area of "Efficient cathode electro-catalyst in microbial fuel cell"

International Invited talk:

I. Delivered one international invited talk on the topic of "Applications of Polymers in Gene Therapy" at Yonsei Cancer Research Center, Faculty of Medicine, Yonsei University, South Korea on 21 st Dec, 2007.
II. Delivered one invited talk on Direct methanol and microbial fuel cell at the Bilateral Italy-India Workshop "***Renewable energy technologies at the crossroads of "glocal" energy grids***" held at the University of Camerino, Italy on 18th September 2018.

- **Organising scientific conferences:** Yes (three times).
- **Patents and inventions:**

1. Authors: Patit Paban Kundu and Ratan Pal Singh; Topic: Processes for cross-linking cellulose ethers under mild conditions; **US patent No 9,024,011, year 2015.**
2. Authors: Patit Paban Kundu and Ratan Pal Singh; Topic: Processes for cross-linking cellulose ethers under mild conditions; **European Patent No EP2576030B1, dated 01-03-2017.**

Sl. No	Patent No.	Year	Authors	Title
1.	US patent No 9,024,011	2015	Patit Paban Kundu and Ratan Pal Singh;	Processes for cross-linking cellulose ethers under mild conditions
2.	European Patent No EP2576030B1	2017	Patit Paban Kundu and Ratan Pal Singh	Processes for cross-linking cellulose ethers under mild conditions
3.	Indian Patent No 476144 (Jointly with JSW Cement)	2023	Patit Paban Kundu and D. K. Thirumalazhagan, Jagabandhu Kole and Mr. Nilesh Narwekar	Development of calcite filled biodegradable ribbons made from a blend of polypropylene, PBAT and PLA for cement packaging applications
4.	Indian Patent No 503713	2024	Patit Paban Kundu	Development of formaldehyde modified thermoplastic starch and its blending with LDPE for biodegradable packaging bags
5.	Indian Patent Appl No. IN 202211066668	21/11/2022	Patit Paban Kundu, Deepak Kumar	Development of biodegradable and water repellent polypropylene based coating material for packaging applications

- **Technology related to the patent application** "Development of formaldehyde modified thermoplastic starch and its blending with LDPE for biodegradable packaging bags" has been transferred to AGRSAR INNOVATIVES LLP, Greater NOIDA. One MOU is signed on 7th Sept, 2022 between IIT Roorkee and AGRSAR INNOVATIVES LLP, Greater NOIDA for the transfer of this technology for 18 lakhs. This is the highest amount till date for transfer of technology in IIT Roorkee.

- **Books written:**

• Books authored	• 12 (chapters)
• Editorship	• 01 (book editor)

- **Book Written by Professor P. P. Kundu**

  Kundu, Patit Paban and Datta, Kingshuk (editors): A book entitled "Progress and Recent Trends in Microbial Fuel Cells" 1st edition, 9 th June, 2018; published by Elsevier Science (UK), e**Book ISBN:** 9780444640185; **Paperback ISBN:** 9780444640178.

- **Book Chapters written by Professor P. P. Kundu**

1. Ruchira Rudra, Prasanta Pattanayak, Patit Paban Kundu, Book chapter on "Conducting Polymer-Based Microbial Fuel Cell" in "Enzymatic Fuel Cells: Materials and Applications", Volume No.-44, Page No.-173-187, February 2019, Name of the Publisher- Material Research Forum LLC (US).

2. Mukhopadhyay,Piyasi; Kundu, P. P. (2018): *Chapter 19 entitled* “Stimuli-responsive polymers for oral insulin delivery” in “stimuli responsive Polymeric Nanocarriers for Drug delivery Applications-Advanced nanocarriers for therapeutics” edited by Abdel Salam Hamdy Makhlouf and Nedal Y. Abu Thabit, Woodhead Publishing series in Biomaterials, Elsevier Group, UK.

3. Laha, Soumita; Dutta, Kingshuk; Kundu, P. P. (2018): Chapter 14 on “Biodegradation of Low density Polyethylene films” in the book “Handbook of research on microbial tools for environmental waste management” edited by Vinay Mohan Pathak and Navneet (IGI Global); Release Date: April, 2018; Pages: 496; ISBN13: 9781522535409, ISBN10: 1522535403, EISBN13: 9781522535416; DOI: 10.4018/978-1-5225-3540-9

4. Rudra, Ruchira; Kumar, Vikash; Nandy, Arpita; Kundu, Patit Paban (2018): Performances of separator and membrane –less MFC in the book entitled **"Microbial fuel cell: A bioelectrochemical system that converts waste to watts"** published by M/s. Capital Publishing Company, India and M/s. Springer, Switzerland; **ISBN 978-3-319-66793-5**.

5. Kundu, P. P. and Mondal, S. (2016): Polybenzimidazole as Membrane in Direct Methanol Fuel Cell *in* “***Novel Applications in Polymers and Its Waste Management”, Editors:*** *Badal Jageshwar Prasad Dewangan*, Maheshkumar Narsingrao Yenkie, Apple Academic Press (USA). **Hard ISBN:** 9781771884754, **E-Book ISBN:** 9781771884761.

6. Chatterjee, Abhipriya and Kundu, Patit Paban (2016): The Therapeutic Role of the Components of Aloe Vera in Activating the Factors that Induce Osteoarthritic Joint Remodeling in “***Novel Applications in Polymers and Its Waste Management”, Editors:*** *Badal Jageshwar Prasad Dewangan*, Maheshkumar Narsingrao Yenkie, Apple Academic Press (USA), **Hard ISBN:** 9781771884754, **E-Book ISBN:** 9781771884761.

7. Kundu, Patit Paban; Dutta, Kingshuk (2015): Current status of Hydrogen fuel Cell for portable application, Compendium of hydrogen energy Vol 4 (ed. Ball et al.), WoodHead Publishers, USA.

8. Dutta, Kingshuk; Kundu, Patit Paban; Kundu, Arunabha (2014): Fuel cells – exploratory fuel cells: Micro-fuel cells in “Chemistry, Molecular Sciences and Chemical Engineering” Edited by Jan Reedijk, Elsevier Publisher, UK.

9. Kundu, Patit P. and Sarkar, Kishor (2011): Natural Polymric Vectors in Gene Therapy in “Biopolymers: Biomedical and Environmental Applications” Edited by Sushel Kalia and Luc Averous, John Wiley and Sons, USA.

10. Kundu, P. P.; Sharma, Vinay; Kumari, Kamlesh (2011): Chitosan copolymers and IPNs for controlled drug delivery in “Chitosan: Manufacture, Properties, and Usage”, Nova Science Publishers, Inc.

11. Bhowmick, Arundhuti; Banerjee, Subhas; Kundu, P. P. (2013): Chapter 197 entitled “Hydroxyapatite packed chitosan-PMMA nano-composite: a promising material for construction of synthetic bone”, in the book “Multifaceted Development and Applications of Biopolymers towards Biology, Biomedical and Nanotechnology”, edited by Pradip Dutta and Joydip Dutta (Springer, USA).

12. Kundu, P. P.; Nandy, Arpita; Mukherjee, Amrita; Pramanick, Nilkamal (2013): chapter entitled “Microbial Synthesis of Polyhydroxyalkanoates and its Biomedical Applications”, Encyclopaedia on Biomedical Polymers and Polymeric Biomaterials (Taylor and Francis, USA).

TEACHING PORTFOLIO

Of

PROFESSOR PATIT PABAN KUNDU

Documentation of teaching qualifications

1. Participation in courses and training

1.1 Participation in courses:

For the last twenty-five years, I taught various courses at Department of Chemical Engineering, Indian Institute of Technology, Roorkee, Department of Polymer Science & Technology, University of Calcutta, Kolkata and Department of Chemical Engineering, SLIET, Longowal (Deemed University), Punjab. As I have worked in three different Institutes in my teaching career, I have to adjust according to the need of technical education required for that particular Institute. My 1st Institute (SLIET, Longowal) was primarily a teaching institute engaged in teaching in vocational and technical education. Although, I primarily engaged in teaching UG students (these students are promoted to the UG programme from these vocational programmes), still I had to teach from the very basics such that they can understand the science behind. For my 2nd university (Department of Polymer Sc & Technology, University of Calcutta, Kolkata), it is pretty easy as the UG students admitted in the technology programmes are basically post graduate students as the students admitted in UG technology programmes are already science undergraduate (a prerequisite for admission in UG Polymer Sc & Technology programme is B.Sc honours in chemistry). Thus, they have the primary knowledge of chemistry and I as teacher can start directly to the technology of polymers and polymerization. Moreover, due to strong link with the industry, we are able to help in providing jobs to the students. As a teacher, only thing, I need to be adjusted, is allowing some students to enter in the class even when class is already started; the students are late due to several factors such as traffic jam, late train etc (Kolkata is a big cosmopolitan city). My current and 3rd Institute (Indian Institute of Technology, Roorkee) is a premier institute (institute of National Importance, INI); even it is highly ranked in world level (QS Rank 380). Here, students are placed in campus interview but they are mostly placed in service sector (non-core engineering sector). This is a big problem for teachers who are engaged in teaching the core engineering subjects. The majority of students know that they will be recruited in either ICT, service or finance. Thus, they have no interest in learning the core subjects like Polymer Science & Engineering. On the other hand, IIT Roorkee is a research Institute, engaged in research at PG level (thesis) and Ph.D. level. Thus, as a teacher, I need to adjust a lot during teaching at UG and PG level. My approach of teaching at the UG level is to keep it simple, problem oriented like citing examples of use of polymers in everyday life. In PG and Ph.D. level courses, I always prefer to cite practices at our laboratory. This makes the class more interesting.

1.2 Participation in Training

I participated in one leadership training organised by Indian Institute of Technology, Benarash, India and Judges business school, University of Cambridge, UK (two weeks during Dec 8 to 21st, 2019 at IIT Banaras, India and one week during 20 to 24 th Jan, 2020 at University of Cambridge, UK). In this training, teaching pedagogy using ICT was emphasized. Also, the evolution of a teacher as a leader, both in the class and in the lab is also discussed. A leader is one who has follower. A true teacher is a true leader when he has followings among the students.

2. Roles in higher education

2.1 Role as Course Coordinator, instructor, teacher and counsellor

The following eleven courses were taught by me and I also worked as course coordinator for these courses. All the courses were of one semester duration. As a teacher, I try to cover as much as possible the curriculum. But, my didactics is not limited to printed curriculum. In the students, I try to inculcate an attitude of seeking knowledge. My current students are of Z-generation having more materialistic attitude and thus, they are more vulnerable to mental disturbance. As a teacher and as counsellor, I try to instil the feeling that they should think about their parents who want them to be good human beings. The aim of education is not for earning good money. The aim of education is to gain knowledge which can be useful for the prosper of the society, nation and as whole world. I always try to instil this essence of knowledge in my students.

Course No 1:

Role: course coordinator, instructor, teacher and counsellor.

No of times taught: I have taught the following course two times to the 3rd Semester undergraduate (UG) students of the department at Indian Institute of Technology, Roorkee.

NAME OF DEPTT./CENTRE: **Department of Chemical Engineering**

1.Subject Code: **CH -203** Course Title: **Mechanical Operations**

2.Contact Hours: **L: 3** **T: 1** **P: 2/2**

3.Credits**:** **4** 5. Semester**: Autumn**

6. Pre-requisite: **Nil**

7. Objective: To impart Knowledge on particle size analysis, size reduction, separation of solid particles from fluids and flow through porous media.

8. Details of Course:

S. No.	Contents	Contact Hours
1.	**Particles Size Analysis:** Sieve analysis, size distribution, size averaging and equivalence, size estimation in sub-sieve range, effectiveness of screen.	**4**
2.	**Size Reduction:** Theory of crushing and grinding, laws of crushing and grinding, crushing and grinding equipment and their selection.	**4**
3.	**Storage of Solids:** Angle of slide and repose, design of bins, silos, and hoppers, Jansen's equation.	**4**
4.	**Particle Mechanics:** Motion of particle in fluid, effect of particle	**4**

	shape, Stoke's law, hindered settling, jigging and classification.	
5.	**Sedimentation and Flotation:** Gravity and centrifugal sedimentation, design of sedimentation tank and continuous thickeners, mechanism of flotation, flotation agents and flotation equipment.	**6**
6.	**Flow Through Packed Beds:** Characteristics of packings, flow of a single fluid through a packed bed, problem of channeling and wetting, counter current gas- liquid flow through packed beds, loading and flooding characteristics, industrial applications.	**6**
7. **8.**	**Fluidization:** Fluidization characteristics, aggregative and particulate fluidization, voidage and minimum fluidization velocity, characteristics, industrial applications of fluidization. **Filtration:** Flow through filter cake and medium, washing and	**5** **5**
	drying of cake, filter aids, selection of filtration equipment, constant	
  9.	rate and constant pressure filtration. **Conveying of Solids:** Pneumatic and hydraulic conveying of solids,	 **4**
	general characteristics and flow relations, mechanical conveyers. **Total**	 **42**

Suggested Books:

S.No.	Name of Authors/ Books/Publishers	Year of Publication
1.	Backhurst, J. R. and Harker J. H.,"Coulson and Richardson Chemical Engineering", Vol. II",5th Ed., Butterworth-Heinemann.	2002
2.	Brown G.G. and Associates,"Unit Operations",CBS Publishers.	1995
3.	McCabe W.L., Smith J.C and Harriott P., "Unit Operations of Chemical Engineering", 7th Ed. , McGraw Hill.	2005
4.	Geankoplis C.J., Transport Processes and Separation Process Principles, 4th Ed.,Prentice Hall.	2003
5.	Narayanan C.M. & Bhattacharya B.C., "Mechanical Operation for Chemical Engineers –Incorporating Computer Aided Analysis", Khanna Publishers.	1992

Course No 2:

Role: course coordinator, instructor and teacher and counsellor.

No of times taught: I have taught the following course one time to the 1st Semester undergraduate (UG) students of the department at Indian Institute of Technology, Roorkee.

NAME OF DEPTT/CENTRE: **Department of Chemical Engineering**

1. Subject Code: **PEN-101** Course Title: **Introduction to Polymer Science and Engineering**
2. Contact Hours: **L: 2** **T: 0** **P: 0**
3. Examination Duration (Hrs.): **Theory:2** **Practical:0**
4. Relative Weightage**: CWS :0** **PRS : 0 MTE : 100** **ETE:0 PRE:0**
5. Credits**: 2** 6. Semester**: Autumn** 7. Subject Area**: PCC**
8. Pre-requisite**: Nil**

9..Objective: To impart introductory knowledge of polymer engineering

9. Details of Course:

S. No.	Particulars	Contact Hours
1	**Introduction:** Types of polymers; Blends; Composites; Materials and applications of polymers	1
2	**Engineering Polymers:** Types of engineering polymers; Thermoplastics; Thermosets; Elastomers; Polyolefins; Polyethylene; Polypropylene	5
3	**High Performance Polymers:** Types of high performance polymers; Polyesters; Polycarbonate; Polyamide; Polyetherimides; Poly-amide-imide; High temperature Resistant polymers; Lyotropic and thermotropic liquid crystal polymers	5
4	**Polymer Engineering**: Polymerization engineering; Polymer Processing; Additives; Polymer products; Processing; Introduction to rheology and various polymer processing techniques and equipment	6
5	**Polymeric Systems and Materials** Polymer blends; Polymer Composites; Rubbers and elastomers; Films and fibers; Bio; bio-degradable and bio-medical polymers and functional polymers	6
6	**Applications of Polymers:** Applications of polymers in commodity Electronics; Medical and other applications; Conducting polymers	5

	Total	**28**

11. Suggested Books

S. No.	Name of Authors / Books / Publisher	Year of Publication
1.	H. S. Kaufman, J. J. Falcetta, "Introduction to Polymer Science & Technology"' SPE Textbook, John Wiley & Sons	2010
2	D. J. Williams, "Polymer Science & Engineering", Prentice Hall, Inc.	2010
3.	V. R. Gowariker, N. V. Vishwanathan, Jaydev Sreedhar, "Polymer Science", New Age (I)	2011

Course No 3:

Role: course coordinator, instructor and teacher and counsellor.

No of times taught: I have taught the following course two times to the 3rd Semester undergraduate (UG) students of the department at Indian Institute of Technology, Roorkee**.**

NAME OF DEPT./CENTRE: **Department of Chemical Engineering**

1. Subject Code: **CHN-211** Course Title: **Fluid and Fluid Particle Mechanics**

2. Contact Hours: **L: 3** **T: 1** **P: 2/2**

3. Examination Duration (Hrs.): **Theory:3** **Practical :0**

4. Relative Weightage**: CWS:20** **PRS:20 MTE:20** **ETE:40 PRE:0**

5. Credits**: 4** 6. Semester**: Autumn** 7.Subject Area**: PCC**

8. Pre-requisite**: Nil**

9. Objective: To provide knowledge of particle size analysis, size reduction, separation of particles by filtration, sedimentation and flow through porous media.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Particle Size Reduction and Analysis:** Theory of crushing and grinding, crushing and grinding equipment and their selection. Sieve analysis, size	**6**

	distribution, size averaging and equivalence, size estimation in sub-sieve range,	
2.	**Storage of Solids :**Bins, silos, hoppers, Janseen's equation.	**2**
3.	**Fluid Handing Machinery and Flow Measurement:** Pumps; Blowers and compressors- classification, operating and performance characteristics, selection criteria and design specifications; Constant area and constant head meters; Weirs and notches.	**7**
4.	**Particle Mechanics :**Motion of particles in fluid, effect of particle shape, Stock's law, hindered settling, jigging and classification	**4**
5.	**Sedimentation and Flotation:** Gravity and centrifugal sedimentation, design of sedimentation tanks and continuous thickners, mechanism of flotation, flotation agents, coagulants and flotation equipment.	**6**
6.	**Filtration :**Flow through filter media and formation of cakes, washing and drying of cake, filter aids, selection of filtration equipment, constant rate and constant pressure filtration.	**4**
7.	**Flow Through Packed Beds :**Characteristics of packings, flow of a single fluid through a packed bed, problems of channeling and wetting, counter-current gas-liquid flow through packed beds-loading and flooding	**5**
	characteristics.	
8.	**Fluidization and Solid Conveying :** Fluidization characteristics, aggregative and particulate fluidization, voidage and minimum fluidization velocity, voidage correlations, gas-solid fluidization characteristics; Pneumatic and hydraulic transport of solids-general characteristics and flow relations	**8**
	Total	**42**

11. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	Backhurst J. R.and Harker J. H., "Coulson and Richardson Chemical Engineering", Vol. II", 5th Ed., Butterworth-Heinemen.	2002
2.	Brown G. G., "Unit Operations", CBS publishers.	1995
3.	Narayanan C.M. and Bhattacharya B.C., "Mechanical Operations for Chemical Engineers-Incorporating Computer Aided Analysis", Khanna publishers.	1992
4.	McCabe W. L., Smith J. C. and Harriott P., "Unit Operations of Chemical Engineering", 7th Ed., McGraw Hill.	2005

Course No 4:

Role: course coordinator, instructor and teacher and counsellor.

No of times taught: I have taught the following course one time to the 3rd Semester undergraduate (UG) students of the department at Indian Institute of Technology, Roorkee**.**

NAME OF DEPTT./CENTRE: **Department of Chemical Engineering**

1. Subject Code: **PEN-203** Course Title: **Polymer Blends**
2. Contact Hours: **L: 2** **T: 1** **P: 0**
3. Examination Duration (Hrs.): **Theory:2** **Practical :0**
4. Relative Weightage**: CWS:25** **PRS:0 MTE:25** **ETE:50 PRE:0**
5. Credits**: 3** 6. Semester**: Autumn** 7. Subject Area**: PCC**
8. Pre-requisite**: Nil**

9 Objective: To impart knowledge of principles, properties, and applications of polymer blends

10 Details of Course:

S. No.	Contents	Contact Hours
1	**Introduction:** Introduction to polymer solutions, polymer blends, rubber toughened plastics, interpenetrating networks, molecular composites.	**2**
2	**Miscibility and Phase Separation:** Polymer-polymer miscibility, thermodynamic theories of miscibility, factors governing miscibility, prediction and enhancement of miscibility; Immiscible systems and phase separation; binodal and spinodal decomposition.	**5**
3	**Compatibility and Compatibilization:** Immiscible and compatible systems; compatibility and compatibilization; compatibilization by block, graft and randon copolymers, compatibilization by functional polymer, compatibilization by reactive blending	**5**
4	**Blends of Semi-Crystalline Polymers:** Blends of an amorphous polymer / a semi-crystalline polymer; structure and morphology of a blend of anamorphous polymer / a semi-crystalline polymer; crystallization in a blend of anamorphous polymer / a semi-crystalline polymer; blends oftwosemi-crystalline polymers, structure and morphology of a blend of two semi-crystalline polymers; crystallization in a blend of two semi-crystalline polymers	**4**
5	**Rubber Toughened Polymers**: Toughening mechanism, rubber	**6**

	toughening, processing, structure, properties and morphology of rubber toughened polymers.	
6	**Molecularly Reinforced Polymer Blends**: Molecular composites, self reinforced LCP blends, macromolecular nano composites, rigid polymer, flexible polymer solvent ternary systems, solution processing, melt processing, properties, applications.	4
7	**Interpenetrating Networks:** Introduction, processing, properties, and applications.	2
	Total	**28**

11. Suggested Books

S. No.	Name of Authors / Books / Publisher	Year of Publication
1.	Hope P. and Folkes B.M., "Polymer Blends and Alloys", Blackie.	**1993**
2.	Paul D.R. and Sperling H.S., "Multicomponent Polymer Materials", ACS.	**2005**
3.	Paul D. R. and Newman S., "Polymer Blends", Vol-1&2 Academic Press.	**2008**
4.	Utracki L. A., "Polymer Alloys and Blends", Hanser.	**2007**

Course No 5:

Role: course coordinator, instructor and teacher and counsellor.

No of times taught: I have taught the following course five times to the 8th Semester undergraduate (UG) students, 2nd Semester Post Graduate (PG) students and Ph.D. students of the department at Indian Institute of Technology, Roorkee.

NAME OF DEPARTMENT: **Department of Chemical Engineering**

1. Subject Code: **CHE-534** Course Title: **Novel Separation Techniques**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Relative Weight: **CWS: 20-35 PRS: 0 MTE: 20-30 ETE:40-50 PRE: 0**

5. Credits**: 4** 6. Semester**: Spring** 7.Subject Area**: PEC**

8. Pre-requisite**: Nil**

9. Objective: To provide knowledge of advance separation processes used in chemical and biochemical industries.

10. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Separation processes in chemical and biochemical industries, categorization of separation processes, equilibrium and rate governed processes.	**3**
2.	**Membrane Separation:** Membrane materials, Polymeric membranes, Asymmetric and symmetric membranes,Perm-selectivity, Physical factors in membrane separation, Pore size, osmotic pressure, partition coefficient and permeability; Transport through porous membranes- bulk flow, gas diffusion, Knudsen diffusion, liquid diffusion; Transport through nonporous membranes, solution diffusion for liquid mixtures, solution diffusion for gas mixtures, membrane separation factor, ideal membrane separation factor, external mass transfer resistances, concentration polarization and fouling.	**8**
3.	**Membrane separation processes:** Dialysis, electro-dialysis, reverse osmosis, Gas permeation, pervaporation, Liquid membrane separation.	**9**
4.	**Adsorption:** Sorbents, adsorbents, surface area and BET equation, Pore volume and distribution, adsorbent materials- silica gel, activated carbon, molecular sieve carbon, molecular sieve zeolite and polymeric adsorbent. **Ion exchange**: Inorganic ion exchangers, Ion exchange resins, ion exchange capacity of resins, anion exchange and cation exchange resins; Ion exchange equilibria. **Chromatography:** Sorbents for chromatography, types of chromatography, ion exchange chromatography, Gel permeation chromatography, application of chromatography.	**9**
5.	**Adsorption kinetics and thermodynamics:** Adsorption isotherms-Freunlich and Langmuir isotherm, gas mixtures and extended isotherms, composite isotherms for binary liquid adsorption**.**	**4**
6.	**Kinetic and transport considerations in adsorptions:** Convection dispersion model, modes time dependent adsorption- frontal, displacement and differential; internal transport, external transport, effective pore diffusivity; ideal fixed bed adsorption, real fixed bed adsorption-mass transfer zone, breakthrough curves, effect of favorable and unfavourable isotherms, scaling of laboratory experiment using constant pattern front.	**9**

		Total	**42**

11.	Suggested Books:	
S. No.	**Name of Books / Authors**	**Year of Publication**
1.	King C. J., "Separation Processes", Tata McGraw Hill.	1982
2.	Seader J. D. and Henley E. J. "Separation Process Principles", 2nd Ed., Wiley-India.	2006
3.	Basmadjian D., "Mass Transfer and Separation Processes: Principles and Applications", 2nd Ed., CRC.	2007
4.	Khoury F. M., "Multistage Separation Processes", 3rd Ed., CRC.	2004
5.	Wankat P. C., "Separation Process Engineering", 2nd Ed., Prentice Hall.	2006

Course No 6:

Role: course coordinator, instructor and teacher and counsellor.

No of times taught: I have taught the following course five times to the 2nd Semester undergraduate (UG) students of the department of polymer science & technology at University of Calcutta, Kolkata.

NAME OF DEPTT./CENTRE: **Department of Polymer Science & Technology**

1. **Subject: Mechanism and Kinetics of Polymerization**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Credits**: 4** 5. Semester**: Spring**

6. Pre-requisite**:** **Nil**

7. Objective: To provide basic understanding of kinetics and mechanism of polyemrization

8. Details of Course:

S. No.	**Contents**	**Contact Hours**
1.	**Introduction:** polymer, monomer, Classification of Polymers	**4**

2.	**Addition polymerization:** free radical, anioic and cationic polymerization. overall scheme, rate expression for cationic and anionic polymerization **Kinetics and mechanism of free radical polymerization:** overall scheme, rate expression for radical polymerization; integrated rate of polymerization expression; methods of initiation: thermal decomposition, redox initiation, photochemical initiation; dead-end polymerization; chain length and degree of polymerization, kinetic chain length, chain transfer, deviation from ideal kinetics, autoacceleration, polymerization-depolyerization equilibrium.	**12**
4.	**Kinetics of Copolymerization by radical chain polymerization**: binary copolymer equation, types of copolymers, integrated binary copolymer equation.	**8**
5.	**Kinetics of ionic polymerization:** anionic, cationic and coordination polymerization.	**8**
6.	**Kinetics of condensation polymerization:** reactivity of functional groups, average functionality, Rate expression for condensation polymerization- catalyzed and non-catalyzed; equilibrium considerations- closed and open drive system; control of molecular weight, branching and crosslinking.	**10**
	Total	**42**

7. Suggested Books:

S. No.	**Authors / Name of Book / Publisher**	**Year of Publication**
1	Ghosh, Premamoy, "Polymer Science and Technology: Plastics, Rubber, Blends and Composites", Tata McGraw Hill, 3rd Ed.	2017
2	Chanda, Manas, "Advanced Polymer Chemistry: A Problem Solving Guide", Marcel Dekker, 1st Ed	2000
3	Carraher, C.E., "Polymer Chemistry", CRC Press, 10th Ed.	2017
4	P.J. Flory, Principles of Polymer Chemistry, Cornell University Press	1995

Course No 7:

Role: course coordinator, instructor and teacher and counsellor.

No of times taught: I have taught the following course two times to the 2nd Semester postgraduate (PG) students of the department at University of Calcutta, Kolkata.

University of Calcutta

NAME OF DEPT./CENTRE: **Department of Polymer Science & Technology**

Course Title: **Bio- Polymer Science & Technology**

Contact Hours: **L: 3** **T: 1** **P: 0**

Examination Duration (Hrs.): **Theory: 3** **Practical :0**

Credits: **4** Semester: **Spring**

1. Pre-requisite: **Nil**

2. Objective: To impart knowledge about biopolymers and their applications, engineering and processing.

3. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Definition, examples, applications and classification of biopolymers based on different sources; General characteristics of biopolymers; Advantages and disadvantages of biopolymers.	**5**
2.	**Synthesis and Characterization of Bio-polymers:** Structure and properties of proteins, polysaccharides, DNA, RNA, glycoproteins, proteoglycans, glycosaminoglycans.	**8**
3.	**Biodegradation of Biopolymers:** Mechanism of biodegradation; Biodegradation kinetics.	**4**
4.	**Engineering of Biopolymers:** Principles of engineering the properties of biopolymer molecules; Chemical modification; Biopolymer based composites and blends.	**8**
5.	**Biopolymer Processing:** Process technology for the production of biopolymeric nanoparticles, nanofibers, nanofilms, microfilms, 3D architecture of any shape.	**8**
6.	**Application of Biopolymers**: Application of biopolymers in tissue engineering, medical surgery, drug delivery, wound healing, packaging, automobile industry, electronics industry, household items	**9**
	TOTAL	**42**

4. Suggested Books:

S. No.	Name of Books / Authors /Publisher	Year of Publication / Reprint
1.	Dumitriu S., "Polymeric Biomaterials", Marcel Dekker.	2002
2.	Hyon S. H., "Polymeric Biomaterials", Plennum Press.	1984
3.	Mark H. F., (Ed.) "Encyclopaedia of Polymer Science and Engineering", John Wiley & Sons.	1989
4.	Shuiz S. and Bhirmer K., "Principles of Protein Structure", Academic Press.	2003
5.	GuilakF., Butler D.L., Goldstein S.A. andS.A. Mooney, "Functional Tissue Engineering", Springer-Verlag New York, 1st Edition.	2003

Course No 8:

Role: course coordinator, instructor and teacher and counsellor**.**

No of times taught: I have taught this course seven times to the 3rd Semester undergraduate (UG) students of the department at University of Calcutta, Kolkata.

NAME OF DEPT./CENTRE: **Department of Polymer Science & Technology**

Course Title: **Plastics Technology 1**

Contact Hours: **L: 3** **T: 1** **P: 2**

Examination Duration (Hrs.): **Theory: 3** **Practical :2**

Credits: **4** . Semester: **Autumn**

Course Details:

Sl. No.	Topic content	Lecture
1.	Polyethylenes; modified polyethylenes, Polypropylene and copolymer of PP, modified Polyolefins like crosslinked & filled polyolefins, Polyisobutylene.	(10)
2.	Engineering Polymers Polyesters such as PET, PBT, Polycarbonates, Polyacetal	(6)
3.	Polyester Resins- unsaturated polyesters resins: Raw material: poly-basic acids, polyfunctional glycols. Curing of resins through unsaturation of the resin/polymer backbone. Curing systems, catalysts and accelerators. Polyester based composites & their recipes, Water reducible polyesters, high solid polyesters/ polyesters for powder coatings Moulding compositions, DMC,SMC,fibre and film forming compositions.	(10)
4.	Phenolics: Basic components of the polymer. Different kinds of phenols and their derivatives, different kinds of aldehydes used. Novolacs and Resol: effect of the ratio of phenol to aldehyde on the nature and the property of the polymer. Theory of resinification and effect of pH on the reaction mechanism and the reaction product. Curing of phenolics; Modification of phenolics such as novolac-epoxy oil soluble and oil reactive. Phenolic moulding compounds, ingredients, compounding and applications.	(9)
5.	Amino resins: Basic raw materials used like urea/melamine/ aniline/ formaldehyde. Synthesis of UF and MF resins. Theory of resinification and effect of pH on the reaction mechanism and the reaction product. Properties and application of the UF, MF and AF resins, Modification of resins with alcohols and phenols, Moulding materials, compounding, processing and applications.	(7)
	Total	**(42)**

Suggested Books:

1. Handbook of Thermoplastics, O. Olabisi, Marcel Dekker, 1997.
2. Plastics Materials J. A. Brydson, Butterworth Scintific, 1990.
3. Polymer chemistry, Seymour and Carraher, Marcel Dekker, 2003.
4. Structures of Cellulose, Atlla, American Chemical society, 2003.
5. Styrene Based Plastics and their Modifications, Svec, Ellis Harwood, 1991

Course No 9:

Role: course coordinator, instructor and teacher and counsellor.

No of times taught: I have taught the following course seven times to the 3rd Semester undergraduate (UG) students of the Department of Chemical Engineering, at SLIET, Longowal, Punjab.

NAME OF DEPTT./CENTRE: **Department of Chemical Engineering**

1. Course Title: **Chemical Process Calculations**

2.Contact Hours: **L: 3** **T: 1** **P: 0**

3.Examination Duration (Hrs.): **Theory : 3** **Practical : 0**

4.Credits**: 4** 5. Semester**: Autumn**

6.Pre-requisite**:** **Nil**

7. Objective: To provide basic knowledge of principles of material and energy balances applied to chemical engineering systems.

8. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** Units and dimension in chemical engineering, units conversion of dimensional equations, stoichiometric and composition relations, concept of degrees of freedom and linear independence of a set of equations.	**5**
2.	**Material Balance:** Concept of material balance, open and closed systems, steady state and unsteady state, multiple component system, selection of a basis, problem solving strategy.	**4**
3.	**Material Balance without Chemical Reaction for Single and Multiple Units:** Conservation of mass/atom, material balance for systems without chemical reactions involving single unit and multiple units.	**5**
4.	**Material Balance with Chemical Reaction for Single and Multiple Units:** Concept of excess reactant, extent of reaction, material balance for systems with chemical reactions involving single unit and multiple units.	**6**
5.	**Recycle, Bypass, Purge and Industrial Applications:** Calculations for a cyclic processes involving recycle/ purge/ bypass, material balances involving gases, vapors, liquids and solids and use of real gas relationships, material balance involving gases, vapors, liquids & solids and uses of real gas relationships, vapor-liquid equilibrium and concepts of humidity & saturation, analysis of systems with	**7**

6.	bypass, recycle and purge, analysis of processes involving condensation, crystallization and vaporization. Energy Balance: Conservation of energy with reference to general energy balance with and without chemical reactions, chemical engineering problems involving reversible processes and mechanical energy balance.	4
7.	Applications of Energy Balance: Calculations of heat of change of phase (solid – liquid & liqid – vapor), heat of reaction, heat of combustion, heat of solutions and mixing, determination of temperatures for adiabatic and non-adiabatic reactions, use of psychometric and enthalpy- concentration diagrams.	6
8.	Simultaneous Material and Energy Balances: Degrees of freedom analysis for multicomponent systems, combined steady state material and energy balances for units with multiple sub-systems.	3
9.	Unsteady State Material and Energy Balances: Transient materials and energy balances involving with and without chemical reactions.	2
	Total	42

9. Suggested Books:

S. No.	Name of Authors / Books / Publishers	Year of Publication/ Reprint
1.	Himmelblau D.M. and Riggs J. B.,“ Principles and Calculations in Chemical Engineering”, 8th Ed., Prentice Hall of India.	2012
2.	Felder R.M. and Rousseau R.W., “Elementary Principles of Chemical Processes”, 3rd Ed.., John Wiley.	2005
3.	Bhatt B.I. and Vora S.M., “Stoichiometry”, 5th Ed., Tata McGraw-Hill	2010
4.	Narayanan K.V. and Lakshmikutty B., “Stoichiometry and Process Calculations”, Prentice Hall of India.	2006
5.	Hougen D.A., Watson K.M. and Ragatz R.A., “Chemical Process Principles”, Part-I, 2nd Ed., CBS Publishers.	1995

Course No 10:

Role: course coordinator, instructor and teacher and counsellor.

No of times taught: I have taught the following course seven times to the 2nd Semester undergraduate (UG) students of the Department of Chemical Engineering, at SLIET, Longowal, Punjab.

SLIET, Longowal, Punjab

NAME OF DEPTT./CENTRE: **Department of Chemical Engineering**

2. **Subject: Introduction to Polymer Science & Technology**

2. Contact Hours: **L: 3** **T: 1** **P: 0**

3. Examination Duration (Hrs.): **Theory: 3** **Practical: 0**

4. Credits**: 4** 5. Semester**: Spring**

6. Pre-requisite**:** **Nil**

7. Objective: To provide basic understanding of the classification of polymers and kinetics of polymerization

8. Details of Course:

S. No.	Contents	Contact Hours
1.	**Introduction:** polymer, monomer, average chain length and molecular weight of polymers	**2**
2.	**Classification of polymers:** classification based on (i) origin (natural, synthetic and semi-synthetic) (ii) application and physical properties (resin, plastic, rubber, fiber) (iii) Thermal response (Thermoplastics and thermosetting), (iv) line structure (branched, crosslinked and linear polymer), (v)Tacticity (atactic, synditactic and isotactic) (vi) polarity (polar and non-polar) and (vii) crystallinity (amorphous, crystalline and semi-crystalline), (viii) Polymerization processes (addition and condensation polymerization).	**4**
3.	**Kinetics of free radical polymerization:** overall scheme, rate expression for radical polymerization; integrated rate of polymerization expression; methods of initiation: thermal decomposition, redox initiation, photochemical initiation; dead-end polymerization; chain length and degree of polymerization, kinetic chain length, chain transfer, deviation from ideal kinetics, autoacceleration, polymerization-depolyerization equilibrium.	**10**
4.	**Techniques of polymerization:** bulk, solution, suspension and emulsion polymerization; kinetics of emulsion polymerization.	**6**
5.	**Kinetics of Copolymerization by radical chain polymerization**: binary copolymer equation, types of copolymers, integrated binary copolymer equation.	**6**
6.	**Kinetics of ionic polymerization:** anionic, cationic and coordination polymerization.	**4**
7.	**Kinetics of condensation polymerization:** reactivity of functional groups, average	**10**

	functionality, Rate expression for condensation polymerization- catalyzed and non-catalyzed; equilibrium considerations- closed and open drive system; control of molecular weight, branching and crosslinking.	
	Total	**42**

9. Suggested Books:

S. No.	Authors / Name of Book / Publisher	Year of Publication
1	Ghosh, Premamoy, "Polymer Science and Technology: Plastics, Rubber, Blends and Composites", Tata McGraw Hill, 3rd Ed.	2017
2	Chanda, Manas, "Advanced Polymer Chemistry: A Problem Solving Guide", Marcel Dekker, 1st Ed	2000
3	Carraher, C.E., "Polymer Chemistry", CRC Press, 10th Ed.	2017
4	Joel R. Fried, Polymer Science & Technology, Prentice Hall, Inc, New Jersey, USA	1986

Course No 11:

Role: course coordinator, instructor and teacher and counsellor.

No of times taught: I have taught the following course two times to the 2nd Semester post graduate (PG) students of the Department of Chemical Engineering, at SLIET, Longowal, Punjab.

NAME OF DEPTT./CENTRE: **Department of Chemical Engineering**

1. Course Title: **Polymer Rheology & Processing**
2. Contact Hours: **L: 3** **T: 1** **P: 2**
3. Examination Duration (Hrs.): **Theory:3** **Practical :2**
5. Credits**: 4** 6. Semester**: Spring**
6. Pre-requisite**:** Nil
7. Objective: To impart knowledge of polymer processing technology and equipment.
8. Details of the Course:

S. No.	Contents	Contact Hours
1.	**Introduction to Polymer Rheology and processing:** Introduction to various Rheological response functions, processing behavior of polymers with that of rheology	2
2.	**Basic Rheological Concepts:** Flow Classification: Steady Simple Shear Flow, Unsteady Simple Shear Flow, Extensional Flow; Non-Newtonian Flow Behavior: Newtonian Fluids, non-Newtonian Fluids, Viscoelastic Effects	3
3.	**Continuum Aspect of Rheology:** Phenomenological models to	5

	illustrate viscoelastic effects: Maxwell's Model, Voigt Model and Standard Linear Solid Model; Boltzmann's superposition theorem; Temperature dependence of Viscosity; Intrinsic viscosity of polymer solutions	
4.	**Rheological Models:** Models for the Steady Shear Viscosity Function, Model for the Normal Stress Difference Function, Model for the Complex Viscosity Function, Model for the Dynamic Modulus Functions, Models for the Extensional Viscosity Function; Other Relationships for Shear Viscosity: Viscosity-Temperature Relationships, Viscosity-Pressure Relationship, Viscosity-Molecular Weight Relationship	7
5.	**Rheometry:** Rotational Viscometers: Cone and Plate Viscometer, Parallel-Disc Viscometer; Capillary Rheometers: Constant Plunger Speed Circular Orifice Capillary Rheometer, Constant Plunger Speed Slit Orifice Capillary Rheometer, Constant Speed Screw Extrusion Type Capillary Rheometers, Constant Pressure Circular Orifice Capillary Rheometer (Melt Flow Indexer); Extensional Viscometers: Filament Stretching Method, Extrusion Method	8
6.	**Constitutive Theories and Equations forSuspensions and rheology of complex polymeric fluid:** Importance of Suspension Rheology, Shear Viscous Flow: Effect of Shape, Concentration and Dimensions on the Particles, Effect of Size Distribution of the Particles	3
		Total 28

9. List of Practical:

1. Rheology of polymer by cone plate rheometer
2. Rheology of polymer by parallel plate rheometer
3. Study of Rheological behavior of Polymer gel
4. Study of rheological behavior of polymeric adhesives
5. Understanding of G', G" and tanδ parameters for polymeric materials
6. Dynamic Mechanical Analysis of Polymeric materials

10. Suggested Books:

S. No.	Name of Books / Authors	Year of Publication
1.	LarsonR. G.,"The Structure and Rheology of Complex Fluids", Oxford.	1998
2.	BirdR. B., ArmstrongR. C. andHassagerO., "Dynamics of Polymeric Liquids", Volume I and II, John Wiley and Sons.	1987
3.	Montgomery T. Shaw, "Introduction to Polymer Rheology", John Wiley and Sons.	2011
4	Piau J. M. and Agassant J. F., "Rheology of Polymer melt processing", Elsevier.	1996
5.	Shenoy AV, "Rheology of Filled Polymer Systems" Kluwer Academic Publishers	1999
6.	Han CD, "Rheology and Processing of Polymeric Materials" Vol-1, Oxford University Press	2007

2.2 Other Academic Roles

During my 24 years and 8 months of teaching career, I have participated in various academic activities in my place of work. Administrative Experience/Posts & responsibilities held in India are tabulated as below:

S. No	Post	Organization /University	Duration		Experience (in years and months)
			From	To	
1.	Head of Department, Department of Polymer Sc & Technology	University of Calcutta	2.11.2010	1.11.2012	2 years
2.	Professor-in-charge, Training & Placement	University of Calcutta	1.4.2009	31.12.2009	09 months
3	Head of Department	SLIET, Longowal	1.4.2005	31.03.2008	3 years
4.	Coordinator /Head of the Department, Department of Disability Studies	SLIET, Longwal	1.09.2004	30.11.2005	1 year 2 months
5	Chairman, Board of Studies	SLIET, Longowal	1.4.2005	31.03.2008	3 years
6.	Chairman, Board of Studies	University of Calcutta	2.11.2010	1.11.2012	2 years
7	Member, Board of studies	Punjab Technical University	1.4.2000	31.03.2003	3 years
8.	Member of academic council (SENATE)	SLIET, Longowal	1.4.2007	28.09.2008	1 year 5 months
9	Member of academic council (SENATE)	SLIET, Longowal	29.03.2017	28.03.2019	Two years
10	Member of academic council (SENATE)	University of Calcutta	02.02.2012	1.11.2012	10 months

11	Member of executive council (BOG)	SLIET, Longowal	01.01.2007	31.12.2007	1 year
12	Others (specify) Member, Regional Advisory Council for CIPET, Uttarakhand	Ministry of Chemicals & Petrochemicals, Shastri Bhawan, New Delhi	1.10.2018	Till date	2 years 8 months

3. Teaching and supervision experience

In the section 2 (subsection 2.1), I have documented eleven courses taught by me over last 25 years and 1 month of my teaching career. Mainly, I taught polymer related courses along with some chemical engineering courses. Thus, I have varied experience of teaching at three different institutes and varied groups of UG, PG and Ph.D. students of Polymer Sc & Technology and Chemical Engineering.

During the last 25 years and 1 month of my teaching career, I have guided several UG students for their dissertation (a part of UG programme); In total around 120 UG students were guided. I have also guided around 24 master's theses (M. Tech and M. Phil) and 20 Ph. D. theses. As I had to train them in research methodology in their respective areas, I had to put a lot of efforts to train them, keeping in view their personal and academic background. I believe in inter-disciplinary research. Thus, my research areas encompass the area of biotechnology, energy, environment and polymer sc & technology. In my group, a lot biology students were inducted for their Ph.Ds. Thus, I had to put extra effort and patience to train them in their research. They all were well trained and completed their Ph.D. under my guidance.

4. Educational contributions

During last 25 years and 1 month of my teaching career, I have taken part in various academic activities like writing books and book chapters, formulating course materials, invited talk in the national /international conferences, teaching/lecturing at other universities. These activities are tabulated as below:

4.1 Book and Book Chapters:

- **Book Written by Professor P. P. Kundu**

  Kundu, Patit Paban and Datta, Kingshuk (editors): A book entitled **"**Progress and Recent Trends in Microbial Fuel Cells" 1st edition, 9 th June, 2018; published by Elsevier Science (UK), e**Book ISBN:** 9780444640185; **Paperback ISBN:** 9780444640178.

- **Book Chapters written by Professor P. P. Kundu**

1. Ruchira Rudra, Prasanta Pattanayak, Patit Paban Kundu, Book chapter on "Conducting Polymer-Based Microbial Fuel Cell" in "Enzymatic Fuel Cells: Materials and Applications", Volume No.-44, Page No.-173-187, February 2019, Name of the Publisher- Material Research Forum LLC (US).
2. Mukhopadhyay,Piyasi; Kundu, P. P. (2018*): Chapter 19 entitled "*Stimuli-responsive polymers for oral insulin delivery" in "stimuli responsive Polymeric Nanocarriers for Drug delivery Applications-Advanced nanocarriers for therapeutics" edited by Abdel Salam Hamdy Makhlouf and Nedal Y. Abu Thabit, Woodhead Publishing series in Biomaterials, Elsevier Group, UK.
3. Laha, Soumita; Dutta, Kingshuk; Kundu, P. P. (2018): Chapter 14 on "Biodegradation of Low density Polyethylene films" in the book "Handbook of research on microbial tools for environmental waste management" edited by Vinay Mohan Pathak and Navneet (IGI Global); Release Date: April, 2018; Pages: 496; ISBN13: 9781522535409, ISBN10: 1522535403, EISBN13: 9781522535416; DOI: 10.4018/978-1-5225-3540-9
4. Rudra, Ruchira; Kumar, Vikash; Nandy, Arpita; Kundu, Patit Paban (2018): Performances of separator and membrane –less MFC in the book entitled **"Microbial fuel cell: A bioelectrochemical system that converts waste to watts"** published by M/s. Capital Publishing Company, India and M/s. Springer, Switzerland; **ISBN 978-3-319-66793-5**.
5. Kundu, P. P. and Mondal, S. (2016): Polybenzimidazole as Membrane in Direct Methanol Fuel Cell *in "**Novel Applications in Polymers and Its Waste Management", Editors:** Badal Jageshwar Prasad Dewangan*, Maheshkumar Narsingrao Yenkie, Apple Academic Press (USA). **Hard ISBN:** 9781771884754, **E-Book ISBN:** 9781771884761.
6. Chatterjee, Abhipriya and Kundu, Patit Paban (2016): The Therapeutic Role of the Components of Aloe Vera in Activating the Factors that Induce Osteoarthritic Joint Remodeling in *"**Novel Applications in Polymers and Its Waste Management", Editors:** Badal Jageshwar Prasad Dewangan*, Maheshkumar Narsingrao Yenkie, Apple Academic Press (USA), **Hard ISBN:** 9781771884754, **E-Book ISBN:** 9781771884761.
7. Kundu, Patit Paban; Dutta, Kingshuk (2015): Current status of Hydrogen fuel Cell for portable application, Compendium of hydrogen energy Vol 4 (ed. Ball et al.), WoodHead Publishers, USA.
8. Dutta, Kingshuk; Kundu, Patit Paban; Kundu, Arunabha (2014): Fuel cells –exploratory fuel cells: Micro-fuel cells in "Chemistry, Molecular Sciences and Chemical Engineering" Edited by Jan Reedijk, Elsevier Publisher, UK.
9. Kundu, Patit P. and Sarkar, Kishor (2011): Natural Polymric Vectors in Gene Therapy in "Biopolymers: Biomedical and Environmental Applications" Edited by Sushel Kalia and Luc Averous, John Wiley and Sons, USA.
10. Kundu, P. P.; Sharma, Vinay; Kumari, Kamlesh (2011): Chitosan copolymers and IPNs for controlled drug delivery in "Chitosan: Manufacture, Properties, and Usage", Nova Science Publishers, Inc.
11. Bhowmick, Arundhuti; Banerjee, Subhas; Kundu, P. P. (2013): Chapter 197 entitled "Hydroxyapatite packed chitosan-PMMA nano-composite: a promising material for construction of synthetic bone", in the book "Multifaceted Development and

Applications of Biopolymers towards Biology, Biomedical and Nanotechnology", edited by Pradip Dutta and Joydip Dutta (Springer, USA).

12. Kundu, P. P.; Nandy, Arpita; Mukherjee, Amrita; Pramanick, Nilkamal (2013): chapter entitled "Microbial Synthesis of Polyhydroxyalkanoates and its Biomedical Applications", Encyclopaedia on Biomedical Polymers and Polymeric Biomaterials (Taylor and Francis, USA).

4.2. Involvement with formulation of academic programme as Head of Department

Sl. No.	Nomenclature of innovative academic programme	Date of approval of academic council	Year of introduction
1.	B. Tech (Polymer Sc & Technology), CU	31.03.2011	2011 (new syllabus)
2.	M. Tech (Polymer Sc & Technology), CU	31.03.2011	2011 (new syllabus)
3.	M. Tech (Polymer Technology), SLIET	31.03.2007	2007

4.3 Invited Talk in national/international conferences

National Talk:

i. Delivered one invited talk on the topic "Polymeric Nanocomposites" during the period of 12th Nov, 2005 for the A. I. C. T. E. sponsored staff development programme, organized by Department of Physics, SLIET, Longowal.
ii. Delivered one invited talk on the topic "Polymer Blends & Composites Used in Fuel Cell" during National Conference organized by the School of Physics & Material Science, Thapar University, Patiala on 2nd Feb 2007.
iii. Delivered one invited talk on the topic "Response Surface Methodology as Optimization Tool in Rubber Compounding" at the national seminar organized by Department of Mathematics, SLIET, Longowal on Jan 20, 2007.
iv. Delivered one invited talk on Linseed oil based polymers during international conference organized by Rubber Technology Center, IIT Kharagpur on 30.11.2011.
v. Delivered one invited talk on Polymeric vectors for gene delivery during national conference on Polymer at IISER, Kolkata on 11 th Dec, 2011.
vi. Delivered one invited talk in the area of Direct methanol fuel cell in AICTE sponsored short tern course, organized by Material Science Center, IIT Kharagpur on 12 Nov, 2012.
vii. Delivered one invited talk in the area of Linseed oil based polymers from cationic polymerizations at the UGC-NRC-M programme organized by the Department of Materials Engineering, IISc, Bangalore on 19 th July, 2012.
viii. Delivered one invited talk in the area of Polymers in drug delivery at the International Polymer Conference organized by Kottayam University, Kerala on 28th Nov, 2014.
ix. Invited talk on chitosan based polymeric carrier for drug delivery in the International Conference on "Harnessing Engineering, Technology, and Innovation for Sustainable Growth (HETIS-2016)" on 1st October 2016 organized by DR SSB University Institute of Chemical Engineering and Technology, Panjab University, Chandigarh [formerly DCET, PU Chandigarh].
x. Invited talk on Development of Cathode catalyst for Microbial Fuel Cell delivered at IIT Kanpur on 6 th April, 2019 during the national conference organized in honour to Prof. Anil K Bhowmick on his retirement from the service from IIT Kharapur.

xi. Delivered one invited talk in the SPARC funded workshop titled “Upscaling and field scale application of bio-electrochemical systems for wastewater treatment and bioenergy recovery” on February 27, 2020 at Indian Institute of Technology Kharagpur in the area of "Efficient cathode electro-catalyst in microbial fuel cell"

International Invited talk:

I. Delivered one international invited talk on the topic of “Applications of Polymers in Gene Therapy” at Yonsei Cancer Research Center, Faculty of Medicine, Yonsei University, South Korea on 21 st Dec, 2007.

II. Delivered one invited talk on Direct methanol and microbial fuel cell at the Bilateral Italy-India Workshop “***Renewable energy technologies at the crossroads of "glocal" energy grids***” held at the University of Camerino, Italy on 18th September 2018.

4.4 Lecturing in other national/international universities

Item	Organization	Activity
Visiting Professor during the period of 7th May to 31 st May, 2018	Tripura University, Agartala, India	Teaching Polymer & Chemical Engineering at PG level during this period. Every day, I need to take two classes of two hours' duration during these three-weeks.
Resource person during 18-20 th July, 2012 at UGC-Network program in Materials	Indian Institute of Science, Bangalore, India	This is a Summer Short Term Course, conducted by the Department of Materials Engineering as part of UGC network. Lectured in the area of vegetable oil based polymers.
Expert delegate for Indo Italy joint meet on 17-19 Sept, 2018	***University of Camerino, Italy***	Indo-Italy joint meet on “Renewable Energy Technologies at crossroad of glocal energy grids”. Lectured in the area of microbial fuel cell.
Three week Training on Leadership by MHRD, GOI as “LEADERSHIP FOR ACADEMICIAN PROGRAMME”	Two weeks at IIT BHU and one week at Judges Business School, University of Cambridge	Leadership programme. Attended lectures on various leadership skills.

5. Critical reflection

Teaching-learning process is always an evolutionary process as the class teacher has to deal new students in every year. For me, it is even more evolutionary as I have taught in three different Institutions in my teaching career. My 1st teaching Institute is in Punjab, a northern province of India, where Punjabi is native language. Although I used to teach in English, for the sake of students, I used to write more on the blackboard (in 1996, PPT was not popular). At my 2nd Institute (University of Calcutta), all students were Bengali (myself is also Bengali) and all students are post B.Sc students. Thus, communication was at very best with them. At my 3rd and current Institute (IIT Roorkee), I used to teach through power point presentation. The method adapted in teaching for UG and PG programmes are totally different. For UG, I try to cite more in everyday use of polymers and problems faced during use of polymers such that students can get attracted to the subject. For PG and Ph.D. lectures, I try to correlate my lectures with the lab experiences. For supervision of theses (B.Tech/M.Tech /Ph..D), I follow a mixed model of guidance where I provide plenty of freedom to my students after certain initial guidance. Initially, I provide them the broad area of my research and told them to choose any of them after going through my research publications. When they finalize the area, I told them to go through in more details my research papers in this particular area and also go through other research papers (only top-rated research papers) and told them to finalize their topic of research. For UG students, I assign a small portion of research work, whereas for PG students, I assign a research work which can later be published in the form of research paper. For Ph.D. students, I first told them to collect all related papers in their particular topic and try to publish that collection in the form of a review paper. In the mean -time, I assign the new student to my old students in the similar area for their research training (when I start anew in a new Institute, I took the responsibility of their research training). So, for the first six months to a year, I used to supervise all their research activities (almost directed research) and after that, I allow them to design their own experiments and provide freedom to work according to their desire.

6. Educational development over time

Twenty-five years back when I joined in the teaching profession just after my Ph.D., I need to put a lot of time in the preparation of my lectures and initially I was shaky. As time passed and after teaching a course a number of times, I tried some experiments to make my lectures more attractive such as group learning activity (provide a problem to a group of students with a challenge to complete first and get a reward like to have a tea and snacks with that group sponsored by me). As years passed by, I tried to use technology more in my teaching. For the last five years, I used to teach through power point presentation along with the use of internet knowledge. Sometimes, I challenge my students with recent developments in the area of polymers and tell them to find their uses by searching the internet. The winner of the challenge is rewarded with a gift (usually chocolate, sometimes coffee). Sometimes, I put some marks to their final grades against these challenges. So, over the years, an element of fun is introduced in my teaching methodology.

7. Teaching and learning philosophy

My philosophy in the teaching learning process is based on three D's - Duty, Dedication and Devotion. As in India, education is subsidized and the Government pay the salary to the teachers, I feel that it is my primary duty to put my full effort in teaching to pay pack to the public (The government pay salary from the tax payers' money). From the core of my heart, I believe that I came to this world for a short time of my life-span to serve mankind. I got the opportunity to serve through teaching. Every service including service to the human is ultimately directed towards GOD. Thus, I take the teaching not as a profession but as a service to the nation, to the world and ultimately service to the GOD and do it with full dedication and devotion.

RESEARCH

PORTFOLO

OF

PROFESSOR PATIT PABAN KUNDU

Past Research Experience in area of Biopolymers and Biomaterials, Sustainable Energy and Environment and Polymer Rheology

Important research areas to be considered:

(1) Sustainable Environment: Microbial Synthesis of Polymers- Application as Green Smart Polymers

i. Moumita Khamrai, Sovan Lal Banerjee, Patit Paban Kundu. Modified bacterial cellulose based self-healable polyeloctrolyte film for wound dressing application. **Carbohydrate Polymers (Elsevier Sc, UK, IF 7.2)**. 2017;174:580-590.

In this investigation, we prepare a self-healable polyelectrolyte film via crosslinking the cationically charged chitosan (Cts) with anionically modified bacterial cellulose (BC), which is a green source of nano-filler. This polyelectrolyte film is able to show dynamic self-healing activity at physiological pH condition via adapting ionic interaction, a state of non-covalent bond. BC was prepared using *Glucanoacetobacter xylinus* (MTCC7795) bacteria and after that its surface was modified with anionic poly(acrylic acid) using "grafting from" technique. It was observed that the notch (single and multiple) created over the composite film was disappeared by showing vibrant diffusion and ionic interlocking in contact with buffer solution having physiological pH. The XTT assay revealed that the composite film is non-toxic in nature and it was witnessed that the composite film was capable of delivering curcumin, a hydrophobic drug that has an ability to show antimicrobial activity and wound healing capability.

ii. Moumita Khamrai, Sovan Lal Banerjee, Saikat Paul, Anup Kumar Ghosh, Priyatosh Sarkar, Patit Paban Kundu. A Mussel Mimetic, Bioadhesive, Antimicrobial Patch Based on Dopamine-Modified Bacterial Cellulose/rGO/Ag NPs: A Green Approach toward Wound-Healing Applications. **ACS Sustainable Chemistry & Engineering (American Chemical Society, IF 7.6**), 2019, 7, 12083−12097.

The mussel mimetic property, dopamine (DOPA), a catechol containing compound was used to modify the isolated BC from G. *xylinus* (MTCC7795) via amidation reaction between the carboxylated BC and DOPA and successively characterized by ^{1}H NMR and FTIR analyses. The free hydroxyl group of the DOPA moiety of DOPA modified BC (BC-DOPA) was utilized to prepare the reduced graphene oxide/ silver nano particles (rGO/Ag NPs) incorporated composite film (BC-DOPA/rGO/Ag NPs). The antimicrobial action of the prepared film was carried out against both Gram-positive and Gram negative bacteria. The bactericidal property of the composite film determined using zone of inhibition (ZOI) method and live-dead assay (DAPI-PI analysis). From the *in vitro* wound healing assay over the NIH 3T3 cell line and A549 human lung epithelial cell line reveales that the presence of rGO and Ag NPs in the composite film accelerates the wound healing process.

iii. Moumita Khamrai, Sovan Lal Banerjee, Saikat Paul, Anup Kumar Ghosh, Priyatosh Sarkar, Patit Paban Kundu. Ag NPs Ornamented Modified Bacterial Cellulose Based Self-healable L-B-L Assembly via Schiff Base Reaction: A Potential Wound Healing Patch. **ACS Applied Biomaterials (American Chemical Society), In press.**

Here, we have reported the synthesis of layer by layer (L-B-L) biocompatible and self-healable bacterial cellulose-based transdermal patch via Schiff base reaction. The L-B-L assembly consisting of covalently crosslinked ethylene diamine (EDA) modified bacterial cellulose (EDA-CMBC) isolated from *Glucanoacetobacter xylinus* (MTCC7795) bacterial strain and aldehyde modified pectin (CHO-PECTIN). The formation of the imine bond via the Schiff base reaction between amine and the aldehyde functionality assists the self-healing process after being scratched in the presence of a pH 7.4 buffer solutions, monitored via optical microscopy and AFM analyses. The formation of the L-B-L assembly was confirmed using FESEM analysis whereas the presence of the Ag NPs has been confirmed by UV-vis spectroscopy and HRTEM analyses. The antimicrobial activity of the Ag NPs incorporated transdermal patch system has been studied over Gram-positive and Gram-negative using ZOI method as well as cell viability assay using the fluorescent dyes (DAPI) and (PI). The cyctotoxicity and wound healing property of the patch system has been studied over NIH 3T3 fibroblast and A549 epithelial cell lines.

iv. Nilkamal Pramanik, Rakesh Das, Tanmoy Rath and P. P. Kundu: Microbial Degradation of Linseed Oil-Based Elastomer and Subsequent Accumulation of Poly(3-Hydroxybutyrate-co-3-Hydroxyvalerate) Copolymer. **Applied Biochemistry and Biotechnology (Springer Sc),** volume 174, pages1613–1630(2014).

The microbial synthesis of environment-friendly poly(3-hydroxybutyrate--co-3-hydroxyvalerate), PHBV, has been performed by using an alkaliphilic microorganism, *Alkaliphilus oremlandii* OhILAs strain (GenBank Accession number NR_043674.1), at pH 8 and at a temperature of 30–32 °C through the biodegradation of linseed oil-based elastomer. The yield of the copolymer on dry cell weight basis is 90 %. The elastomers used for the biodegradation have been synthesized by cationic polymerization technique. The yield of the

PHBV copolymer also varies with the variation of linseed oil content (30–60 %) in the elastomer. Spectroscopic characterization (^{1}H NMR and FTIR) of the accumulated product through biodegradation of linseed oil-based elastomers indicates that the accumulated product is a PHBV copolymer consisting of 13.85 mol% of 3-hydroxyvalerate unit. The differential scanning calorimetry (DSC) results indicate a decrease in the melting (T_m) and glass transition temperature (T_g) of PHBV copolymer with an increase in the content of linseed oil in the elastomer, which is used for the biodegradation. The gel permeation chromatography (GPC) results indicate that the weight average molecular weight (M_w) of PHBV copolymer decreases with an increasing concentration of linseed oil in the elastomer. The surface morphology of the elastomer before and after biodegradation is observed under scanning electron microscope (SEM) and atomic force microscope (AFM); these results indicate about porous morphology of the biodegraded elastomer.

v. Nilkamal Pramanik et al, Aromatic π-Conjugated Curcumin on Surface Modified Polyaniline/Polyhydroxyalkanoate Based 3D Porous Scaffolds for Tissue Engineering Applications, **ACS Biomaterial Science & Engineering (Americal Chemical Society, IF 4.2),** 2016, 2, 12, 2365–2377. https://doi.org/10.1021/acsbiomaterials.6b00595.

Curcumin-entrapped polyaniline (PAni)-conjugated poly(3-hydroxybutyrate-*co*-3-hydroxyvalerate) (PHBV) electroconductive porous scaffolds were fabricated for application in tissue engineering. The physical and chemical characterizations of the as-prepared biomaterials were performed by UV–vis and ATR/FT-IR spectrophotometric, thermogravimetric, fluorescence microscopic, and X-ray diffractometric analyses. It was observed that compared to the pure PHBV copolymer, which is an insulator, the electroconductivity of the PAni-modified PHBV copolymer increased up to the value of 5.78×10^{-5} S cm^{-1}. An antimicrobial study revealed that the curcumin-loaded biomaterials exhibited better bactericidal effect against Gram-positive bacterial strains compared to Gram-negative strains. The composite also demonstrated significant compatibility toward blood and fibroblast cells and exhibited the maximum cell viability (90% to 80%). Cell migration and proliferation on the injured tissues were found to occur at a faster rate, resulting in faster repair, in the presence of anti-inflammatory and anticancer curcumin drug loaded composites compared to that of the pure PHBV copolymer.

(2) Circular Polymers

(a) Microbial Biodegradation of Polyethylene to valuable Products:

i. Shritama Mukherjee, Uttam Roychoudhury and Patit P. Kundu **(2017):** Biodegradation of polyethylene via complete solubilization by the action of Pseudomonas fluorescens, biosurfactant produced by Bacillus licheniformis and anionic surfactant. **Journal of Chemical Technology & Biotechnology (john Wiley, IF 2.75),** 93 (5), 1300-1311, https://doi.org/10.1002/jctb.5489.

Long hydrocarbon (~CH_2) chain, absence of polar bonds and highly hydrophobic nature of polyethylene, make it one of most difficult environmental pollutants to degrade. In the present study, commercially available polyethylenes were treated with biosurfactant produced by *Bacillus licheniformis*, anionic surfactant and bacterially treated with *Pseudomonas fluorescens* in different combinations to achieve higher biodegradation. Polyethylene was slightly oxidized by *P. fluorescens* in the first month and the oxidation of polyethylene induced by the biosurfactant during the second month was enhanced by the presence of lower amounts of carbonyl groups as observed in FTIR analysis. During the third month, highly oxidized polyethylene was entirely solubilized by the action of 10% SDS forming two-layered liquid consisting of yellow oil-like liquid as upper layer and an aqueous colourless lower layer. Biodegradable aliphatic acids, alcohols and short hydrocarbon molecules of 10–30 carbon chains were identified by GC–MS analysis in the aqueous solution. Weight loss of 7.13 ± 0.05% was also observed in polyethylene samples which were treated with SDS in the first month, then bacterially treated with *P. fluorescens* in the second month and finally treated with biosurfactant in the third month. Polyethylene became biodegradable after complete solubilization in water by treating consecutively with *Pseudomonas fluorescens* in the first month, then with biosurfactant in the second month and finally treating with 10% sodium dodecyl sulphate (SDS) at 60 °C for the third month. Simultaneous treatment of polyethylene with *P. fluorescens*, surfactant and biosurfactant has a tremendous effect on the oxidation and biodegradation of polyethylene.

ii. Shritama Mukherjee, et al Anionic surfactant induced oxidation of low density polyethylene followed by its microbial bio-degradation, **International Biodeterioration & Biodegradation (Elsevier Sc, UK, IF 4.07),** Volume 117, **February** 2017, Pages 255-268. https://doi.org/10.1016/j.ibiod.2017.01.013.

Hydrocarbon solubilization ability of surfactants was utilised for the deterioration of polyethylene during its thermal oxidation. Carbonyl index of polyethylene treated with Sodium dodecyl sulphate (SDS) at 60 °C for 1 month was found to be higher than thermally oxidised polyethylene as observed in FTIR study. Moreover, higher oxidation of polyethylene was witnessed after treatment of control polyethylene with 1%–10% of sodium dodecyl benzene sulphonate, sodium stearate, sodium octyl sulphate and sodium dodecyl sulphate at 60 °C for 1 month. Oxidation level of polyethylene treated by surfactant was higher as the availability of soluble oxygen and chain scission increased due to the attachment of surfactant to the polyethylene surface. Weight loss of 7.006 ± 0.05%, 1.76 ± 0.05% and 0.83 ± 0.05% were maximum which was achieved after bacterial treatment of oxidised polyethylene with 6%, 8% and 10% SDS, with *L. fusiformis* using peptone for 1 month, respectively. Along with weight loss after bacterial incubation, a decrease in the amount of carbonyls and an increase in the amount of unsaturated hydrocarbon were observed for the conversion of carbonyls into unsaturated hydrocarbon through biotic Norrish-type mechanisms. The biodegradation through β-oxidation mechanisms, by which oxidised polyethylene molecule was utilised to produce necessary energy for bacteria, was confirmed by a decrease in intrinsic viscosity and a decrease in the viscosity average molecular weight (M_v) of bacterially treated polyethylene. Nevertheless, an increase in the amount of carbonyls was observed after 1 month of bacterial incubation of polyethylene treated with SDBS and thermally oxidised polyethylene which was due to oxidation by oxidative enzymes released by *Lysinibacillus fusiformis*.

(b) PET Polymer Waste Management- Glycolization of PET waste and its subsequent use

i. Katoch, Sunain, Sharma, Vinay and Kundu, P. P., Synthesis and Characterization of Saturated Polyester and nanocomposites derived from Glycolyzed PET waste with varied compositions for food packaging applications. ***Bulletin of Materials Science*** **(*Springer and Indian Academy, Bangalore,* Impact Factor:1.39).** Vol. 36, No. 2, April 2013, pp. 277–286**.**

Saturated polyester resin, derived from the glycolysis of polyethyleneterephthalate (PET) was examined as an effective way for PET recycling. The glycolyzed PET (GPET) was reacted with the mixture of phthalic anhydride and ethylene glycol (EG) with varied compositions and their reaction kinetic were studied. During polyesterification of GPET, acid and EG, the parameters like degree of polymerization (DPn), extent of reaction (p) acid value and hydroxyl values were measured. The thermomechanical properties and the morphologies of the saturated polyester nanocomposites were examined by using a differential scanning calorimetry (DSC), dynamic mechanical analysis (DMA), wide angle X-ray diffraction (WAXRD) and transmission electron spectroscopy (TEM). Nanocomposites with lower content of organoclay showed interc alated morphology while by increasing the amount of organoclay, the exfoliated morphology was more prevalent. Water vapour transmission (WVT) was determined for saturated polyester nanocomposite sheets according to ASTM E96-80.

ii. Katoch, Sunain and Kundu, P. P., Thermal and Mechanical Behavior of Unsaturated Polyester (Derived from PET Waste) and Montmorillonite filled nanocomposites synthesized by IN-SITU polymerization. ***Journal of Applied Polymer Science ISSN: 1097-4628*** (*John Wiley, USA*, **Impact Factor: 2.25**), Nov 2011, 122/4, 2731-2740.

Postconsumer poly(ethylene terephthalate) waste bottles were glycolyzed as precursors of unsaturated polyester resin (UPR) and their montmorillonite (MMT)-filled nanocomposites. The glycolysis product (hydroxyl-terminated oligomers) was converted into UPR with various acid contents. These resins were miscible with styrene and could be cured with peroxide initiators to produce thermosetting unsaturated polyester (UP). Nanocomposites composed of

UP matrix and organically modified clay were prepared by in situ polymerization. These were characterized for thermal and dynamic mechanical properties. Transmission electron microscopy was also used to study the morphology at different length scales and showed the nanocomposites to be compromised of a random dispersion of intercalated/exfoliated aggregates throughout the matrix. With an increase in unsaturated acid content (for a fixed content of clay), the value of storage modulus varied from 2737 to 4423 MPa. The glass-transition temperatures of these nanocomposites ranged from 54 to 78°C, and the crosslink density varied from 3.70 × 105 to 5.72 × 105 mol/m3. The X-ray diffraction (XRD) of modified MMT exhibited a peak that vanished completely in the polymer nanocomposites. Thus, the XRD results apparently indicated a distortion of the platy layers of nanofiller in the UP nanocomposites. The nanocomposites showed higher modulus values (2737–4423 MPa) compared to the pristine polymer (2693 MPa). From thermogravimetric analysis, all of the nanocomposites were stable up to 200°C and showed a two-stage degradation.

iii. Bhattacharyya, Aditi; Mukhopadhyay, Piyasi; Kundu, P. P. (2014): Synthesis of a Novel pH − sesitive Polyurethane-Alginate Blend with Polyethylene Terephthatlate waste for Oral Delivery of Protein, ***Journal of Applied Polymer Science ISSN: 1097-4628*** (*John Wiley, USA*). (**Impact Factor: 2.25**), *131*, 40650-40655.

With the aim of using poly(ethylene terephthalate) (PET) waste for the synthesis of a value added product, we prepared polyurethane (PU) from bishydrohxyethylene terephthalate (BHET), a byproduct obtained from the glycolysis of PET. Biodegradable, water-swelling PU was synthesized by the reaction of BHET, hexamethylene diisocyanate, and poly(ethylene glycol) (PEG). Both BHET and PU were characterized by Fourier transform infrared spectroscopy, and the formation of PU was further confirmed by NMR analysis. The swelling behavior of PU in water was examined in terms of the various molecular weights of PEG. Semi- interpenetrating network beads of PU and sodium alginate were prepared with calcium chloride ($CaCl_2$) as a crosslinker to attain a pH sensitivity for successful oral protein/drug delivery.

Bovine serum albumin (BSA) was used as a model protein. The pH-responsive swelling behavior and protein (BSA) release kinetics in different pH media corresponding to the gastrointestinal tract (pH 1.2 and 7.4) were investigated. The degree of swelling in the case of the PU−alginate beads at pH 1.2 was found to be at a minimum, whereas the degree of swelling was significantly elevated (1080%) at pH 7.4. This substantiated the pH sensitivity of the polymeric beads with a minimum loss of encapsulated protein in the stomach and the almost complete release of encapsulated protein in the intestine. This revealed good opportunities for oral protein/drug delivery with a polymer derived from waste PET. Moreover, the fungal biodegradation study confirmed its compatibility with the ecological system.

iv. Bhattacharyya, Aditi; Mukherjee, Debarati; Mishra, Roshnara; Kundu, P. P. (2017): Preparation of polyurethane −alginate/chitosan core shell nanoparticles for the purpose of oral insulin delivery, **European Polymer Journal** (**Elsevier Science, Impact Factor 3.76**). 92, 294-313.

Waste polyethylene terephthalate (PET) is depolymerized through glycolysis and the glycolyzed product, bis (2-hydroxyethylene) terephthalate (BHET) is utilized in the synthesis of polyurethane as diol. Polyurethane (PU) is incorporated in a core- shell nanoparticle formulation along with alginate (ALG) and chitosan (CS) to develop an efficient oral insulin delivery vehicle. Fourier transform infrared (FT-IR) spectrums of the polyurethane-alginate/chitosan (PU-ALG/CS) nanoparticles confirm the presence of all elements distinctly. Nanoparticles of average particle size 90–110 nm are clearly visible from the images of scanning electron microscope (SEM) and transmission electron microscope (TEM). Unique characteristics of insulin loaded PU-ALG/CS nanoparticles are noticed in both in vitro and in vivo studies. More than 90% insulin encapsulation efficiency, sustained swelling, controlled insulin release from mucoadhesive nanoparticle formulation are the major causes of long term hypoglycaemic effects in diabetic mice and improved insulin bioavailability (10.36%). PU-ALG/CS nanoparticles are also found to be safe, according to the acute toxicity studies.

v. Singh, Amandeep; Banerjee, Sovan Lal; Dhiman, Vandana; Bhadada, Sanjay Kumar; Priyatosh Sarkar, Khamrai, Moumita; Kumari, Kamlesh; Kundu, Patit Paban: Fabrication of calcium hydroxyapatite incorporated Polyurethane-Graphene oxide Nanocomposite porous Scaffolds from Poly(ethyleneterephthalate) Waste: A Green Route toward Bone Tissue Engineering, **Polymer (Elsevier Sc, UK, IF 4.23).** 8 May, 2020, 195, 122436-50**.** https://doi.org/10.1016/j.polymer.2020.122436.

Biodegradable porous polymeric scaffolds were prepared from Polyurethane (PU) for the purpose of osteoblast cells regeneration to utilize in the restoration of damage bone tissues. The PU was synthesized from post-consumer discarded Poly ethylene terephthalate **(**PET) waste by glycolysis method. The produced monomer bis(2-hydroxyethyl) terephthalate (BHET) was reacted with diisocynate and there after with selected chain extender glycol. In this study, graphene oxide (GO) was used as a polyol in the esterification reaction. Also, the GO acted as a nano filler that imparted the strength to the system along with antimicrobial activity. The various composites of PU-GO/hydroxyapatite (Hap) were prepared by varying the content of GO/Hap from 0 to 10% of total weight of the composite. The porous scaffolds were developed from composites by solvent casting/particulate leaching (SCPL) method. Furthermore, the physical, morphological, elemental, mechanical and thermo-mechanical properties of scaffolds were analyzed. The prepared scaffolds were subjected to U2OS human embryonic osteoblast cell line to analyze the response of osteoblast cells. *In vitro* studies such as cell growth, degradation, and cyto-compatibility were carried out. The outcomes of this study have asserted that the developed scaffolds are compatible for U2OS cells growth, thus can be used for bone tissue regeneration.

(3) Biopolymers and Biomaterials - Application of Functional Smart Materials

(a) Oral Insulin Delivery

i. Piyasi Mukhopadhyay and Patit Paban Kundu (2015): Chitosan-graft-PAMAM/alginate core-shell nanoparticles: a safe and promising oral insulin carrier in Animal mode**l, RSC advances (RSC, UK, IF 3.0)**, 5, 93995-94007.

Efficient, biodegradable and bio-safe polymeric nano carrier in oral insulin delivery is a major thrust in biomedical field. PAMAM grafted chitosan (CS-g-PAMAM) is prepared using a Michael type addition reaction by *grafting* polyamidoanime (PAMAM) onto native chitosan, to improve the water solubility, pH responsiveness, and insulin encapsulation efficiency for the enhancement of relative oral bioavailability of insulin. The insulin loaded nanoparticles were prepared by formation of an ionotropic pre-gelation of an alginate (ALG) core entrapping insulin, followed by PAMAM grafted chitosan (CS-g-PAMAM) polyelectrolyte complexation, to meet successful research in oral insulin delivery. Mild preparation process without involving harsh chemicals is aimed to improve insulin bio-efficiency *in vivo*. The nanoparticles showed excellent core shell architecture with an average particle size of 98-150 nm in dynamic light scattering (DLS), showing ~97% of insulin encapsulation and 27% of insulin loading capacity. Again, *In vitro* release data confirms a pH sensitive and self sustained release of encapsulated insulin, protecting it from the enzymatic deactivation in the gastrointestinal tract. The oral administration of these nanoparticles exhibits a pronounced hypoglycemic effect in diabetic mice, producing a relative bioavailability of ~11.78%. As no acute systemic toxicity is observed with its peroral treatment, these core-shell nanoparticles can effectively serve as an efficient carrier of oral insulin in mice model.The above system shows relative bioavailability of ~11.78%, almost matching reported world standard of around 15 %. Thus, further studies can be done for the products for human trial.

ii. Piyasi Mukhopadhyay, Kishor Sarkar, Sourav Bhattacharya, Aditi Bhattacharyya, Roshnara Mishra, P P Kundu (2014): pH sensitive N-succinyl chitosan grafted polyacrylamide hydrogel for oral insulin delivery. **Carbohydrate Polymers (Impact Factor – 7.2).** *Volume 112, Pages 627-637*.

Overall, the results indicated successful preparation of a pH sensitive, porous PAA/S-chitosan and its application in oral insulin delivery. Indeed, the PAA/S-chitosan was able produce better con-trolled release of insulin following a non-fickian mechanism, which was quite low in acidic stomach and almost complete in alkaline medium, as compared to the native PAA-chitosan. Finally, insulin loaded PAA/S-chitosan showed significant hypoglycemic effects in diabetic mice after delivery, producing insulin relative bioavailability of 4.43%. Moreover, in vivo toxicity and histopathological study demonstrated no toxicity (liver, kidney) at peroral treatment of the hydrogels. Hence, this PAA/S-chitosan seems to be a promising candidate for successful oral insulin administration.

iii. Mukhopadhyay, Piyasi; Maity, Subhajit; Mondal, Sudipta; Chkarborty, Abhay Sankar; Prajapati, A. K.; Kundu, P. P.(2018): Preparation, characterization and in vivo evaluation of pH sensitive, safe quercetin-succinylated chitosan-alginate core-shell-corona nanoparticle for diabetes treatment, **Carbohydrate Polymers (Elsevier Science, Impact Factor 7.2)**, 2018 182, 42-51.

The study aims for development of an efficient polymeric carrier for evaluating pharmaceutical potentialities in modulating the drug profile of quercetin (QUE) in anti-diabetic research. Alginate and succinyl chitosan are focused in this investigation for encapsulating quercetin into core-shell nanoparticles through ionic cross linking. The FT-IR, XRD, NMR, SEM, TEM, drug entrapment and loading efficiency are commenced to examine the efficacy of the prepared nanoparticles in successful quercetin delivery. Obtained results showed the minimum particle size of ~91.58 nm and ~95% quercetin encapsulation efficiently of the particles with significant pH sensitivity. Kinetics of drug release suggested self-sustained QUE release following the non-fickian trend. A pronounced hypoglycaemic effect and efficient maintenance of glucose homeostasis was evident in diabetic rat after peroral delivery of these quercetin nanoparticles in comparison to free oral quercetin. This suggests the fabrication of an efficient carrier of oral quercetin for diabetes treatment.

(b) **Bone Tissue Engineering- Application of Functional Smart Materials**

i. Sarim Khan, Viney Kumar, Partha Roy, Patit Paban Kundu, TiO_2 doped chitosan/hydroxyapatite/halloysite nanotube membranes with enhanced mechanical properties and osteoblast-like cell response for application in bone tissue engineering, 2019, **RSC Advances (RSC, UK, IF 3.0)**, 9, Pages 39768-39779.

Sarim Khan, Muskan Garg, S Chockalingam, P Gopinath, Patit Paban Kundu, TiO_2 doped chitosan/poly (vinyl alcohol) nanocomposite film with enhanced mechanical properties for application in bone tissue regeneration, **International Journal of Biological Macromolecules (Elsevier Sc, UK, IF 5.16)**, 2020, 143, Pages 285-296.

The current therapeutic strategies for healing bone defects suffer from the lack of anti-infective efficacy of the graft, resulting into nonunion in the segmental bone defects. A membrane with enhanced anti-infective efficacy, mechanical strength and osteoconductivity would represent an improvement in the therapeutic strategy. The present study aims to optimize the content of Halloysite Nanotubes (HNTs) and TiO_2 in the polymer matrix of Chitosan (CTS) and a constant amount of nano-Hydroxyapatite (5%) with the sole objective of mimicking the mechanical and biological microenvironment of the natural bone extracellular matrix with an enhanced anti-

infective efficacy. HNTs are a low-cost alternative to MWNCTs for enhancing the mechanical properties and anti-infective efficacy of the composite. From the first stage of the study, it was concluded that the membranes possessed enhanced mechanical properties and optimum biological properties at 7.5% (w/w) loading of HNTs in the composite. In the second stage of this investigation, we studied the effect of addition of TiO_2 nanoparticle (NP) and TiO_2 nanotube (NT) in small amounts to CTS/n-HAP/HNT nanocomposite at 7.5% HNT loading, with an aim to augment the anti-infective efficacy and osteoconductivity of this mechanically strong membrane. The study revealed a significant enhancement in the anti-infective efficacy, osteoblast-like MG-63 cell proliferation and ALP expression with the addition of TiO_2 NT. The CHH-TiO_2NT film is able to successfully inhibit the S.aureus and E.coli growth within
16 hours and simultaneously allows enhanced proliferation of osteoblast like cell on its surface. The study supports the potential exploitation of CHH-TiO_2NT (7.5% HNT & 0.2% TiO_2 NT) membranes as a template for bone tissue regeneration.

ii. Arundhati Bhowmick et al, Multifunctional zirconium oxide doped chitosan based hybrid nanocomposites as bone tissue engineering materials, **Carbohydrate Polymers** (Elsevier **Sc, UK, IF 7.2)**, Volume 151, 20 October 2016, Pages 879-888, https://doi.org/10.1016/j.carbpol.2016.06.034.

This paper reports the development of multifunctional zirconium oxide (ZrO_2) doped nancomposites having chitosan (CTS), organically modified montmorillonite (OMMT) and nano-hydroxyapatite (HAP). Formation of these nanocomposites was confirmed by various characterization techniques such as Fourier transform infrared spectroscopy and powder X-ray diffraction. Scanning electron microscopy images revealed uniform distribution of OMMT and nano-HAP-ZrO_2 into CTS matrix. Powder XRD study and TEM study revealed that OMMT has partially exfoliated into the polymer matrix. Enhanced mechanical properties in comparison to the reported literature were obtained after the addition of ZrO_2 nanoparticle into the nanocomposites. In rheological measurements, CMZH I–III exhibited greater storage modulus (G') than loss modulus (G''). TGA results showed that these nanocomposites are thermally more stable compare to pure CTS film. Strong antibacterial zone of inhibition and the lowest minimum inhibition concentration (MIC) value of these nanocomposites against bacterial strains proved that these materials have the ability to prevent bacterial infection in orthopedic implants. Compatibility of these nanocomposites with pH and blood of human body was established. It was observed from the swelling study that the swelling percentage was increased with decreasing the hydrophobic OMMT content. Human osteoblastic MG-63 cell proliferations were observed on the nanocomposites and cytocompatibility of these nanocomposites was also established. Moreover, addition of 5 wt% OMMT and 5 wt% nano-HAP-ZrO_2 into 90 wt% CTS matrix provides maximum tensile strength, storage modulus, aqueous swelling and cytocompatibility along with strong antibacterial effect, pH and erythrocyte compatibility.

iii. Arundhati Bhowmick et al, Development of biomimetic nanocomposites as bone extracellular matrix for human osteoblastic cells, **Carbohydrate Polymers (Elsevier Sc, UK, IF 7.2)**, Volume 141, 5 May 2016, Pages 82-91. https://doi.org/10.1016/j.carbpol.2015.12.074.

Here, we have developed biomimetic nanocomposites containing chitosan, poly(vinyl alcohol) and nano-hydroxyapatite-zinc oxide as bone extracellular matrix for human osteoblastic cells and characterized by Fourier transform infrared spectroscopy, powder X-ray diffraction. Scanning electron microscopy images revealed interconnected macroporous structures. Moreover, in this study, the problem related to fabricating a porous composite with good mechanical strength has been resolved by incorporating 5 wt% of nano-hydroxyapatite-zinc oxide into chitosan-poly(vinyl alcohol) matrix; the present composite showed high tensile strength (20.25 MPa) while maintaining appreciable porosity (65.25%). These values are similar to human cancellous bone. These nanocomposites also showed superior water uptake, antimicrobial and biodegradable properties than the previously reported results. Compatibility with human blood and pH was observed, indicating nontoxicity of these materials to the human body. Moreover, proliferation of osteoblastic MG-63 cells onto the nanocomposites was also observed without having any negative effect.

(4) Sustainable Energy
(a) Microbial Fuel Cell

i. Nandy, Arpita; Kumar, Vikash; Kundu, Patit P. (2013): Utilization of proteinaceous materials for power generation in a mediatorless Microbial Fuel Cell by a new electrogenic bacteria Lysinibacillus sphaericus VA5. **Enzyme and Microbial Technology (Impact Factor 3.5)**, Elsevier Publications**,** vol. 53 issue 5 October 10, 2013. p. 339-344.

In this study, a bacterial strain, *Lysinibacillus sphaericus* which is relatively new in the vast list of biocatalysts known to produce electricity has been tested for its potential in power production. It is cited from the literature that the organism is deficient in some sugar or polysaccharide processing enzymes and thus is tested for its ability to utilize substrates mainly rich in protein components like beef extract and with successive production of electricity. The particular species has been found to generate a maximum power density of 85 mW/m^2 and current density of ≈270 mA/m^2 using graphite felt as electrode. The maximum Open Circuit Voltage and current has been noted as 0.7 V and 0.8 mA during these operational cycles. Cyclic voltammetry studies indicate the presence of some electroactive compounds which can facilitate electron transfer from bacteria to electrode. The number of electrogens able to generate electricity in mediator free conditions are few, and the study introduces more divergence to that population. Substrate specificity and electricity generation efficacy of the strain in treating wastewater, especially rich in protein content has been reported in the study. As the species has been found to be efficient in utilizing proteinaceous material, the technique can be useful to treat specific type of wastewaters like wastewater from slaughterhouses or from meat packaging industry. Treating them in a more economical way which generates electricity as a outcome must be preferred over the conventional aerobic treatments. Emphasizing on substrate specificity, the study introduces this novel *Lysinibacillus* strain as a potent biocatalyst and its sustainable role in MFC application for bioenergy generation.

ii. Nandy, Arpita; Kumar, Vikash; Kundu, Patit Paban (2016): Effect of electric impulse for improved energy generation in mediatorless dual chamber microbial fuel cell through electroevolution of Escherichia coli, **Biosensor and bioelectronics (Elsevier Sc, UK; I.F. 10.2)**, 79, 796-801. DOI: 10.1016/j.bios.2016.01.023.

The main emphasis of this study is to understand the electroactive behavior of a microbe in microbial fuel cell (MFC) under specific selection pressure. This study explores potential of a non-electrogenic microbe for power production in a mediatorless MFC under the influence of a specific stress. Electric pulse of specific magnitude has been applied to *Escherichia coli* cells in a MFC and compared the results with unpulsed (control) MFC. Maximum power density of 187.77 mW/m^2 and 284.44 mW/m^2 for the control and experimental MFC has been observed at corresponding current density of 1444.44 mA/m^2 and 1777.77 mA/m^2. The results show improved performance for the pulsed (experimental) system, despite of initial downfall with respect to the control system. This suggests bacterial adaptation against electrical pulses which leads to evolution of an efficient electrogen. This observation is further confirmed by analyzing the results of Cyclic Voltammetry (CV), Scanning Electron Microscopy (SEM) Electrochemical Impedence Spectroscopy (EIS), enlightening different attributes like electrochemical property, bacterial morphology and impedance. The study is focused on development of a microbial fuel cell catalysed by *E. coli*, through triggering electroactive property in the microbe by exposing it to external stress. This study is unique in nature as it is mediatorless, economical and describes about a new method of natural bacterial evolution.

iii. Kumar, Vikash; Nandy, Arpita; Salahuddin, M.; Kundu, P. P. (2015): Performance Assessment of Partially Sulphonated PVDF-co-HFP as Polymeric Electrolyte Membrane in Single Chambered Microbial Fuel Cell, **Applied Energy, Elsevier Publications (Impact Factor 8.8),** Volume 137, Pages 310–321.

In the present study, PVdF-co-HFP copolymer and its sulfonated derivatives have been analyzed as polymer electrolyte membrane in single chamber MFCs. The sulfonation of PVdF-co-HFP copolymer was performed by treating with chlorosulfonic acid for 5, 7 and 9 h, resulting in 23%, 30%, and 18% of degree of sulfonation (DS) in the respective SP-5, SP-7, and SP-9 membranes. On observing the membranes under field emission scanning electron microscope fitted with EDAX, porosity was found to be increasing with increase in the duration of sulfonation except for 9 h duration. The elemental analysis of the membranes indicated the presence of higher sulfur and oxygen content with the increasing sulfonation duration except for 9 h duration, for which crosslinks were formed via sulfone linkages. The membranes were characterized for their ion exchange capacity (IEC) and proton conductivity; IEC value of 0.21 meq g^{-1}, 0.42 meq g^{-1}, and 0.12 meq g^{-1} and proton conductivity of 0.0012 S cm^{-1}, 0.00363 S cm^{-1}, and 0.0006 S cm^{-1} were observed for SP-5, SP-7, and SP-9 membranes. Open air cathode MFCs with membrane electrode assemblies (MEA) containing sulfonated and non-sulfonated PVdF-co-HFP membranes have been analyzed for their overall MFC performance. It was observed that amongst these membranes, MFC with SP-7 membrane showed the maximum power and current density of 290.176 ± 15 mW m^{-2} and 1390.866 ± 70 mA m^{-2} with an overall ~89% COD removal in 28 days operation, using electrogenic mixed firmicute consortium. In overall, the study illustrates the impression of sulfonated PVdF-co-HFP membranes as PEM and its application in MFC for harvesting bio-energy.

iv. Rudra, R.; Kumar, V.; Pramanik, N.; Kundu, P. P. (2017): Graphite oxide incorporated crosslinked polyvinyl alcohol and sulfonated styrene nanocomposite membrane as separating barrier in single chambered microbial fuel cell, **Journal of Power Sources (Elsevier Sc., UK; IF-8.2),** 341, 285-293.

Different membranes with varied molar concentrations of graphite oxide (GO), '*in situ*' polymerized sulfonated polystyrene (SS) and glutaraldehyde (GA) cross linked polyvinyl alcohol (PVA), have been analyzed as an effective and low cost nanocomposite barrier in single chambered microbial fuel cells (MFCs). The synthesized composite membranes, namely $GO_{0.2}$, $GO_{0.4}$ and $GO_{0.6}$ exhibited comparatively better results with reduced water uptake (WU) and swelling ratios (SR) over the native PVA. The variation in properties is illustrated with membrane analyses, where $GO_{0.4}$ showed an increased proton conductivity (PC) and ion exchange capacity (IEC) of 0.128 S cm^{-1} and 0.33 meq g^{-1} amongst all of the used membranes. In comparison, reduced oxygen diffusivity with lower water uptake showed a two-fold decrease in $GO_{0.4}$ over pure PVA membrane (~2.09 × 10^{-4} cm s^{-1}). A maximum power density of 193.6 mW m^{-2} (773.33 mW m^{-3}) with a current density of 803.33 mA m^{-2} were observed with $GO_{0.4}$ fitted MFC, where ~81.89% of chemical oxygen demand (COD) was removed using mixed firmicutes, as biocatalyst, in 25 days operation. In effect, the efficacy of GO incorporated crosslinked PVA and SS nanocomposite membrane has been evaluated as a polymer electrolyte membrane for harnessing bio-energy fromsingle chambered MFCs.

(b) Direct Methanol Fuel Cell- Application of Functional Materials

i. Das, Suparna; Dutta, Kingshuk; Kumar, Piyus; Kundu, Patit Paban (2014): Partial sulfonation of PVdF-co-HFP: A preliminary study and characterization for application in direct methanol fuel cell. **Applied Energy, Elsevier Publications (Impact Factor 8.848)**, 113, 169-177.

Sulfonation of PVdF-*co*-HFP was conducted by treating the copolymer with chlorosulfonic acid. The efficiency of this sulfonated copolymer towards application as a polymer electrolyte membrane in direct methanol fuel cell (DMFC) was evaluated. For this purpose, we determined the thermal stability, water uptake, ion exchange capacity (IEC), methanol crossover, and proton conductivity of the prepared membranes as functions of duration and degree of sulfonation. The characteristic aromatic peaks obtained in the FT-IR spectra confirmed the successful sulfonation of PVdF-*co*-HFP. The effect of sulfonation on the semi-crystalline nature of pure PVdF-*co*-HFP was determined from XRD analysis. Water uptake results indicated that a sulfonation time of 7 h produced maximum water uptake value of about 20%, with a corresponding IEC and proton conductivity values of about 0.42 meq g^{-1} and 0.00375 S cm^{-1} respectively. The maximum current density was recorded to be 30 mA cm^{-2} at 0.2 V potential.

ii. Dutta, Kingshuk; Das, Suparna; Kumar, Piyus; Kundu, Patit Paban:Polymer electrolyte membrane with high selectivity ratio for direct methanol fuel cells: A preliminary study based on blends of partially sulfonated polymers polyaniline and PVdF-co-HFP, ***Applied Energy*, Elsevier Publications (Impact Factor 8.848)**, 2014; 118:183-191.

Poly(vinylidene fluoride-*co*-hexafluoro propylene) is a prospective material for the fabrication of polymer electrolyte membranes (PEMs) for direct methanol fuel cells, primarily due to its low methanol permeability, high mechanical integrity and significantly low cost compared to conventionally used Nafion. However, low proton conductivity has hindered its independent use; therefore, most studies on this prospective copolymer have been done by using it in conjunction with Nafion. Nevertheless, partial sulfonation of this copolymer has resulted in increased proton conductivity while maintaining its low methanol permeability. Therefore, it seems appropriate that blending this sulfonated copolymer with a second low-cost component, which can complement its low conductive nature, can result in PEMs with high selectivity. Use of partially sulfonated polyaniline, as the second component, produced selectivity ratio of 5.85×10^5 Ss cm^{-3}, ion-exchange capacity of 0.71 meq g^{-1}, and current density of 90.5 mA cm^{-2} at +0.2 V and 60 °C and corresponding maximum power density of 18.5 mW cm^{-2}.

iii. Kumar, Piyush; Dutta, Kingshuk; Das, Suparna; Kundu, Patit Paban: Membrane prepared by incorporation of crosslinked sulfonated polystyrene in the blend of PVdF-*co*-HFP/Nafion: A preliminary evaluation for application in DMFC, ***Applied Energy*, Elsevier Publications (Impact Factor 8.848)**, 2014; 123:66-74.

Sodium salt of sulfonated styrene (SS) was polymerized *in situ* within the polymeric blend of PVdF-*co*-HFP/Nafion. The electrical efficiency of this cross-linked semi interpenetrating network membranes were evaluated for its potential application as a polymer electrolyte membrane in direct methanol fuel cell (DMFC). The characteristic aromatic peaks obtained in the FT-IR spectra confirmed the successful incorporation of SS within the polymeric blend. Xray diffraction analyses were conducted to determine the presence of crystalline and amorphous domains within the structure of the blend membrane. Water uptake measurements at room temperature indicate that above a threshold value of 20 wt% of incorporated SS (S-20), water uptake of the semi-IPN membranes increases up to 24%, with an IEC value equal to Nafion, i.e. 0.8 meq g^{-1}. The maximum current density was recorded to be 120 mA cm^{-2} at

0.2 V, with a cell efficiency (power density) of 24 mW cm^{-2} at 60 °C. In addition, proton conductivity and methanol permeability test results indicate that the prepared membrane S-20 is comparable to that of Nafion-117 membrane.

iv. Das, Suparna; Dutta, Kingshuk; Kundu, Patit Paban (2015): Nickel nanocatalysts supported on sulfonated polyaniline: potential toward methanol oxidation and as anode materials for DMFCs, **Journal of Material Chemistry A** (**Royal Chemical Society, UK, I.F 10.4**), 3 (21), 11349-11357; **DOI:** 10.1039/C5TA01837D.

The development of potential anode catalysts and catalyst supporting matrices for application in direct methanol fuel cells (DMFCs) has been an active area of research for the last couple of decades. The conventionally used Pt catalyst suffers from (a) high cost, (b) limited abundance and (c) the catalyst poisoning effect induced by the in situ generated carbon monoxide. In this work, a comparatively less expensive and more abundant Ni metal catalyst [supported on Vulcan carbon, polyaniline (PAni) and partially sulfonated PAni (SPAni)] has been utilized as a potential alternative to the Pt metal catalyst for the oxidation of methanol. SPAni emerged as the best matrix for the deposited Ni catalyst nanoparticles. This combination generated a peak current density of 306 μA cm^{-2} at +0.57 V. In addition, the Ni/SPAni catalyst produced a higher I_F/I_B ratio compared to the commercial Pt–Ru/C catalyst. Furthermore, a current density of 135 mA cm^{-2} (at +0.2 V potential) and a maximum power density of 27 mW cm^{-2} were obtained at 60 °C upon utilizing Ni/SPAni as the anode catalyst for DMFCs. The results, thus obtained, were better than those obtained for the commercial Pt–Ru/C, as well as, the Ni/C and Ni/PAni catalysts.

v. Dutta, Kingshuk; Das, Suparna; Kundu, Patit Paban (2015): Partially sulfonated polyaniline induced high ion-exchange capacity and selectivity of Nafion membrane for application in direct methanol fuel cells. ***Journal of Membrane Science*** (**Elsevier Science, I.F. 7.2**), Volume 473, Pages 94–101.

Traditionally used Nafion membranes in direct methanol fuel cells (DMFCs) suffer from high methanol permeabilities, as well as, high material costs; therefore, alternative and more efficient polymer electrolyte membrane (PEM) materials need to be synthesized in order to realize better cell performances. We recently synthesized and reported the use of low cost partially sulfonated polyaniline (SPAni) as a co-constituent along with partially sulfonated poly(vinylidene fluoride-*co*-hexafluoro propylene) as an effective PEM material. This PEM material exhibited extremely low methanol permeability and very high membrane selectivity. Based on these positive attributes, we demonstrate in this work that blend of Nafion and SPAni can serve as an alternative PEM material; since PEM fabricated using 30 wt% of SPAni and 70 wt% of Nafion produced selectivity ratios of 7.91×10^{4} Ss cm^{-3} (at 20 °C) and 1.97×10^{5} Ss cm^{-3} (at 60 °C), an ion-exchange capacity of 1.2 meq g^{-1} (at 20 °C), methanol permeabilities of 9.12×10^{-8} cm^{2} s^{-1} (at 20 °C) and 1.2×10^{-7} cm^{2} s^{-1} (at 60 °C), and a current density of 128.7 mA cm^{-2} at +0.2 V and 60 °C and a corresponding maximum power density of 25.76 mW cm^{-2} using 6 M methanol feed concentration. The cell performance, thus observed, is far better than that produced by pristine Nafion membrane under the same operating conditions.

vi. Mandal, Sudipta; Soam Shweta,; Kundu, Patit Paban (2015): Reduction of methanol crossover and improved electrical efficiency in Direct Methanol Fuel Cell by the formation of a thin layer on Nafion 117 membrane: Effect of dip-coating of a blend of Sulphonated PVdF-co-HFP and PBI, ***Journal of Membrane Sci.*, Elsevier Publications (Impact Factor 7.2),** Volume 474, Pages 140–147.

The surface of Nafion 117 membrane was modified by dip-coating of a blend of polybenzimidazole (PBI) and partially sulfonated polyvinylidinefluoride-co-hfp (SPVDF-co-HFP) polymer without any significant change in the thickness of the membrane. The dip-coated membranes were characterized by FTIR spectroscopy, thermogravimetry and rheology; ion exchange capacity (IEC), proton conductivity and methanol permeability were also measured to find the suitability of these membranes in the direct methanol fuel cell (DMFC), especially keeping in view with a reduced methanol crossover and improved electrical efficiency. The IEC and proton conductivity of the membranes were observed to be lower than pristine Nafion 117 membrane. On the other hand, the methanol permeability of coated membranes was found to be very less than the pristine Nafion 117 membrane. Although, a very thin coat of the blends of PBI and SPVdF-co-HFP was applied on Nafion 117, the dynamic rheological studies indicated that the glass transition temperature of Nafion 117 shifted to a higher temperature, leading to higher stability of coated membranes at higher temperature in comparison to the stability of Nafion. The high thermal stability of the coated membranes compared to Nafion was also corroborated from the thermogravimetric analysis. All these results indicated that the coated Nafion 117 membrane could be electrically efficient at high temperature for DMFC applications.
From the DMFC performance test, it was observed that the Nafion 117 membrane coated with 70:30 PBI and SPVDF-co-HFP showed the best electrical performance (39 mW/cm^{2} at 0.2 V)

at the temperature of 90 °C, whereas for pristine Nafion 117 membrane, the maximum electrical performance of the DMFC was observed to be 36 mW/cm^2 at the same voltage and at 60 °C.

(5) Polymer Rheology

Starting from my Ph.D days, I have working experience in the area of polymer rheology. I have guided one Ph.D. student and published nine research papers in the area of rheology.

i. Patit P. Kundu, Ratan Pal Singh, Effect of addition of surfactants on the rheology of gels from methylcellulose in N,N-dimethylformamide, **Journal of Applied Polymer Science (John Wiley)**, Volume 108, Issue 3, 5 May 2008, Pages 1871-1879.

The effect of highly substituted cationic cetyl trimethyl ammonium bromide (CTAB), less substituted cationic hexadodecyl ammonium bromide (HDAB), CTAB- and HDAB-modified montmorillonite (CTABMONT and HDABMONT), and nonionic surfactants on the rheological properties of methylcellulose (MC) *N*,*N*-dimethylformamide (DMF) gels have been studied. The storage modulus of the MC-MDF gels increases with an increase in frequency. During the frequency scan, the storage and loss modulus of MC-DMF gel crosses over each other at two different frequencies. At the crossover points, the loss tangent is found to be unity. The addition of CTAB- and HDAB-modified nanofiller increases in the gel strength of MC-DMF gel. The storage modulus of MC-DMF gel in the presence of CTABMONT is found to be higher than that of CTAB-modified MC-DMF gel. Whereas, the storage modulus of MC-DMF gel in the presence of HDABMONT is lower than that of HDAB-modified MC-DMF gel. On the other hand, the addition of nonionic surfactant (Brij78) decreases the gel strength.

ii. Ratan Pal Singh, Patit Paban Kundu, Thermogelation of methylcellulose from solution in *N*,*N*-dimethylformamide and characterization of the transparent gels, **Journal of Applied Polymer Science (John Wiley),**Volume110, Issue 5, **5** December 2008. Pages 3031-3037.

A transparent gel was prepared through the cooling of a methylcellulose (MC) solution in *N*,*N*-dimethylformamide (DMF) at 80°C to a lower temperature. The temperature at which gelation occurred was dependent on the concentration of the solution. The gel temperature increased with an increase in the concentration of MC. The gelation of MC in DMF was studied by means of optical microscopy (OM), differential scanning calorimetry, and dynamic mechanical analysis (DMA). The OM studies revealed the presence of loosely bound beads of MC with DMF at a lower concentration. These beads became interconnected to rods, and subsequently, a continuous, thick gel was formed as the concentration increased. From DMA studies, it was observed that the loss modulus of the gel crossed over the storage modulus at two different frequencies. This indicated the presence of two types of network structures generated from the weak and strong associations of MC with the organic solvent DMF.

iii. Ratan Pal Singh, Patit Paban Kundu, Studies on rheological, thermal, and morphological properties of methylcellulose gel in aqueous medium, **Polymer Engineering and Science (John Wiley)**, Volume59, Issue10, October 2019, Pages 2024-2031.

The rheological, morphological, and thermal behavior of aqueous methylcellulose (MC) gels was investigated by optical microscope, dynamic mechanical analyzer (DMA), and differential scanning calorimeter. The double crossover between the storage modulus and loss modulus during the frequency scan in DMA suggests the transition from gel to sol state. These gel networks are comprised of bead-rod structures, which is visible under the optical microscope.

Furthermore, the degelation mechanism of gels comprises of the thermodynamic viable bead burst phenomenon. The reheated samples of MC under dynamic compression show partial irreversibility of the MC aqueous system, indicating the possible presence of weakly coupled random coils and helix. The phenomenon of turbidity of MC aqueous gels is discussed with the help of a large bead model, in which the small-sized beads present in aqueous solution collide with each other to form large beads.

iv. **Kundu, P. P.** and Tripathy, D. K. (1998): Rheological Properties of Poly[ethylene-co-(methylacrylate)], Polychloroprene and their Blends. ***Polymer*** **(Impact Factor 4.23),** ***ISSN: 0032-3861*** *(Elsevier Publishers, UK)* <u>39/10</u>, 1869-1864.

Rheological properties of blends of poly[ethylene-co-(methylacrylate)] (PEMA, methyl acrylate content 22%) and polychloroprene (CR) have been studied through capillary and dynamic elongational flow. Both capillary and dynamic out of phase viscosity (η'_E) decreases with increased shear rate and frequency in accordance with the power law. On the other hand dynamic extensional viscosity (η'_E) shows a non-linear relationship with frequency with an initial increase followed by a sharp drop at around 11 Hz. The positive activation energy of shear flow indicates lowering of viscosity at higher temperature. 30/70 and 70/30 PEMA/CR blends show maximum relative positive deviation (RPD) in case of shear and dynamic flow respectively. RPD increases linearly with shear rate for capillary flow whereas for dynamic flow, RPD shows non-linear relationship with frequency. The increase of RPD with temperature for both capillary and dynamic flows indicates better interaction between PEMA and CR in their blends.

v. **Kundu, P. P.**, Tripathy, D. K. and Gupta, B. R. (1996): Effect of Rheological Parameters on the Miscibility and Polymer-Filler Interactions of the Black-Filled Blends of Polyethylene – Vinyl Acetate and Polychloroprene. ***Journal of Applied Polymer Science*** **(Impact Factor: 2.25),** ***ISSN: 1097-4628*** *(John Wiley & Sons, USA)* <u>61</u>, 1971-1983.

Miscibility of 30 phr loaded black-filled (N110) blends of polyethylene-vinyl acetate (EVAc,

VAc content 28%) and polychloroprene (CR) are investigated through shear and dynamic deformations. Both shear (η_a) and dynamic elongational (η'_E) viscosities are conducive to their miscibility as both show positive deviation for all blends, though dynamic out-of-phase (η''_E) viscosity shows negative-positive deviation. Both η_a and η'_E follow the power law relationship with shear rate ($\dot{\gamma}_{wa}$) and frequency (ω), respectively. Both storage (E') and loss (E'') modulii increases with frequency. The higher dissipative energy at around 11 Hz may be due to its syncronization with molecular vibrations of the polymer segments. The

effect of rheological parameters like strain rate and temperature on the relative change in shear (RV_S) and dynamic elongational (RV_D) viscosities is reported for the variation of blend composition with 30 phr loaded black-filled compounds. The variation of both RV_S and RV_D follows a third order polynomial equation with carbon black loading in 50/50 EVAc/CR blend; all the polynomial constants are function of temperature and strain rate.

Annexure 1

(i) Statistics for List of Publications: Web of Science (WOS) researcher ID- AAU-5364-2020; SCOPUS ID-35475516300

(a) Nos as per SCOPUS : 220

	Single author	Double authors	More than two authors
No of Papers in Scopus listed journals	01	46	173
No of citations per Scopus	47	1984	3828

(b) (i) **H-Index (as per Google Scholar): 52**

(ii) I10 Index (as per Google Scholar): 192

(iii) **Nos as per google scholar: 232**

	Single author	Double authors	More than two authors
No of Papers as per google scholar	01	46	173
No of citations as per google scholar	52	2107	5429

(ii) **As per study by Stanford University, myself is declared as topmost 2 % scientist in the world in the field of Polymer Science & Engineering (World rank:1092).**

(ii **AS per AD Scientific Index (screen shot attached at the end), in last five years of citation, I am ranked 13 amongst all of faculties in IIT Roorkee and 2 % of top most scientist of India and World in the area of Chemical Engineering.**

Last updated on 02.03.2024

List of Publications

Two hundred thirty two papers have been published in international journals of repute (with around 1130 total impact factors and 9578 total citations with present H-Index of 52, i10 index of 192).

Numbers of published papers with Impact Factor between 3 and 5 : 110

Numbers of published papers with Impact Factor more than 5 : 90

Year 2024 (Four Publications)

1. Kumar, Deepak; Pal, Ravi Raj; Das, Neeladri; Roy, Partha; Saraf, Shubhini A; Bayram, Sinan; Kundu, Patit P. (2024): Synthesis of flaxseed gum/melanin-based scaffold: A novel approach for nano-encapsulation of doxorubicin with enhanced anticancer activity, **International Journal of Biological Macromolecules (Elsevier Sc, UK, IF 8.2, 0141-8130 ISSN),** 256, 127964-75. https://doi.org/10.1016/j.ijbiomac.2023.127964
2. Saha, Dipankar; Roy, Bidesh; Pattanayak, Satyajit; Mishra, Laxman; Kundu, Patit Paban (2024): Performance, emission, combustion, exergy, exergoeconomic and sustainability analyses of EGR incorporated CI engine fuelled with areca nut husk nano-additive dosed plastic oil–water-diesel emulsion blend, **Thermal Science and Engineering progress (Elsevier Sc, UK, Impact Factor:4.8),** 47, 102317- 32. https://doi.org/10.1016/j.tsep.2023.102317
3. Singh, Amandeep; Kumari, Kamlesh; Dhiman, Vandana; Bhadada, Sanjay; Kundu, Patit Paban (2024): Recycled Polyurethane (rPU)-Block-Hydroxybutyl-Terminated Poly(dimethylsiloxane) (hbPDMS) (rPU-b-hbPDMS) Copolymer Nanocomposites for Osteoblast Cell Regeneration, **ACS Applied Polymer Materials (American Chemical Society, USA; Impact Factor:5),** In Press.

4. Geetanjali; KUndu, Patit Paban (2024): Lemon grass derived porous carbon impregnated with NiWO4 as anode electrocatalyst to improve energy output in single chambered microbial fuel cell, **International Journal of Hydrogen Energy(Elsevier Sc, UK, Impact Factor 7.2)**, In Press.

Year 2023 (Six Publications)

5. Kaur Dhillon, Simran; Kundu, Patit Paban (2023): Transitional trimetallic alloy embedded polyacrylamide hydrogel derived nitrogen-doped carbon air-cathode for bioenergy generation in microbial fuel cell, **Sustainable Energy Technologies and Assessments (Elsevier Sc, UK, Impact Factor 8.0)**, 55, 103001-11. https://doi.org/10.1016/j.seta.2022.103001
6. Kaur Dhillon, Simran; Kundu, Patit Paban (2023): Transition metal sulfide/oxide nanoflowers decorated on poly (aniline-2-sulfonic acid) modified polyacrylamide derived carbon cathode catalyst for bioenergy generation in microbial fuel cells, **Electrochimica Acta (Elsevier Sc, UK, IF 6.6), 461, 142697-710** https://doi.org/10.1016/j.electacta.2023.142697
7. Rinki; Geetanjali; Kundu, Patit Paban (2023): Nickel-Cobalt oxides coated on polypyrrole nanotubes as bifunctional electrode catalyst for enhancing the performance of the microbial fuel cells, **Materials Sc & Engineering :B (Elsevier Sc, Impact Fcator 3.6),** 297, 116735-45. https://doi.org/10.1016/j.mseb.2023.116735
8. Kaur Dhillon, Simran; Dziegielowski, Jakub; Kundu, Patit Paban;, Di Lorenzo, Mirella (2023): Functionalised graphite felt anodes for enhanced power generation in membrane-less soil microbial fuel cells, **RSC Sustainability (Royal Chemical Society, UK; Impact Factor:),** 1/2, 310-325. DOI: 10.1039/D2SU00079B.
9. Kumar, Deepak; Kundu, Patit Paban (2022):Poly (acrylamide-co-acrylonitrile) hydrogel-derived iron-doped carbon foam electrocatalyst for enhancing oxygen reduction reaction in microbial fuel cell, **International Journal of Hydrogen Energy (Elsevier Sc, UK, Impact Factor 7.2)**, 48/21, 7884-7895. https://doi.org/10.1016/j.ijhydene.2022.11.109
10. Kumar, Deepak; Gautam, Arti; Kundu, Patit Paban (2023): Synthesis of acrylamide-g-melanin/itaconic acid-g-psyllium based nanocarrier for capecitabine delivery: In vivo and in vitro anticancer activity, **International Journal of Pharmaceutics (Elsevier Sc, UK, Impact Factor:5.8),** 635, 122735- 12244. https://doi.org/10.1016/j.ijpharm.2023.122735

Year 2022 (Twelve Publications)

11. Chaturvedi, Amit; Kundu, Patit Paban (2022): Co-Doped Zeolite–GO Nanocomposite as a High-Performance ORR Catalyst for Sustainable Bioelectricity Generation in Air-Cathode Single-Chambered Microbial Fuel Cells, **ACS Appl. Mater. Interfaces (American Chemical Society, USA, Impact Factor 9.5),** 14/29, 33219–33233. https://doi.org/10.1021/acsami.2c07638
12. Kumar, Deepak; Gautam, Arti; Tripathi, Deepak Kumar; Poluri, Krishna Mohan; Kundu, Patit Paban (2022): Synthesis, characterization and biological influences of rifaximin loaded melanin/zinc oxide nanoparticles**, Journal of Drug Delivery Science and Technology (Elsevier Sc, UK, Impact Factor: 5),** 77, 103875-84. https://doi.org/10.1016/j.jddst.2022.103875
13. Chaturvedi, Amit; Kundu, Patit Paban (2022): Enhancing sustainable bioelectricity generation using facile synthesis of nanostructures of bimetallic Co-Ni at the combined support of halloysite nanotubes and reduced graphene oxide as novel oxygen reduction reaction electrocatalyst in single-chambered microbial fuel cells, **International Journal of Hydrogen Energy(Elsevier Sc, UK, Impact Factor 7.2)**, 68, 29413-29429. https://doi.org/10.1016/j.ijhydene.2022.06.273
14. Chaturvedi, Amit; Dhillon, Simran Kaur; Kundu, Patit Paban (2022): 1-D semiconducting TiO_2 nanotubes supported efficient bimetallic Co-Ni cathode catalysts for power generation in single-chambered air-breathing microbial fuel cells, **Sustainable Energy Technologies and Assessments (Elsevier Sc, UK, Impact Factor 8.0)**, A/53, 102479-90. https://doi.org/10.1016/j.seta.2022.102479
15. Kumar, Deepak; Gautam, Arti; Rohatgi, Soma; Kundu, Patit. P (2022): Synthesis of vildagliptin loaded acrylamide-g-psyllium/alginate-based core-shell nanoparticles for diabetes treatment, **International Journal of Biological Macromolecules, (Elsevier Sc, UK, IF 8.2,** 0141-8130 ISSN**),** 218, 82-93. https://doi.org/10.1016/j.ijbiomac.2022.07.066
16. Dhillon, Simran Kaur; Chaturvedi, Amit; Gupta, Divyani; Nagaiah, Tharamani C; Kundu, Patit Paban (2022): Copper nanoparticles embedded in polyaniline derived nitrogen-doped carbon as electrocatalyst for bio-energy generation in

microbial fuel cells**, Environmental Science and Pollution Research (Springer Nature, Impact factor 4.3)**, pages 1-18, Published online on 21st June, 2022 https://doi.org/10.1007/s11356-022-21437-x.

17. Geetanjali; Kaur Dhillon, Simran; Kundu, Patit Paban (2022): Development of polypyrrole nanotube coated with chitosan and nickel oxide as a biocompatible anode to enhance the power generation in microbial fuel cell, **Journal of Power Sources (Elsevier Sc, UK Impact Factor 9.2),** volume 539, 231539-50.
18. Kaur Dhillon, Simran; Kundu, Patit Paban (2022): Polyaniline interweaved iron embedded in urea-formaldehyde resin-based carbon as a cost-effective catalyst for power generation in microbial fuel cell, **Chemical Engineering Journal (Elsevier Sc, UK, Impact Factor 16.74),** 431/4, 133341-50.
19. Kaur Dhillon, Simran; Kundu, Patit Paban (2022): Magnesium Cobaltite Embedded in Corncob-Derived Nitrogen-Doped Carbon as a Cathode Catalyst for Power Generation in Microbial Fuel Cells, **ACS Appl. Mater. Interfaces (American Chemical Society, USA, Impact Factor 9.5),** 14/42, 47633–37649. https://doi.org/10.1021/acsami.2c12279
20. Kumar, Deepak; Gautam, Arti; Kundu, Patit Paban (2022): Synthesis of pH-sensitive grafted psyllium: Encapsulation of quercetin for colon cancer treatment, **Journal of Applied Polymer Science (John Wiley & Sons, Impact Factor: 3.3),** 139/4, 51552-68.
21. Kaur Dhillon, Simran; Jain, Rahul; Kundu, Patit Paban (2022): Catalytic advancements in carbonaceous materials for bio-energy generation in microbial fuel cells: a review, **Environmental Science and Pollution Research (Springer Nature, Impact Factor 4.2)**, https://doi.org/10.1007/s11356-021-17529-9.
22. Chaturvedi, Amit; Kundu, Patit Paban (2022): Nanostructured Graphene Utilization in Microbial Fuel Cells for Green Energy and Wastewater Treatment: Recent Developments and Future Perspectives, **Journal of Hazardous, Toxic, and Radioactive Waste (American Society of Civil Engineers, Impact Factor 1.44)**, 26/2, Pages 03122002-10 . DOI: 10.1061/(ASCE)HZ.2153-5515.0000692.

Year 2021 (Eight Publications)

23. Chaturvedi, Amit; Chaturvedi, Akansha; Tharamani C. Nagaiah, Kundu, Patit Paban (2021): Synthesis of Co-Fe nanoparticle supported on titanium oxide-nanotubes (TiO2-NTs) as enhanced oxygen reduction reaction electrocatalyst, **Matreials Today: Proceedings (Elsevier Sc, UK**; **Impact Fcator: 2.59)**, 45, 5518-5522.
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