ANNUAL REPORT 2020

From Left: 1st Row: Gaurav Vishwakarma, Kannan M. P., Devaraj Krishnan, Sooraj B. S., Sritama Mukherjee, **Prof. T. Pradeep**, Tanvi Gupte. **2nd Row:** Abhijit Nag, Esma Khatun, Swetashree Acharya, Anil Kumar Avula, Subrata Duary, Paulami Bose, Priya K., Sugi K. S. **3rd Row:** Asish Kurian, Bijesh Malla, Anagha Jose, B. K. Spoorthi, Arijit Jana, Vishal Kumar, Tripti Ahuja, A. Suganya. **4th Row:** Amrita Chakraborty, Dhivyaraja K., Angshuman Ray Chowdhuri, Pallab Basuri, Vivek Yadav, Madhuri Jash, Sandeep Bose, S. Jenifer. **5th Row:** Ananthu Mahendranath, Srikrishnarka Pillalamarri, Kartheek Joshua, Mohd. Azhardin Ganayee, Tanmayaa Nayak, Sujan Manna, Biswajit Mondal, Jayoti Roy. **6th Row:**, Sudhakar Chennu, Md. Rabiul Islam, Ankit Nagar, Sourav Kanti Jana, Sundar Raj, Ganesan Paramasivam, Amoghavarsha R. Kini, and Ramesh Kumar Soni.

Pradeep Research Group

Indian Institute of Technology Madras

Chennai 600 036, India

Please visit the links for annual reports of 2014, 2015, 2016, 2017, 2018, and 2019.
(In case security permission is requested, please allow; you need to do it only once.)

Our team

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Ph.D. Students

- A. Anil Kumar
- A. Suganya
- Amoghavarsha R. Kini
- Amrita Chakraborty
- Anagha Jose
- Ankit Nagar*
- Arijit Jana
- Bijesh Malla
- Gaurav Vishwakarma
- Jayoti Roy
- M. P. Kannan*
- Madhuri Jash
- Md Rabiul Islam
- Mohd. Azhardin Ganayee
- Pallab Basuri
- Paulami Bose
- S. Jenifer*
- Sandeep Bose
- Sooraj B. S.
- B. K. Spoorthi
- Srikrishnarka Pillalamarri*
- Sritama Mukherjee*
- Subrata Duary
- Sudhakar Chennu
- Sugi Shivan
- Sujan Manna
- Swetashree Acharya
- Tanmayaa Nayak
- Tanvi Gupte*
- Vishal Kumar*
- Vivek Yadav

* Interdisciplinary/Joint students

Our struggle is to be creative every day.

Postdoctoral/Research Associates

- Dr. Abhijit Nag
- Dr. Angshuman Ray Chowdhuri
- Dr. Biswajit Mondal
- Dr. Esma Khatun[$]
- Dr. Ganesan P.
- Dr. Kartheek Joshua
- Dr. Sourav Kanti Jana
- Dr. Tripti Ahuja[$]

Administrative Officer

- K. Priya

Project Technicians

- Asish Kurian
- Devaraj. K
- E. Sundarraj

M.S. Students

- Ananthu Mahendranath
- Ramesh Kumar

M.Sc./ M.Tech/ B.Tech

- Deeksha
- Raga Madhuri
- Sanjiit Gayen
- Soumya Samanta
- Subhadip Das

[$]Institute postdoctoral fellows

What's Inside?

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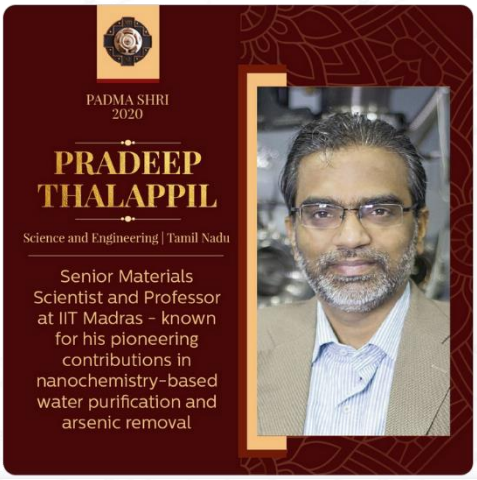
Glimpses of 2020

Prof. Pradeep with Prof. Ajay Sood, FRS during his visit to IITM and ICCW.

Prof. Pradeep with eminent scientists during the International Conference on Nano Science and Technology- 2020 (ICONSAT-2020) organized by S. N. Bose National Centre for Basic Sciences, Kolkata during March 5 -7, 2020.

Awards and Honors



Nation conferred the Padma Shri (the fourth highest civilian award in India) award on Prof. Pradeep.

IIT Madras
January 29 ·

#PadmaShri 2020, Prof. T Pradeep from #IITMadras speaks about his affordable technologies for purifying water by removing pesticides and arsenic, which is now being used by nine million people across the Country, to J Sam Daniel Stalin of NDTV. Prof. Pradeep also talks about nanotechnology, extracting water out of air & enhancing quality of research at IITs & Universities to improve their global ranking. Department of Science and Technology, Government of India Ministry of Human Resource Development, Government of India

https://www.youtube.com/watch?v=1BFgp9Qcm58&feature=youtu.be

Prof. T. Pradeep has been chosen as one of the winners of Nikkei Asia Prizes 2020. First presented in 1996, and thus in the 25th edition, “the Prizes shine a spotlight on individuals who have contributed to the region’s sustainable development and to the creation of a better future in Asia.”

Prof. Pradeep was bestowed with a National Water Awards by Government of India, Ministry of Jal Shakti. It was presented on November 11, 2020.

Prof. T. Pradeep has been selected for the Chemical Research Society of India (CRSI) silver medal 2021, along with Professor Jiten Bera of IIT Kanpur.

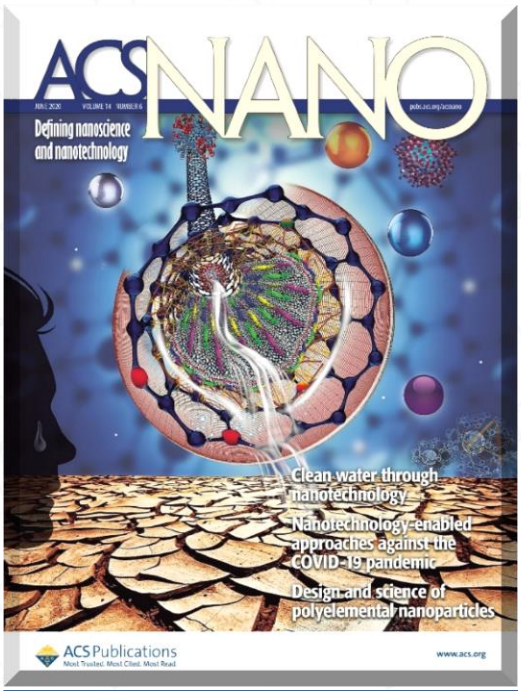
Publications

Journal Publications*

1. A covalently integrated reduced graphene oxide-ion exchange resin electrode for efficient capacitive deionization, Md Rabiul Islam, Soujit Sen Gupta, Sourav Kanti Jana, Pillalamarri Srikrishnarka, Biswajit Mondal, Sudhakar Chennu, Tripti Ahuja, Amrita Chakraborty and Thalappil Pradeep, Adv. Mater. Interfaces, (2020). (Just Accepted)
2. New routes for multi-component atomically precise metal nanoclusters, Esma Khatun and Thalappil Pradeep, ACS Omega, (2020) (DOI: 10.1021/acsomega.0c04832). (Invited Perspective) (Just accepted).
3. Reaction between Ag_{17}^{+} and acetylene outside the mass spectrometer: Dehydrogenation in the gas phase, Madhuri Jash, Rabin Rajan J. Methikkalam, Mohammad Bodiuzzaman, Ganesan Paramasivam and Thalappil Pradeep, Chem. Commun., 56 (2020) 15623–15626 (DOI: 10.1039/d0cc05837h).
4. Microdroplet impact-induced spray ionization mass spectrometry (MISI MS) for online reaction monitoring and bacteria discrimination, Pallab Basuri, Subhashree Das, Shantha Kumar Jenifer, Sourav Jana and Thalappil Pradeep, J. Am. Soc. Mass Spectrom., (2020) (DOI: 10.1021/jasms.0c00365). (Article ASAP).
5. Evaluating the impact of tailored water wettability on performance of CO_2-capture, Adil Rather, Pillalamarri Srikrishnarka, Avijit Baidya, Arpita Shome, Thalappil Pradeep, Uttam Manna and Thalappil Pradeep, ACS Appl. Energy Mater., 3 (2020) 10541–10549 (DOI: 10.1021/acsaem.0c01603). (Article ASAP).
6. Atom transfer between precision nanoclusters and polydispersed nanoparticles: A facile route for monodispersed alloy nanoparticles and their superstructures, Paulami Bose, Papri Chakraborty, Jyoti Sarita Mohanty, Nonappa, Angshuman Ray Chowdhuri, Esma Khatun, Tripti Ahuja, Ananthu Mahendranath and Thalappil Pradeep, Nanoscale, 12 (2020) 22116–22128 (DOI: 10.1039/D0NR04033A).
7. Dithiol-induced contraction in Ag_{14} clusters and its manifestation in electronic structure, Mohammad Bodiuzzaman, Esma Khatun, Korath Sugi, Ganesan Paramasivam, Wakeel Dar, Sudhadevi Antharjanam and Thalappil Pradeep, J. Phys. Chem. C, 124 (2020) 23426–23432 (DOI: 10.1021/acs.jpcc.0c07140).
8. Atomically precise noble metal cluster-assembled superstructures in water: Luminescence enhancement and sensing, Abhijit Nag, Papri Chakraborty, Athira Thacharon, Ganesan

Paramasivam, Biswajit Mondal, Mohammad Bodiuzzaman and Thalappil Pradeep, J. Phys. Chem. C, 124 (2020) 22298–22303 (DOI: 10.1021/acs.jpcc.0c06770).

9. Smartphone-based fluoride-specific sensor for rapid and affordable colorimetric detection and precise quantification at sub-ppm levels for field applications, Sritama Mukherjee, Manav Shah, Kamalesh Chaudhari, Arijit Jana, Chennu Sudhakar, Pillalamarri Srikrishnarka, Md Rabiul Islam, Ligy Philip and Thalappil Pradeep, ACS Omega, 5 (2020) 25253–25263 (DOI: 10.1021/acsomega.0c03465).
10. Dual emitting Ag_{35} nanocluster protected by 2-pyrene imine thiol, Arijit Jana, Papri Chakraborty, Wakeel Ahmed Dar, Sourov Chandra, Esma Khatun, M. P. Kannan, Robin H. A. Ras and Thalappil Pradeep, Chem. Commun., 56 (2020) 12550-12553 (DOI: 10.1039/d0cc03983g).
11. Co-crystals of atomically precise noble metal nanoclusters, Mohammad Bodiuzzaman, Wakeel Dar and Thalappil Pradeep, Small, 2003981 (2020) 1-15 (DOI: 10.1002/smll.202003981). (Article ASAP).
12. $[Ag_{15}H_{13}(DPPH)_5]^{2+}$ and $[Ag_{27}H_{22}(DPPB)_7]^{3+}$: Two new hydride and phosphine co-protected clusters and their fragmentation leading to naked clusters, Ag_{13}^+ and Ag_{25}^+, Madhuri Jash, Esma Khatun, Papri Chakraborty, Chennu Sudhakar and Thalappil Pradeep, J. Phys. Chem. C, 124(2020) 20569–20577 (DOI: 10.1021/acs.jpcc.0c05867).
13. Manifestation of structural differences of atomically precise cluster assembled solids in their mechanical properties, Korath Sugi, Payel Bandyopadhyay, Mohammad Bodiuzzaman, Abhijit Nag, Manjapoyil Hridya, Wakeel Dar, Pijush Ghosh and Thalappil Pradeep, Chem. Mater., 32 (2020) 7973–7984 (DOI: 10.1021/acs.chemmater.0c02905).
14. Non-stoichiometric copper sulfide nanostructures at the brass-rubber interface: Implications for rubber vulcanization temperature in the tire industry, M.P. Kannan, Anirban Som, Tripti Ahuja, Vidhya Subramanian, A. Sreekumaran Nair and Thalappil Pradeep, ACS Appl. Nano Mater., 3 (2020) 7685–7694 (DOI: 10.1021/acsanm.0c01298).
15. Accelerated microdroplet synthesis of benzimidazoles by nucleophilic addition to protonated carboxylic acids, Pallab Basuri, Louis Edwin Gonzalez, Nicolás Morato, Thalappil Pradeep and R. Graham Cooks, Chem. Sci., 11 (2020) 12686-12694 (DOI: 10.1039/D0SC02467H).
16. Probing subtle changes in molecular orientations using ambient electrospray deposition Raman spectroscopy (AESD RS), Atanu Ghosh, Tripti Ahuja, Kamalesh Chaudhari and Thalappil Pradeep, J. Phys. Chem. C, 124 (2020) 16644–16651 (DOI: 10.1021/acs.jpcc.0c04116).
17. Entrapping atomically precise clusters in cyclodextrin-functionalized aminoclay sheets: Synthesis and enhanced luminescence, Mohd Azhardin Ganayee, C. K. Manju, Wakeel Dar, Biswajit Mondal and Thalappil Pradeep, Ind. Eng. Chem. Res., 59 (2020) 12737–12744 (DOI: 10.1021/acs.iecr.9b07018).
18. Fullerene-mediated aggregation of $M_{25}(SR)_{18}^-$ (M = Ag, Au) nanoclusters, Papri Chakraborty, Abhijit Nag, Biswajit Mondal, Esma Khatun, Ganesan Paramasivam and Thalappil Pradeep, J. Phys. Chem. C, 124 (2020) 14891–14900 (DOI: 10.1021/acs.jpcc.0c03383).
19. Clean water through nanotechnology: Needs, gaps, and fulfillment, Ankit Nagar and Thalappil Pradeep, ACS Nano, 14 (2020) 6420–6435 (DOI: 10.1021/acsnano.9b01730).



Ankit Nagar and Thalappil Pradeep, *ACS Nano*, 2020 (Review Article). **Cover page**

20. Enhanced capture of particulate matter by molecularly charged electrospun nanofibers, Pillalamarri Srikrishnarka, Vishal Kumar, Tripti Ahuja, Vidhya Subramanian, Arun Karthick Selvam, Paulami Bose, Shantha Kumar Jenifer, Ananthu Mahendranath, Mohd Azhardin

Ganayee, Ramamurthy Nagarajan and Thalappil Pradeep, ACS Sustain. Chem. Eng., 8 (2020) 7762–7773 (DOI: 10.1021/acssuschemeng.9b06853).

21. Iron assisted formation of CO_2 over condensed CO and its relevance to interstellar chemistry, Rabin Rajan J. Methikkalam, Jyotirmoy Ghosh, Radha Gobinda Bhuin, Soumabha Bag, Gopi Ragupathy, and Thalappil Pradeep, Phys. Chem. Chem. Phys., 22 (2020) 8491–8498 (DOI: 10.1039/c9cp06983f).
22. Arsenic toxicity: Carbonate's counteraction revealed, Swathy Jakka Ravindran, Shantha Kumar Jenifer, Jayashree Balasubramanyam, Sourav Jana, Subramanian Krishnakumar, Sailaja Elchuri, Ligy Philip, and Thalappil Pradeep, ACS Sustain. Chem. Eng., 8 (2020) 5067–5075 (DOI: 10.1021/acssuschemeng.9b06850).
23. Ligand structure and charge state-dependent separation of monolayer protected Au_{25} clusters using non-aqueous reversed-phase HPLC, Korath Shivan Sugi, Shridevi Bhat, Abhijit Nag, Ganesan Paramasivam, Ananthu Mahendranath, and Thalappil Pradeep, Analyst, 145 (2020) 1337–1345 (DOI: 10.1039/c9an02043h).

Publications with other groups

24. Self-assembly of precision noble metal nanoclusters: Hierarchical structural complexity, colloidal superstructures and applications, Jose V. Rival, Paloli Mymoona, Kavalloor Murali Lakshmi, Nonappa, Thalappil Pradeep, Edakkattuparambil Sidharth Shibu, Small, 2020. (Just accepted).
25. Ferrofluid microdroplet splitting for population-based microfluidics and interfacial tensiometry, Mika Latikka, Matilda Backholm, Avijit Baidya, Alberto Ballesio, Amandine Serve, Gregory Beaune, Jaakko V.I. Timonen, Thalappil Pradeep and Robin H.A. Ras, Adv. Sci., 7 (2020) 2000359 (DOI: 10.1002/advs.202000359). (Early View).
26. Non-enzymatic glucose sensing using $Ni_{60}Nb_{40}$ nanoglass, Soumabha Bag, Ananya Baksi, Sree Harsha Nandam, Di Wang, Xinglong Ye, Jyotirmoy Ghosh, Thalappil Pradeep, and Horst Hahn, ACS Nano, 14 (2020) 5543−5552 (DOI: 10.1021/acsnano.9b09778).
27. Ultrafast intersystem crossing in isolated $Ag_{29}(BDT)_{12}^{3-}$ probed by time-resolved pump-probe photoelectron spectroscopy, Aron Veenstra, Laurenz Monzel, Ananya Baksi, Joseph Czekner, Sergei Lebedkin, Erik Schneider, Thalappil Pradeep, Andreas-Neil Unterreiner, and Manfred Kappes, J. Phys. Chem. Lett., 11 (2020) 2675-2681 (DOI: 10.1021/acs.jpclett.0c00482).
28. Association of co-accumulation of arsenic and organophosphate insecticides with diabetes and atherosclerosis in a rural agricultural community, Ganesan Velmurugan, Krishnan Swaminathan, Sundaresan Mohanraj, Mani Dhivakar, Ganesh Veerasekar, Thomas Alexander, Mathew Cherian, Nalla G Palaniswami, and Thalappil Pradeep, Acta Diabetologica, 57 (2020) 909 (DOI: 10.1007/s00592-020-01516-6).
29. Phosphorylated cellulose nanofibers exhibit exceptional capacity for uranium capture, Janika Lehtonen, Jukka Hassinen, Avula Anil Kumar, Leena-Sisko Johansson, Roni Mäenpää, Nikolaos Pahimanolis, Thalappil Pradeep, Olli Ikkala and Orlando J. Rojas, Cellulose, 27 (2020) 10719–10732 (DOI: 10.1007/s10570-020-02971-8).

***Some of these papers will appear in 2021.**

Editorials of 2020

1. Remembering Professor, Academician, and Editor Lina Zhang, David T. Allen, D. Julie Carrier, Jingwen Chen, Nicholas Gathergood, Jinlong Gong, Hongxian Han, King Kuok (Mimi) Hii, Bing-Joe Hwang, Peter Licence, Michael Meier, Audrey Moores, Ryuhei Nakamura, Thalappil Pradeep, Bert Sels, Bala Subramaniam, Michael K. C. Tam, and Lin Zhuang, ACS Sustainable Chem. Eng. 2020, 8, 44, 16385.
2. Expectations for Manuscripts in ACS Sustainable Chemistry & Engineering: Scope Summary and Call for Creativity, David T. Allen, D. Julie Carrier, Jingwen Chen, Nicholas Gathergood, Jinlong

Gong, Hongxian Han, King Kuok (Mimi) Hii, Bing-Joe Hwang, Asha Liza James, Peter Licence, Michael Meier, Audrey Moores, Ryuhei Nakamura, Thalappil Pradeep, Bert Sels, Bala Subramaniam, Michael K. C. Tam, Lina Zhang, Lin Zhuang, and Rhea M. Williams, ACS Sustainable Chem. Eng. 2020, 8, 43, 16046–16047.

Interview with Prof. T. Pradeep in Asianet (In Malayalam)

3. Expectations for Manuscripts on Biomass Feedstocks and Processing in ACS Sustainable Chemistry & Engineering, D. Julie Carrier, David T. Allen, Nicholas Gathergood, Hongxian Han, Peter Licence, Michael R. Meier, Audrey Moores, Thalappil Pradeep, Bert Sels, Bala Subramaniam, Michael K. C. Tam, and Lina Zhang, ACS Sustainable Chem. Eng. 2020, 8, 30, 11031–11032.
4. Expectations for Manuscripts with Nanoscience and Nanotechnology Elements in ACS Sustainable Chemistry & Engineering, Thalappil Pradeep, David T. Allen, Peter Licence, and Bala Subramaniam, ACS Sustainable Chem. Eng. 2020, 8, 21, 7751–7752.
5. Expectations for Manuscripts on Catalysis in ACS Sustainable Chemistry & Engineering, King Kuok (Mimi) Hii, Audrey Moores, Thalappil Pradeep, Bert Sels, David T. Allen, Peter Licence, and Bala Subramaniam, ACS Sustainable Chem. Eng. 2020, 8, 13, 4995–4996.
6. The Evolution of ACS Sustainable Chemistry & Engineering, David T. Allen, D. Julie Carrier, Jingwen Chen, Nicholas Gathergood, Jinlong Gong, Hongxian Han, King Kuok (Mimi) Hii, Bing-Joe Hwang, Peter Licence, Michael Meier, Audrey Moores, Ryuhei Nakamura, Thalappil Pradeep, Bert Sels, Bala Subramaniam, Michael K. C. Tam, Lina Zhang, Lin Zhuang, Rhea M. Williams, and Paul T. Anastas, ACS Sustainable Chem. Eng. 2020, 8, 1, 1.

Popular Science

1. Plight of doctoral students during the pandemic, The Hindu, May 20, 2020.

Patent Applications

Indian Patents (Granted)

1. A method for preparing cellulose microstructures-templated nanocomposites with enhanced arsenic removal capacity, Thalappil Pradeep, Sritama Mukherjee, 201641044817, December 26, 2016, granted as patent no. 337979 on June 4, 2020.
2. Method for preparing crossed bilayer assembly of 1D nanowires using an atomically precise clusters, T. Pradeep, Anirban Som, Indranath Chakraborty and Tuhina Adit Maark, 6993/CHE/2015, December 28, 2015. granted as patent no. 340305 on July 3, 2020.
3. An enhanced carbon dioxide sorbent nanofiber membrane and a device thereof, T. Pradeep, Anangha Yatheendran, Ramesh Kumar and Arun Karthik, 201841031076, August 20, 2018, granted as patent no. 323314 on August 4, 2020.
4. Cellulose nanocrystal templated iron oxyhydroxide based adsorbent for arsenic removal from water and a device thereof, T. Pradeep, Avijit Baidya, Bibhuti Bhusan Rath and A. Anil Kumar, 201641027660, filed on August 12, 2016, granted as patent no 343818, August 10, 2020.

5. An integrated CDI electrode, T. Pradeep, Md. Rabiul Islam, Soujit Sengupta, Srikrishnarka Pillalamarri, 201741047400 , filed on December 30, 2017, granted as patent no 345270 on August 27, 2020.
6. Methods of making alloys of precise composition in solution by inter-cluster reactions in solution, T. Pradeep, K. R. Krishnadas, Atanu Ghosh, Ananya Baksi, Indranath Chakrabarti and Ganapathy Natarajan, 6907/CHE/2015, filed on Decemeber 14, 2015, granted as patent no. 345596 on August 29, 2020.
7. Organic-templated-boehmite-nanoarchitecture: An adsorbent composition to remove arsenic and fluoride from drinking water, T. Pradeep, Shihabudheen M. Maliyekkal, Anshup, M. Udhaya Sankar and Amrita Chaudhary, 1529/CHE/2010, granted as patent no 346000 on September 3, 2020.
8. Chitosan reinforced mixed oxide nanocomposite for fluoride removal from water and a device thereof, T. Pradeep; Anil Kumar Avula; Bibhuti Bhusan Rath, filed as application number 201641045048, December 30, 2016, granted as patent no. 354374 on December 23, 2020.
9. Multilayer multifunctional nasal filter by T. Pradeep, Arun Karthick, Pillalamarri Srikrishnarka, Vishal Kumar, Sathvik Ajay Iyengar and Ramesh Kumar Soni, filed as application on March 2, 2017, granted as patent number 351038 on November 6, 2020.

Indian Patents (Applied)

1. A point-of-care (POC) amperometric device for selective arsenic sensing, Thalappil Pradeep, Sourav Kanti Jana, and Kamalesh Chaudhari, 202041023576, June 5, 2020.
2. A smartphone based fluoride-specific sensor for rapid and affordable colorimetric detection and precise quantification at sub-ppm levels for field applications, Thalappil Pradeep, Sritama Mukerjee, Manav Shah, and Kamalesh Chaudhari, 202041026054, June 20, 2020.
3. Method for selective extraction of gold by niacin, Thalappil Pradeep and Abhijit Nag, 202041047984, November 03, 2020.
4. Cluster-assisted antiviral medications, Thalappil Pradeep; G Velmurugan; Esma Khatun; Krishnan Swaminathan; S Krishnakumar, 202041012975, March 25, 2020.
5. Multi-charged nanodroplets of water for microbial disinfection, Thalappil Pradeep, Jenifer Shantha Kumar, Tripti Ahuja, Depanjan Sarkar, Pallab Basuri, and Sandeep Bose, 202041015937, April 13, 2020.
6. Ambient microdroplet annealing method for converting polydispersed nanoparticles to their monodispersed analogues,Thalappil Pradeep, Angshuman Ray Chowdhuri, and Spoorthi Bhat, 202041056735, December 28, 2020.

PCT Patents (Applied)

7. URD-119/00US: Methods for coupling a carbon containing moiety to an amine containing moiety, PRF ref: 69066, R. G. Cooks, Thalappil Pradeep, Nicolas Mauricio Morato Gutierez and Pallab Basuri, filed on May 26, 2020.
8. Method for creating nanopores in MoS_2 nanosheets by chemical drilling for disinfection of water under visible light. Thalappil Pradeep, Depanjan Sarkar, Anirban Som, Biswajit Mondal, Swathy Jakka Ravindran, US Patent App. 16/757411, November 30, 2020.

Degree Holders

PhD Graduates

- **Jyotirmoy Ghosh**, Department of Chemistry, IIT Madras, 2019.

  ‘Clathrate hydrates in ultrahigh vacuum under cryogenic conditions’.

- **Debasmita Ghosh**, Department of Chemistry, IIT Madras, 2019.

  'An investigation of the chemical properties of luminescent protein protected atomically precise noble metal clusters'.

- **Md. Bodiuzzaman**, Department of Chemistry, IIT Madras, 2020.

  'Exploring chemical and structural diversity in atomically precise nanoclusters'.

- **Biswajit Mondal**, Department of Chemistry, IIT Madras, 2020.

  'Exploring the chemical and physical properties of 2D MoS_2 for clean water'.

- **Tripti Ahuja**, Department of Chemistry, IIT Madras, 2020.

  'Towards vibrational tomography of ligand protected nanoparticles'.

- **Esma Khatun**, Department of Chemistry, IIT Madras, 2020.

  'An investigation of atomically precise mono and multimetallic nanoclusters'.

- **Krishnan Swaminathan**, **MD**, **FRCP**, Department of Chemistry, IIT Madras, 2020.

  'Association between agrochemicals and non-communicable diseases in rural India: A case study on prevalence of diabetes and atherosclerosis'.

M.Sc Graduates

- **Deeksha**, Department of Chemistry, IIT Madras, 2020.

  'Transformation of nanodiamond particles to carbon onions by ambient electrospray deposition'.

- **Sanjit Gayen**, Department of Chemistry, IIT Madras, 2020.

  'Urea removal using thin-film nanocomposite reverse osmosis membrane'.

- **Soumya Samanta**, Department of Chemistry, IIT Madras, 2020.

  'Exploring intercluster reactions and chemistry of copper nanoclusters'.

- **Subhadip Das**, Department of Chemistry, IIT Madras, 2020.

  'Formation of formaldehyde clathrate hydrates in interstellar conditions'.

- **Noushija M K***, University of Calicut, Kerala, 2020.

  'Luminescent layered hybrid collagen- based material for synthetic skin'.

- **Parvathy M U***, University of Calicut, Kerala, 2020.

  'Atomically precise silver nanoclusters: surface protection by isomeric carboranethiols'.

- **Megha Maria Stanley***, Stella Maris College, Chennai, 2020.

  'Reactivity of silver clusters with gold nanotriangles'.

- **Nishanthi V S***, Stella Maris College, Chennai, 2020.

  'Size and shape-dependent atomic exchange in reactions of nanoclusters with nanoparticles'.

B.Tech Graduate

- **Sathvik Ajay Iyengar***, SRM Institute of Science and Technology, Chennai, 2020.

  'Selective enzyme-conjugated luminescent nanoclusters as organophosphate pesticide biosensors'.

* Graduates from other institutions.

Lectures Delivered

Offline Lectures

1. Nanomaterials to clean water: Science, technology and industry, PSG College of Technology, Coimbatore, January 9, 2020.
2. Nanoparticles with atomic precision, international conference on advances in chemistry with specific reference to catalysis, sensors, drug delivery and energy materials (ICACSEM – 2020), University of Madras, January 9-10, 2020.
3. Atomically precise nanoparticles, Biodesign Institute, Arizona State University, Tempe, February 7, 2020.

At Biodesign Institute, Arizona State University

4. Reactions of clusters, Gordon Research Conference on Atomically Precise Nanochemistry, February 9-14, 2020.
5. Atom exchange in nanoparticles, Department of Chemistry, Purdue University, February 17, 2020.
6. Affordable clean water using advanced materials, Brick Nanotechnology Centre, Purdue University, February 18, 2020.
7. Affordable clean water using advanced materials, DWWS, Government of Punjab, February 27, 2020.
8. Nanoparticles are molecules, ICONSAT Kolkata, March 5, 2020.

At CSIR-NIIST- Thiruvananthapuram

Online Lectures (Virtual)

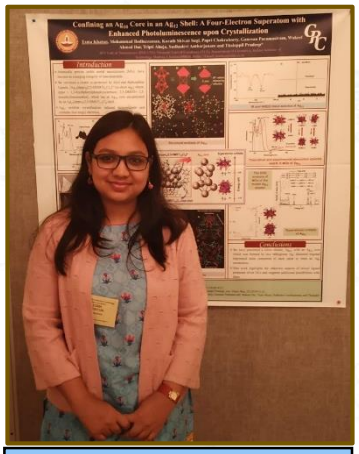
1. Nanoparticles are molecules, ACS Virtual Talk: Science Lecture Series, April 9, 2020.
2. Advanced Nanomaterials- emerging opportunities, HPCL, April 16, 2020.
3. Innovations in academic institutions during and after the pandemic, National Technology Day Lecture, CSIR-IITR, Lucknow, May 11, 2020.
4. Clean water: How can science make a difference? IIT Madras, May 15, 2020.
5. Doing science with roots intact, St. Thomas College, Thrissur, May 25, 2020.
6. Clean Water through Nanotechnology, UKIERI SPARC Webinars, June 24, 2020.
7. Clean water using nanotechnology: Current status, 2nd International Symposium on Functional Nanomaterials in Industrial and Clinical Applications, University of Central Lancashire, July 14-16, 2020.
8. New Molecules, IIT Tirupati, Welcoming the first batch of M.Sc. students, August 31, 2020.
9. Chemistry for clean air, blue skies and clean water, International Day of Clean Air for blue skies Govt. Madhav Science P.G.College Ujjain (M.P.), September 7, 2020.
10. Atom exchange in nanoparticles, Manipal Academy of Higher Education, September 26, 2020.
11. Affordable Excellence: Doing Science in Indian Universities, University of Calicut, September 28, 2020.
12. Affordable Excellence: Doing Science in India, IISER Bhopal, October 16, 2020.
13. How to build academic – industry linkage in colleges, Farook College, October 22, 2020.

14. Nanoparticles are molecules!, IIT Jammu, October 23, 2020.
15. Future of our universities, 11th P. T. Bhaskara Panicker Memorial Lecture, 57th KSSP Annual Meet, October 22-26, 2020.
16. Clean water using nanotechnology: Science, technology and entrepreneurship, BESE Student-led seminar series, King Abdullah University of Science and Technology, October 28, 2020.
17. Atomically precise clusters, National Chemistry Week Lecture, CRSI NE Chapter, November 4, 2020.
18. Clean water using nanotechnology, EFCS 2020, Farook College, December 4-5, 2020.
19. Harvesting humidity for clean water, National Water Mission, Technology Talk, Ministry of Jal Shakti, December 11, 2020.

Students' Activities

International Conferences

1. 'Confining an Ag_{10} Core in an Ag_{12} Shell: A Four-Electron Superatom with Enhanced Photoluminescence upon Crystallization' by **Esma Khatun** at the Atomically Precise Nanochemistry Gordon Research Conference, Hotel Galvez, Galveston, TX United States, February 09-14, 2020.
2. 'Microdroplet-accelerated Synthesis of Substituted Benzimidazoles' by **Pallab Basuri** at the American Society for Mass Spectrometry (ASMS) Reboot, June 01-12, 2020.
3. **Ananthu Mahendranath** attended 2020 CEC Annual Workshop on Electrochemistry, organized by the Center for Electrochemistry at The University of Texas at Austin, from February 22-23, Austin, Texas, USA.



Esma Khatun

National Conferences

4. 'Noble metal nanocomposites: Advanced materials for catalysis' presented by **Amrita Chakraborty** at the Virtual Conference on Materials for Energy Harvesting and Catalysis-MEHC2020, held on May 01–03, 2020.
5. 'Confining an Ag10 Core in an Ag12 Shell: A Four-Electron Superatom with Enhanced Photoluminescence upon Crystallization' by **Esma Khatun** at the Chemistry in House Symposium, IIT Madras, Chennai, December 03–04, 2020.
6. 'Gas-phase ion chemistry of titanium oxofullerene anions, $[H_xTi_{42}O_{60}L_y]^{n-}$ [L= $(OCH_3)_{42}(HOCH_3)_{10}(H_2O)_y$, x = 7,12; y = 3,2; n = 1, 2]' by **Jayoti Roy** at the Chemistry in House Symposium, IIT Madras, Chennai, December 03–04, 2020.
7. 'Smartphone-based Fluoride-specific Sensor for Field Applications' by **Sritama Mukherjee** at the Chemistry in House Symposium, IIT Madras, Chennai, December 03–04, 2020.
8. Oral presentation entitled 'Highly-scalable, Affordable, Conducting Cloth as Wearable Breath Humidity Sensor' by **Srikrishnarka Pillalamarri** at NeSCETIR-2020, Nagaland University, during November 24–27, 2020.
9. Poster presentation entitled 'Highly-scalable, Affordable, Conducting Cloth as Wearable Breath Humidity Sensor' by **Srikrishnarka Pillalamarri** at the Chemistry in House Symposium, IIT Madras, Chennai, December 03–04, 2020.
10. 'Towards vibrational tomography of citrate on dynamically changing individual silver nanoparticles' by **Tripti Ahuja** at the Virtual Raman Imaging Poster Summit 2020, WITec GmbH, September 28 to October 2, 2020.

11. ‘Towards vibrational tomography of citrate on dynamically changing individual silver nanoparticles’ by **Tripti Ahuja** at the Chemistry in House Symposium, IIT Madras, Chennai, December 03–04, 2020.
12. ‘Manifestation of Structural Differences of Atomically Precise Cluster-Assembled Solids in Their Mechanical Properties’ by **Sugi K. S.** at the Chemistry in House Symposium, IIT Madras, Chennai, December 03–04, 2020.
13. ‘Accelerated microdroplet synthesis of benzimidazoles by nucleophilic addition to protonated carboxylic acids’ By **Pallab Basuri** at the 57th Annual Convention of Chemists 2020 & International Conference on Recent Trends in Chemical Sciences (RTCS 2020) organized by Indian Chemical Society, December 28, 2020.

Online Webinar

14. A webinar on Raman spectroscopy: A molecule’s fingerprint by **Tripti Ahuja** on Researcher on Web, November 22, 2020.

Students’ Recognitions

1. **Amrita Chakraborty** has received one of the best oral presentation awards for her talk entitled ‘*Noble metal nanocomposites: Advanced materials for catalysis’* presented at the Virtual Conference on Materials for Energy Harvesting and Catalysis-MEHC2020, held on May 01–03, 2020.
2. **Srikrishnarka Pillalamarri** has received a best poster award for ‘*Highly-scalable, Affordable, Conducting Cloth as Wearable Breath Humidity Sensor’* presented at CiHS-2020 held by the Department of Chemistry, Indian Institute of Technology Madras during December 03–04, 2020.
3. **Dr. Abhijit Nag** has received the Prof. Langmuir Prize for the best Ph.D. thesis in Physical and Theoretical Chemistry for the year 2020.
4. **Dr. Papri Chakraborty** has received the prestigious Humboldt Fellowship for the year 2020-2021.
5. **Dr. Udayabhaskararao Thumu** has received the prestigious Chinese national talent award (2020), Overseas High-level Talent Introduction Program (16th batch). His proposal with National Natural Science Foundation of China (NSFC) on project entitled: A bottom-up nanofabrication approach for record-setting 10 nm-plasmonic cavity at the single quantum emitter limit (Grant No. 22050410280) got approved during the pandemic.

Amrita Chakraborty

Alumni News

- **Dr. Manju C. K.** has joined as a postdoc at the Ohio State University, Departmet of Chemistry and Biochemistry, Newman&Wolfrom lab, 100 W 18th Ave, Columbus, OH, 43210, USA.
- **Dr. Papri Chakraborty** has received the Humboldt Research Fellowship for 2020-21 at Institute of Nanotechnology, Karlsruhe Institute of Technology, Hermann-von-Helmholtz-Platz 1, 76344 Eggenstein-Leopoldshafen, Germany.
- **Dr. Debasmita Ghosh** has joined as a postdoc at the IECB, University of Bordeaux, Institut Européen de Chimie et Biologie, 2 rue Robert Escarpit, 33607 Pessac, France.

- **Dr. Wakeel Dar** has joined as Water Treatment Specialist, ICCW, 2nd floor B-Block, IITM Research Park, Chennai, India.
- **Dr. Ganapati Natarajan** has joined as Principal Scientist, ICCW, 2nd floor B-Block, IITM Research Park, Chennai, India.
- **Dr. Radha Gobinda Bhuin** has got appointed as Senior Research Officer (SRO), Indian Oil Corporation Limited (IOCL), R&D Centre, India.
- **Dr. Jyotirmoy Ghosh** has joined as a postdoc at Purdue University, West Lafayette, IN, USA. Aston Labs, Prof. R. Graham Cooks Research Group, Department of Chemistry, Purdue University.
- **Dr. Shridevi Bhat** has joined as a postdoc at the Stony Brook University, Department of Microbiology and Immunology, New York.
- **Ms. Deeksha** has joined as a PhD student at the school of Molecular Sciences, Arizona State University, USA.
- **Mr. Soumya Samanta** has joined IACS, Kolkata, India.
- **Ms. Pooja Ajayan** has joined as a PhD student in Chemistry, University of California, Riverside under the guidance of Prof. Ming Lee Tang.

Research Grants

Approved this year

1. National facility of cryo-electron microscopy: Remotely operable, 24x7 for academia and industry, SERB, Rs. 28.6 crores (principal investigator)
2. Sustainable ion exchange resin-based technology for rare earth extraction - MOMI Rs.52.51 lakhs (principal investigator)
3. Carborane - protected metal nanoclusters: A new family of materials with atomic precision - DST/Czech 37 lakhs (principal investigator)
4. DST-JSPS joint workshop on cluster science by interdisciplinary approach: Emerging materials and phenomena - DST-JSPS (conference proposal, principal investigator)
5. Atomically precise naked cluster assemblies from ligand-stabilized clusters: New materials for catalysis - DST-DFG - 79 lakhs (principal investigator)

Ongoing

6. Identification and investigation of efficacy of potential biochemical molecules for extraction of gold and other noble metals from tailings and waste sources, Ministry of mines, Rs. 34.64 lakhs (principal investigator)
7. Chemical transformations of clathrate hydrates under ultra-high vacuum, DST, Rs. 76.5 lakhs (principal investigator)
8. Understanding surface properties of atomically engineered cluster-assembled solids, SPARC project with Robin Ras and Olli Ikkala, Aalto, Finland with Tiju Thomas, IITM, Rs. 66.3 lakhs (principal investigator)
9. VAJRA project with Pulickel M. Ajayan, Rice University, Rs. 9.75 lakhs
10. SUTRAM for EASY water, DST, Rs. 890 lakhs (co-principal investigator with Prof. Ligy Philip) as (principal investigator)
11. Affordable clean water in arsenic affected areas, Millennium Alliance, 2018-2020, Rs. 50 lakhs (principal investigator along with Ramesh kumar)
12. Cluster composite nanofibre membranes for rapid, ultra-trace detection of waterborne contaminants, India-German Science and Technology Forum, Total funds Rs. 191.324 lakhs (principal investigator along with InnoNano Research Pvt. Ltd).
13. Dust free glass, Saint-Gobain Research India Ltd. Rs. 36 lakhs (principal investigator with Prof. R. Nagarajan)

Consultancy

1. Steel – Rubber adhesion improvement – Phase 2, MRF Ltd., 2019–2021, Rs. 1.2 Cr (principal investigator)

Implementation Projects

2. Providing, fixing and maintenance of nano material based household water purifiers for providing in arsenic affected habitations of punjab, Government of Punjab, Rs. 48.5 crores (principal investigator), undertaken by ICCW.
3. House-hold arsenic removal units for Government of Punjab, Rs. 4.8 crores (principal investigator), undertaken by ICCW.

Visits

- Two-day International seminar on Sustainability issues in Water and Energy- Nanotechnology Solutions – PSG College, Coimbatore, January 9, 2020.
- International conference on title "Advances in Chemistry with Specific Reference to Catalysis, Sensors and Energy Materials (ICACSEM – 2020)" at Department of Physical Chemistry, School of Chemical Science, University of Madras, Guindy Campus, Guindy, Chennai, January 9–10, 2020.
- 18th Meeting of Project Evaluation and Review Committee (PERC) of Standing Scientific Advisory Group [SSAG] at Jawaharlal Nehru Aluminium Research Development Centre (JNARDDC), Amravati Road, Wadi, Nagpur, October 24, 2020.
- Visit to Arizona State University, Gordon Conference, Rice University, and Purdue University, USA, February 05–19, 2020.
- Three-Day Intercollegiate Workshop on Analytical Instrumentation Techniques at Stella Maris College (Autonomous), Chennai, February 25, 2020.
- Meeting with Principle Secretary, Smt. Jaspreet Talwar, IAS, Water Supply & Sanitation Department, in her office Room No.720, 7th Floor, Mini Secretariat, Sector-9, Chandigarh, Discussions regarding the arsenic project, February 27, 2020.

Visitors to the Lab Before the Lockdown

1. Dr. Debarata Rautarey, Tata Chemicals Pune, India on January 23, 2020.
2. Mr. Rahul C. Mehta, Founder and Managing Director, MentorCap Management, India, January 23, 2020.
3. Dr. Thomas Colacot - Millipore Sigma (a Business of Merck KGaA, Darmstadt, Germany), 6000 N, Teutonia Avenue, Milwaukee, WI 53209, USA, January 24, 2020.
4. Prof. Ajay K. Sood, FRS, former president, INSA, January 24, 2020.
5. Dr. Swaminathan Venkataraman, Adjunct Professor, Physics Department, Penn State University, USA, January 27, 2020.
6. Dr. K. Balasubramanian, Non-ferrous Materials Technology Development Centre, Hyderabad, India, March 19, 2020.

Services

- Member, India-Japan Council of the Department of Science and Technology, 2014-Vice President, Indian Society for Mass Spectrometry, 2014-
- Member, Executive Committee, Neutron Scattering Society of India, 2011-
- Member of the Council of Materials Research Society of India, 2011 –
- Member, Board of studies, Manipal University, 2012-
- Member, Program Advisory Committee of Inorganic and Physical Chemistry, DST, 2018-
- Member, Industry Relevant R &D Expert Committee, DST, 2018-
- Member, Governing Council, Technology Information, Forecasting & Assessment Council (TIFAC)
- Member, Research Advisory Council, Manipal Academy of Higher Education, Manipal Member, 2018-
- Research Advisory Board, Pandit Deendayal Petroleum University, 2019-
- Member, Research Advisory Committee, IIT Ropar, 2019-
- Co-opted Member, Program Advisory Committee of SERB-SUPRA, 2019-
- Member, Technical Committee for examination and use of innovations and technologies in drinking water and sanitation sector, Department of Drinking Water and Sanitation, Ministry of Jal Shakti, 2019-2024
- Member, Program Advisory Committee on Exponential Technologies, DST, 2020
- Member, Editorial Board of the journals, Chemistry of Materials, ACS Nano, Analytical Chemistry, Nanoscale, Particle, Surface Innovations, International Journal of Water and Wastewater Treatment, Nanoscale Advances, and Chemical Communications.
- Associate Editor of the journal, ACS Sustainable Chemistry & Engineering.

Incubation

- **Hydromaterials** has installed 698 community water treatment units in 2020, each supplying arsenic and iron free water to over 900,000 people. Altogether there are 961 units of this kind operational in the country, supplying clean water to 1.2 million people. This year's highlight is the internet-of-things (IoT) enabled community units. Over 100 units of this kind will be completed soon, many are already functional. A picture of one such unit in Amritsar District of Punjab is shown on the right. There are other types of installations too.

Amrit technology has been approved by the Jal Shakti Ministry.

- **InnoDI** has expanded its reach, it has installed more than 150 units across 10 states serving clean water to over 100,000 people and saving over 100 million litres of water every year which otherwise would have gone down the drain. One of the recent installations at Ullal in Karnataka is shown on the left.

- **VayuJal Technologies** is developing a 2000 litres per day (LPD) atmospheric water harvesting unit now, which will be installed at Engineers India Limited, Gurugram, Haryana. We have now 30, 100, 400, and 1000 lpd versions of this product. Shown on the right is the view of the factory.
- **AquEasy Innovations Private Limited** has been established to create efficient water transport solutions. Its prototypes have been tested.
- **EyeNetAqua Pvt. Ltd.** has been established to commercialise sensors for clean water.

All are co-owned by IIT Madras.

- A new initiative of IIT Madras, the **International Centre for Clean Water** has made tremendous progress in all its activities. We have initiated research, implementation, outreach and incubation activities. An overview of these efforts is available at: ICCW Anuual report 2020. Key to these initiatives is the support of all our well-wishers, well-meaning individuals such as Ram and Nandini, pictured on the left, as well as institutions.

Media Reports

An interview about 'Digital Divide due to COVID pandemic' on Asianet News, 3rd June, 2020.

A short documentary titled 'Hawa se Paani' published on YouTube.

Channel: HISTORY TV18

Date: 21st of April 2020.

Links to access these are given below:

1. Sankhedikavidhyayude peril manushyarkidayile verthirivu koodunu, Prof. T. Pradeep samsarikunu, Asianet News, June 03, 2020.

2. Air to Water Generator, April 30, 2020.

Media Reports (Continued)

An article published in The Hindu on 26th January 2020.

PADMA SHRI AWARDEES

Seven unique achievers bring laurels for State

N.R. Madhava Menon, father of modern Indian legal education, and spiritual Guru Sri M get Padma Bhushan

SPECIAL CORRESPONDENT
THIRUVANANTHAPURAM

Seven Keralites whose achievements have remained relatively unsung have been conferred Padma awards on the occasion of Republic Day this year.

N.R. Madhava Menon, the father of modern Indian legal education, will be awarded Padma Bhushan posthumously. Spiritual guru Sri M is the other Keralites selected for Padma Bhushan this year.

Five other Keralites, including puppetry artist Moozhikkal Pankajakshi, social activist Satyanarayanan Mundayoor, and botanist and taxonomist K.S. Manilal will be conferred with Padma Shri.

Born in Thiruvananthapuram, Madhava Menon was founder director of the National Law School of India University (NLSIU) and the National Judicial Academy, Bhopal. He was honoured with Padma Shri in 2003. Madhava Menon passed away in May 2019.

Hailing from Thiruvananthapuram, Sri M (M. Mumtaz Ali) heads the Satsang Foundation. Growing up listening to Sufi tales, Mumtaz Ali had embarked upon a spiritual quest. He later became the disciple of Maheshwarnath Babaji.

Mr. Manilal is the botanist who opened the monumental *Hortus Malabaricus* to English and Malayalam readers. He has discovered many new plant species.

M.K. Kunjol

The other Keralites selected for the Padma Shri are M. K. Kunjol (social work), N. Chandrasekharan Nair (literature and education), Sathyanarayanan Mundayoor and Moozhikkal Pankajakshi.

Mr. Chandrasekharan Nair is a noted Hindi scholar and founder of the Kerala Hindi Sahitya Academy.

Sathyanarayanan

Sathyanarayanan Mundayoor, aka Uncle Moosa from Thrissur, has been recognised for developing libraries as part of a social movement in Arunachal Pradesh. Mr. Mundayoor, who reached Arunachal Pradesh in 1979 at the age of 25 as a "life worker" for the Vivekananda Kendra, opened schools to educate tribal children. He went from "life worker" to a teacher and then an education officer. He took the name Uncle Moosa while writing a column for children in a local newspaper.

In 1998, he decided to place the school libraries of the Vivekananda Kendra in the midst of tribal communities. Tribal girls and boys discovered the joy of reading and also learnt to express themselves through storytelling, skits, and recitation.

Moozhikkal Pankajakshi

Moozhikkal Pankajakshi is the sole practitioner of a fading form of puppetry called Nokkuvidya Pava Kali. She has been balancing the entire Ramayana and Mahabharatha on the tip of her lips for almost her entire life.

She had performed the art form, in which a stick puppet is balanced on the upper lip, for a living. Even after withdrawing from the scene, the 81-year-old has kept the passion for the art alive.

Pankajakshi learnt it from her parents, who used to perform in houses and temples. She started training at the age of 12. Soon, she became the art form's sole exponent.

Assisted by her family, Pankajakshi has visited many places in the country and abroad, showcasing her unique art form.

Having lost her front teeth, which rendered her unable to balance the puppet, she stopped performing some six years ago.

The artist is recuperating from a massive stroke she suffered a few years ago.

An eighth Keralite, Thalappil Pradeep, nanotechnologist who works at IIT, Madras, in Tamil Nadu also gets Padma Shri.

SEE ALSO ▸ PAGE 8

K.S. Manilal, N. Chandrasekharan Nair, Satyanarayanan Mundayoor, M. Pankajakshi, Thalappil Pradeep

An article on The New India Express published on 26th January 2020.

Providing safe drinking water is his mission

EXPRESS NEWS SERVICE @ Chennai

OVER more than two decades, an IIT-Madras professor T Pradeep and his research group have systematically developed advanced yet affordable technologies to solve major water-related problems in the country. His efforts were recognised by Union government, which bestowed Padma Shri, under Science and Engineering category. Over 450 papers have been published and 110-plus patents have been filed or granted. In the last five years, five companies have been incubated, whose technologies are providing nearly 10 million people across India with clean drinking water.

Pradeep told *Express* "I am happy that my team's work has been recognised. Developing affordable and safe drinking water solutions using nanomaterials, from bench-scale science to commercial products, creating knowledge, technology and wealth for social good simultaneously was very satisfying. We have demonstrated that completely home-grown nanotechnology, from excellent science to relevant technology is possible in our institutions, with limited resources available from research grants, in the process transforming students to entrepreneurs."

Academia must engage with society to solve water crisis

Padma Shri Thalappil Pradeep wants students to develop water management solutions

Sharangee.Dutta
@timesgroup.com

For academician Thalappil Pradeep, a journey of 18 years to find affordable solutions to the crisis of potable water was challenging. A professor in the Department of Chemistry in IIT Madras, Pradeep was awarded Padma Shri recently. He was conferred with the award for his work in developing cost-friendly and safe technologies for purifying contaminated drinking water.

Since 2002, Pradeep has been using nanotechnology to decontaminate water. As nanomaterials have fast kinetic energy and low concentration, they can remove toxic elements such as arsenic at a rapid rate and reduced cost. The technology has been instrumental in solving the water crisis in the houses of 1 million people in Punjab, West Bengal, Uttar Pradesh, Assam. Pradeep Research Group, started by him in 1993 at IIT Madras has been working in various projects including to find a low-cost solution to the rampant water crisis along with several state governments.

Taking his technology to the industries, Pradeep has also been instrumental in offering R&D for pesticide removal technology to a water purification giant.

Academic institutions, says Pradeep, must join hands for coming up with a technology that addresses water scarcity and solves drinking water crisis.

"Water contamination is a major problem across India, the solution for which varies from one place to another. Institutes must equip their students with skills to deal with local challenges. This will help resolving issues related to water contamination at a micro-level preventing it to grow into a bigger problem," says Pradeep, while talking to Education Times.

Students must be encouraged to take innovative steps to solve problems related to water. "Faculty assistance and incubator facilities help in exploring new ideas and turn the theoretical classroom knowledge into a productive solution. Students must be offered industry exposure so that they can receive venture funding to carry forward with their entrepreneurial initiatives" Pradeep adds. Expecting people to embrace new technologies overnight is a far-fetched idea. "Rural population that depend on water from taps and tube wells cannot get accustomed to a water filter in their house. Therefore, innovators need to develop technologies that can remove harmful materials right from the source so that safe water is supplied in each house," says Pradeep.

Since introducing villagers to advanced technologies involves massive-scale orientation, the process is expensive too. The arsenic removal technology that he developed has succeeded in offering clean drinking water to 1 million people in Punjab, West Bengal, Uttar Pradesh, Assam, to mention a few.


Thalappil Pradeep

Chemistry has become central to every discipline

Avik.Das1@timesgroup.com

T Pradeep, professor of chemistry at IIT Madras, says many have an aversion to chemistry, thinking it is something smelly and toxic. But chemistry, he says, has undergone a drastic change and is no more just a science of molecules, "not just something that happens in reaction bottles or in a laboratory with colourful solutions." It is a central subject, he says.

He says part of the problem has also been that educational institutions teach the subject in a silo, with little interaction with other departments like biology, biotechnology or engineering. To make the subject more interesting, he says more interdisciplinary studies is required.

HEAR THE PROF

Pradeep is a Padma Shri awardee and an Institute professor in IIT Madras, the highest title a professor can earn in a university. He is the second such professor among the institute's long list of 600 faculty.

The professor, who specialises in molecular and nanoscale materials, says that the time has come to reinvent the face of the subject. "If it was not so important, all the 16 departments of IIT Madras, barring mathematics and management, would not have published their papers in journals of American Chemical Society," he says.

The larger reason, he says, is that the world around has become hugely molecular in nature. "Anything that matters to people, whether it is energy, transportation, electronics, environment, or health, all of them have become molecular. Energy is about molecules, plastics is about molecules, medicines is about molecules," he says.

Chemistry is also continuing to offer new solutions to problems of the planet. New materials are needed for fast and clean energy. New materials are needed to protect the environment. New sensors, pesticides, dyes, pharmaceuticals, etc, are needed. "There is an infinite ocean in all of these," says Pradeep.

Pradeep has been working on affordable clean water technology and has devised an eco-friendly method to degrade the physically stable and chemically inert plastic fluoropolymer — polytetrafluoroethylene (PTFE). Plastics are resistant to degradation. PTFE is used in making Teflon, best known for its use in coating non-stick frying pans and other cookware, as it is hydrophobic (repels water) and possesses fairly high heat resistance.

Opportunities are enormous, Pradeep says, with research areas such as how new polymers can be degraded, how new forms of plastics can be created and other material sciences. But industry leaders like GE and BASF are not just looking for good chemists but also those who have the knowledge of products.

"A student of chemistry has to understand processing, testing, data management. If he is joining the tyre industry, he will have to research nano-scale additives in tyres for new product development. Material chemistry has expanded by leaps and bounds over the years," Pradeep says.

Pradeep's views are similar to that of IIT Delhi director Ramgopal Rao, who told TOI last month that chemistry has become more important than ever as finding new materials has become the elixir of life for the nano and micro-electronics world. Researchers are looking for newer materials like molybdenum disulfide and graphene for use in integrated circuits to boost the performance of devices.

> Students have to pursue a subject for some time to appreciate it. Go after that for some time. After some years in chemistry, one may find it interesting in biology or materials or electronics or computing. All these options are now possible
>
> T Pradeep | INSTITUTE PROFESSOR, IIT MADRAS

Covid: Lockdown leaves research scholars in a lurch

T. SUDHEESH I DC
CHENNAI, JULY 7

While Covid is spreading its tentacles, forcing governments to come up with relief packages for various sectors in the society to save life and livelihood, the struggle of the young research community in various institutions in the country continues to be unheard by the authorities.

Highlighting the plight of research scholars, Rohit Jhunjhunwala, a research scholar with Indian Institute of Technology-Madras (IIT-M), has started an online petition campaign a couple of days back, grabbing the eyeballs of over 2,000 research scholars across the country.

The petition has requested the Ministry of Human Resource Development (MHRD) for an extension of the research period as well as the fellowship to all scholars as their works are affected by the pandemic and subsequent lockdowns.

"Due to the lockdown, all institutes were shut down and the scholars had been asked to vacate the campus in March 2020. Due to the urgency and short duration of the notice by institute authorities, scholars left their valuables, laptops and research notes behind in the hope that they would be able to return soon and restart their research.

"The educational institutes remained shut making scholars unable to access the research infrastructures. This has resulted in a lot of anxiety among scholars about the status of their research work, experiments and the expiry of their fellowship.

All experimental setups have already been degraded or unusable due to the long delay. The fellowships of scholars have expired in the middle of the lockdown leaving them without any means to survive. The financial pressure is a huge mental stress for us along with health and future uncertainties," the petition says.

As per the procedure, it takes five years to finish a PhD degree in institutions. During the research period, a doctoral fellow in a national institution will get a fellowship of Rs 31,000 per month for the first two years and Rs 35,000 per month for the remaining three years or till they submit their theses, whichever is earlier.

T Pradeep, professor, the department of chemistry at IIT-M, told Deccan Chronicle that the MHRD should extend the tenure of research by at least six months along with the fellowship.

The pandemic has created an unprecedented situation in the education sector especially among the research community. Many who had been pursuing research programmes abroad have now returned without completing their work. They do not have new assignments, and even if they do, there is no way to proceed with them. They too remain unpaid.

Research fellows after completing the PhD programme often go for post-doctoral fellowships (PDF) for higher studies and independent research. Many of them are now stuck even if they have postdoctoral offers. They have no support from parent laboratories as institutional resources are limited.

In order to deal with the situation, the government must announce a package of Rs 200 crores to help the young scientific community. In addition to this, the MHRD must fast-track the filling up of scientist posts vacant in various institutions. "The government has also to come up with the decision to create favourable atmosphere in research institutes lifting the restriction imposed due to the pandemic," said Prof Pradeep

An article in Deccan Chronicle published on 7th July, 2020.

Plight of doctoral students during the pandemic

T. Pradeep
May 30, 2020 07:39 pm IST
Updated: May 30, 2020 07:37 pm IST

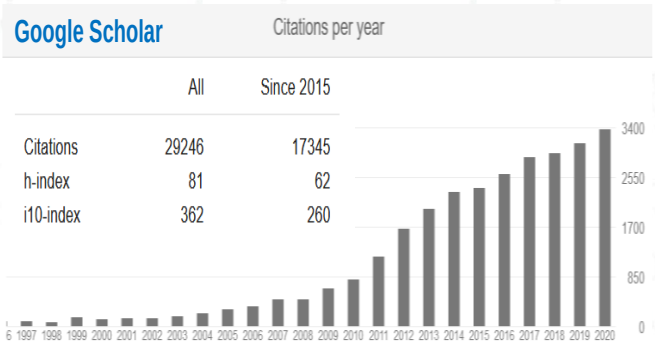
Fallout: COVID-19 will take away at least six months from the productive life of PhD students.

This crisis will most severely affect those who have just finished, or are finishing, their PhD degrees

An article in The Hindu published on 30th May,

An article on Times of India published on 13th August 2020.

Publication Analyses



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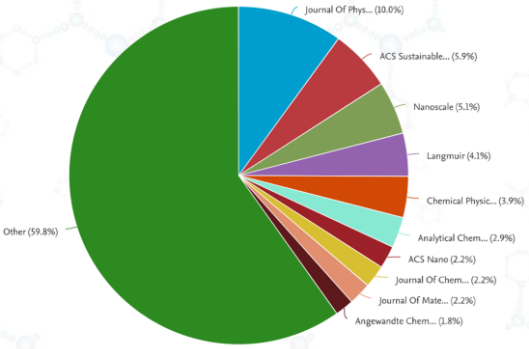
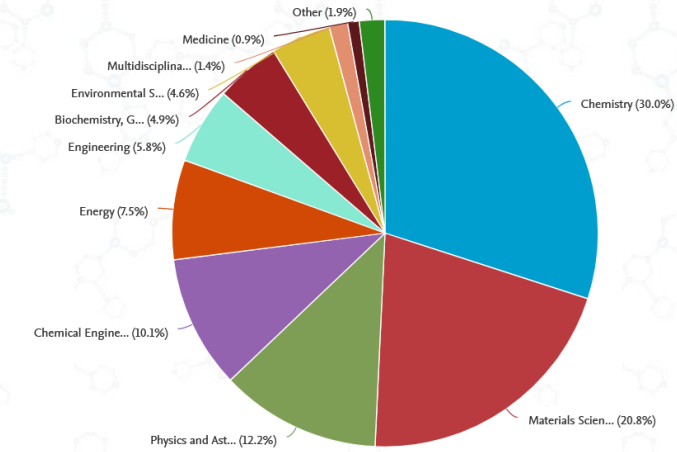
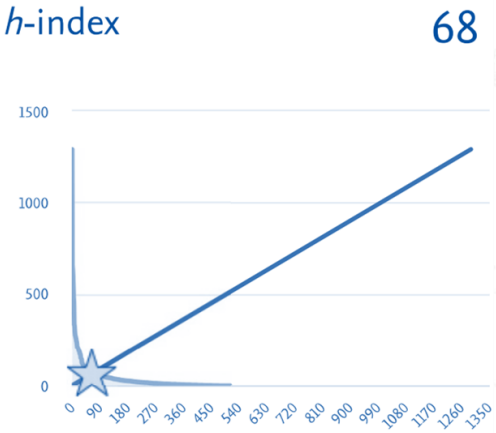


Scopus





Sources:

1. Scopus, visited on December 31, 2020.
2. Google Scholar, visited on December 31, 2020.

ABSTRACTS AT A GLANCE

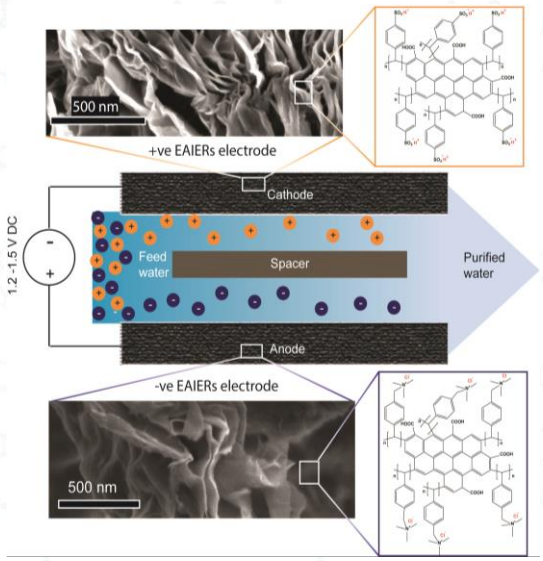
A covalently integrated reduced graphene oxide-ion exchange resin electrode for efficient capacitive deionization

Md Rabiul Islam, Soujit Sen Gupta, Sourav Kanti Jana, Pillalamarri Srikrishnarka, Biswajit Mondal, Sudhakar Chennu, Tripti Ahuja, Amrita Chakraborty, and Thalappil Pradeep

Adv. Mater. Interfaces, 2020. (Just Accepted)

Abstract:

Capacitive deionization (CDI) is an emerging, cost-effective alternative for energy-efficient desalination technology. Efficient electrode materials based on individual reduced graphene oxide (rGO) nanosheets were produced by functionalizing them with polystyrene (rGO-PS) through an *in-situ* polymerization process involving rGO, styrene monomer, and divinylbenzene (DVB). The rGO-PS integrated composite nanostructures were subsequently functionalized with sulfonate and quaternary amine functionalities to achieve positively and negatively charged electro-adsorbent ion-exchange resins (EAIERs), respectively. These EAIERs 'molecular constructs' were used to fabricate CDI electrodes, and deionization was performed to remove various ions. These molecular constructs promoted faster charge transfer at the electrode-electrolyte interface and maintained the electrical conductivity of the active rGO. This led to a high electroadsorption capacity of 15.93 mg/g of Cl^- using NaCl solution with a conductivity of 802 µS in laboratory batch experiments, which is ~5 times higher than the adsorption capacity of rGO electrodes reported earlier (~2-3 mg/g) in comparable experimental conditions. No significant Faradaic redox reactions or chemical changes were observed on the electrode surface, which made these electrodes exhibit



excellent electrochemical stability even after multiple adsorption/desorption cycles.

New Routes for Multi-component Atomically Precise Metal Nanoclusters

Esma Khatun and Thalappil Pradeep

ACS Omega, 2020 (Invited Perspective) (DOI: 10.1021/acsomega.0c04832)

Abstract:

Atomically precise metal nanoclusters (NCs), protected by a monolayer of ligands are regarded as potential building blocks for advanced technologies. They are considered as intermediates between the atomic/molecular regime and the bulk. Incorporation of foreign metals in NCs enhances several of their properties such as catalytic activity, luminescence and so on; hence, it is of high importance for tuning their properties and broadening the scope of applications. In most of the cases, enhancement in specific properties was observed upon alloying due to the synergistic effect. In the past several years, many alloy clusters have been synthesized which show a tremendous change in the

properties than their monometallic analogs. However, controlling the synthesis and tuning the structures of alloy NCs with atomic precision are major challenges.Various synthetic methodologies have been developed so far for the controlled synthesis of alloy NCs. In this perspective, we have highlighted those diverse synthetic routes to prepare alloys which include co-reduction, galvanic reduction, antigalvanic reduction, metal deposition, ligand exchange, intercluster reaction and reaction of NCs with bulk metals. Advancement in synthetic procedures will help in the preparation of alloy NCs with the desired structure and composition. Future perceptions concerning the progress of alloy nanocluster science are also provided.

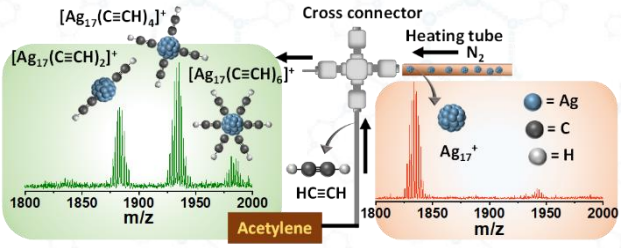
Reaction Between Ag_{17}^{+} and Acetylene Outside the Mass Spectrometer: Dehydrogenation in the Gas Phase

Madhuri Jash, Rabin Rajan J. Methikkalam, Mohammad Bodiuzzaman, Ganesan Paramasivam and Thalappil Pradeep

Chem. Commun., 56, (2020), 15623–15626 (DOI: 10.1039/d0cc05837h)

Abstract:

We present the first example of acetylide protected silver clusters by a reaction between Ag_{17}^{+} and acetylene, conducted around atmospheric pressure. The products were obtained after dehydrogenation of acetylene in the gas phase. The observed reaction mechanism may be helpful to design new catalysts useful in organometallic chemistry.



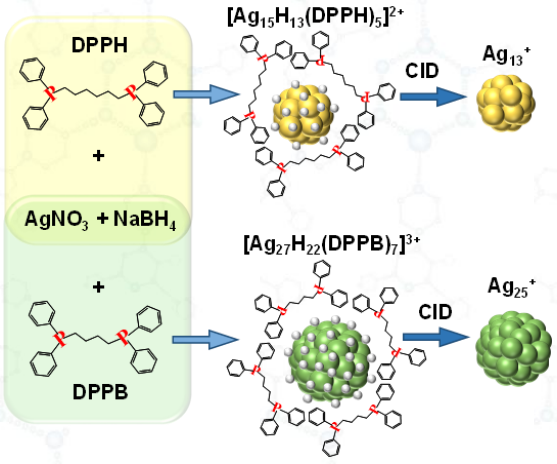
$Ag_{15}H_{13}(DPPH)_5]^{2+}$ and $[Ag_{27}H_{22}(DPPB)_7]^{3+}$: Two New Hydride and Phosphine Co-Protected Clusters and Their Fragmentation Leading to Naked Clusters, Ag_{13}^{+} and Ag_{25}^{+}

Madhuri Jash, Esma Khatun, Papri Chakraborty, Chennu Sudhakar, and Thalappil Pradeep

J. Phys. Chem. C 2020, 124, 20569−20577 (DOI: 10.1021/acs.jpcc.0c05867)

Abstract:

Here, we report the synthesis of two new hydride and phosphine coprotected clusters $[Ag_{15}H_{13}(DPPH)_5]^{2+}$ (DPPH = 1,6-bis(diphenylphosphino)-hexane) and $[Ag_{27}H_{22}(DPPB)_7]^{3+}$ (DPPB = 1,4-bis(diphenylphosphino)butane). The cluster composition was confirmed by high-resolution electrospray ionization mass spectrometric (HRESI MS) studies and also by other supporting data. To the best of our knowledge, the newly synthesized $[Ag_{15}H_{13}(DPPH)_5]^{2+}$ and $[Ag_{27}H_{22}(DPPB)_7]^{3+}$ clusters are the smallest and the largest known hydride and phosphine coprotected silver clusters, respectively,



synthesized in the solution phase. Collision-induced dissociation (CID) was used to probe their fragmentation pattern in the gas phase, which also supported their compositions. During the CID experiment, naked clusters Ag_{13}^{+} and Ag_{25}^{+} got formed starting from the ligated Ag_{15} and Ag_{27} clusters, respectively, where the number of metal atoms remained nearly the same as in the parent clusters. Collision energy-dependent fragmentation pathways of the formation of naked clusters have been explored in detail. We suggest that silver clusters protected by hydride and phosphine ligands may become useful precursors to make new naked clusters in the gas phase.

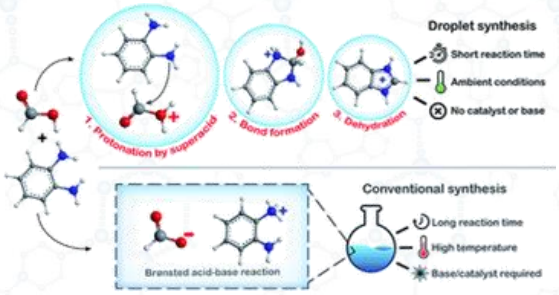
Accelerated Microdroplet Synthesis of Benzimidazoles by Nucleophilic Addition to Protonated Carboxylic Acids

Pallab Basuri, L. Edwin Gonzalez, Nicolás M. Morato, Thalappil Pradeep and R. Graham Cooks

Chem. Sci, 2020 (EDGE ARTICLE) (DOI: 10.1039/D0SC02467H)
Themed collection: Celebrating 10 years of Chemical Science

Abstract:

We report a metal-free novel route for the accelerated synthesis of benzimidazole and its derivatives in the ambient atmosphere. The synthetic procedure involves 1,2-aromatic diamines and alkyl or aryl carboxylic acids reacting in electrostatically charged microdroplets generated using a nano-electrospray (nESI) ion source. The reactions are accelerated by orders of magnitude in comparison to the bulk. No other acid, base or catalyst is used. Online analysis of the microdroplet accelerated reaction products is performed by mass spectrometry. We provide evidence for an acid catalyzed reaction mechanism based on identification of the intermediate arylamides. Their dehydration to give benzimidazoles occurs in a subsequent thermally enhanced step. It is suggested that the extraordinary acidity at the droplet surface allows the carboxylic acid to function as a C-centered electrophile. Comparisons of this methodology with data from thin film and bulk synthesis lead to the proposal of three key



steps in the reaction: (i) formation of an unusual reagent (protonated carboxylic acid) because of the extraordinary conditions at the droplet interface, (ii) accelerated bimolecular reaction because of limited solvation at the interface and (iii) thermally assisted elimination of water. Eleven examples are shown as evidence of the scope of this chemistry. The accelerated synthesis has been scaled-up to establish the substituent-dependence and to isolate products for NMR characterization.

Microdroplet Impact-Induced Spray Ionization Mass Spectrometry (MISI MS) for Online Reaction Monitoring and Bacteria Discrimination

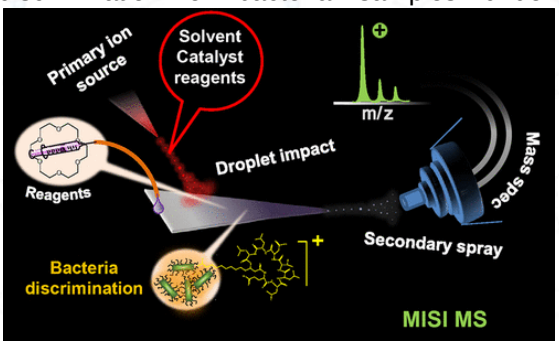
Pallab Basuri, Subhashree Das, Shantha Kumar Jenifer, Sourav Kanti Jana, and Thalappil Pradeep

JASMS, 2020 (doi.org/10.1021/jasms.0c00365)

Abstract:

Microdroplet impact-induced spray ionization (MISI) is demonstrated involving the impact of microdroplets produced from a paper and their impact on another, leading to the ionization of analytes deposited on the latter. This cascaded process is more advantageous in comparison to standard spray ionization as it performs reactions and ionization simultaneously in the absence of high voltage directly applied on the sample.In MISI, we apply direct current (DC)

potential only to the terminal paper, used as the primary ion source. Charge transfer due to microdroplet/ion deposition on the flowing analyte solution on the second surface generates secondary charged microdroplets from it carrying the analytes, which ionize and get detected by a mass spectrometer. In this way, up to three cascaded spray sources could be assembled in series. We show the detection of small molecules and proteins in such ionization events. MISI provides a method to understand chemical reactions by droplet impact. The C–C bond formation reactions catalyzed by palladium and alkali metal ion encapsulation using crown ether were studied as our model reactions. To demonstrate the application of our ion source in a bioanalytical context, we studied the noninvasive in situ discrimination of bacteria samples under



sambient conditions.

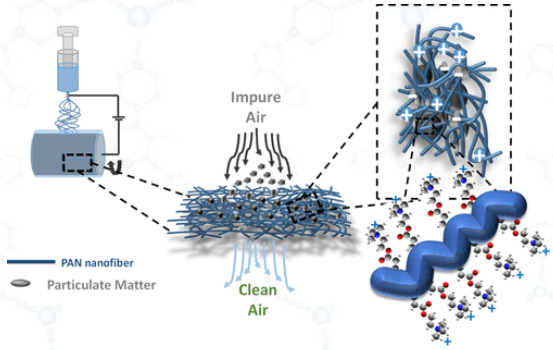
Enhanced Capture of Particulate Matter by Molecularly Charged electrospun Nanofibers

Pillalamarri Srikrishnarka, Vishal Kumar, Tripti Ahuja, Vidhya Subramanian, Arun Karthick Selvam, Paulami Bose, Shantha Kumar Jenifer, Ananthu Mahendranath, Mohd Azhardin Ganayee, Ramamurthy Nagarajan, and Thalappil Pradeep

ACS Sustainable Chem. Eng. 2020, 8, 21, 7762–7773 (DOI: 10.1021/acssuschemeng.9b06853)

Abstract:

As the concentrations of these PMs have been steadily increasing in the Southeast Asian countries, a dire need for protection against these particles is warranted. Filtering out the polluted air using various filtration media, such as face masks and nasal filters, has been the standard method for minimizing exposure to PM. Here, we demonstrate the removal of PM and VOCs by utilizing electrospun nanofibers of polystyrene (PS) and polyacrylonitrile (PAN) with molecular charges imparted on them via chemical treatment.The chemically treated fibers were successful in capturing even particles measuring 300 nm, which are considered to be the most penetrable particles. We report a filtration efficiency of ~93% for removing such particles, which is ~3 ± 1.5% enhancement when compared to the untreated fibers. The fibers have been subjected to extreme haze conditions (~1413 μg m^{-3}) of PM2.5 for a duration of 1 h, and the filtration efficiency was measured to be ~99.01%. These fibers also possess the capability to capture model VOCs such as aniline, toluene, tetrahydrofuran, and chloroform. When PAN, PS, and their chemically treated counterparts were tested for their antibacterial activity, these



filter mats had bactericidal effect on Escherichia coli, Bacillus subtilis, and Enterococcus faecalis. A nasal plug hosting these filter mats has been designed, which can offer personal protection from PM. Enhanced removal of residual particles is extremely important, and this difficult task is made possible with our approach. The efficiency of our approach is due to the charged nature of PM, especially of the smaller size regime.

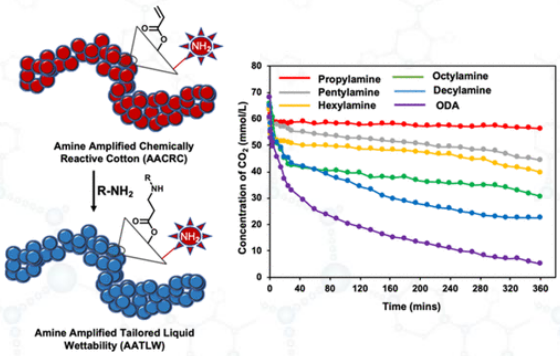
Evaluating the Impact of Tailored Water Wettability on Performance of CO_2 Capture

Adil Majeed Rather, Pillalamarri Srikrishnarka, Avijit Baidya, Arpita Shome, Thalappil Pradeep and Uttam Manna

ACS Appl. Energy Mater. 2020, 3, 11, 10541–10549 (DOI : 10.1021/acsaem.0c01603)

Abstract:

The growing emission of CO_2 is a severe cause of concern due to its adverse impact on the environment and climate change worldwide. In the past, various approaches, including synthesis of porous materials and amino modifications, were adopted for efficient and direct separation of CO_2 from flue gas. Recently, hydrophobicity has been introduced to protect some of the highly potent porous materials and membranes from high humidity and aqueous exposures. While these approaches remained successful in removing CO_2 from flue gas, the exact role of hydrophobicity towards CO_2 separation is not yet validated in the literature. In this current study, an amine-amplified chemically reactive coating on fibrous cotton has been unprecedentedly developed for facile tailoring of different water wettability through the 1,4-conjugate addition reaction under ambient conditions. Further, these amine-amplified interfaces having tailored water wettability were extended to investigate independently the role of: (a) amine amplification and (b) hydrophobicity on the performance of CO_2 separation at room temperature and atmospheric pressure. The increased hydrophobicity on the amine-amplified interface played an important role in improving the CO_2 uptake from 24 mmol/L (water contact angle (WCA) of 86°) to 63 mmol/L (WCA of 151°). However, superhydrophobic coating that lacked the amine amplification process displayed a poor (7 mmol/L) CO_2 separation performance. Thus, controlled amalgamation of amine amplification and bioinspired



superhydrophobicity in fibrous cotton lead to a synergistic impact towards efficient CO_2 separation at ambient temperature and pressure, irrespective of the level of humidity present during the course of the experiments. Thus, this current study would allow to design a more potent CO_2 removal material by strategic association of porosity, amine modulation, and liquid wettability.

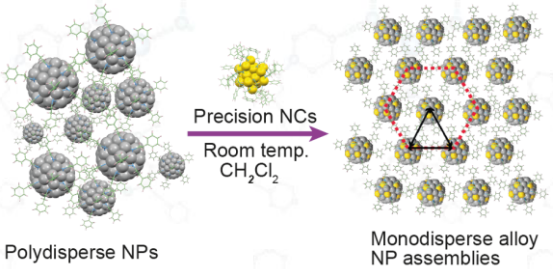
Atom Transfer Between Precision Nanoclusters and Polydispersed Nanoparticles: A Facile Route for Monodispersed Alloy Nanoparticles and Their Superstructures

Paulami Bose, Papri Chakraborty, Jyoti Sarita Mohanty, Nonappa, Angshuman Ray Chowdhuri, Esma Khatun, Tripti Ahuja, Ananthu Mahendranath and Thalappil Pradeep

Nanoscale, 12 (2020) 22116-22128 (DOI: 10.1039/D0NR04033A)

Abstract:

Reactions between atomically precise noble metal nanoclusters (NCs) have been studied widely in the recent past, but such processes between NCs and plasmonic nanoparticles (NPs) have not been explored earlier. For the first time, we demonstrate spontaneous reactions between an atomically precise NC, $Au_{25}(PET)_{18}$ (PET = 2-phenylethanethiol), and polydispersed silver NPs with an average diameter of 4 nm and protected with PET resulting in alloy NPs under ambient conditions. These reactions were specific to the nature of the protecting ligands as no reaction was observed between $Au_{25}(SBB)_{18}$ NC (SBB = 4-(tert-butyl)benzyl mercaptan) and the very same silver NPs. The mechanism involves an interparticle exchange of the metal and ligand species where the metal-ligand interface plays a vital role in controlling the reaction.The reaction proceeds through transient Au25-



xAgx(PET)n alloy cluster intermediates as observed in time-dependent electrospray

ionization massspectrometry (ESI MS). High-resolution transmission electron microscopic (HRTEM) analysis of the resulting dispersion showed the transformation of polydispersed silver NPs into highly monodispersed gold-silver alloy NPs which assembled to form 2-dimensional superlattices. Using NPs of other average sizes (3 and 8 nm), we demonstrated that size plays an important role in the reactivity as observed in ESI MS and HRTEM.

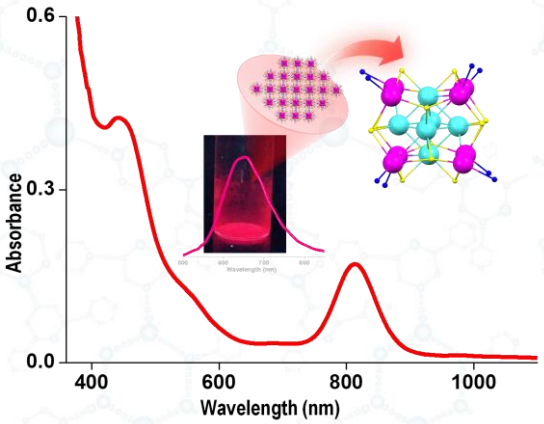
Dithiol-Induced Contraction in Ag_{14} Clusters and Its Manifestation in Electronic Structures

Mohammad Bodiuzzaman, Esma Khatun, Korath Shivan Sugi, Ganesan Paramasivam, Wakeel Ahmed Dar, Sudhadevi Antharjanam, and Thalappil Pradeep

J. Phys. Chem. C, 124 (2020) 23426–23432 (DOI: 10.1021/acs.jpcc.0c07140)

Abstract:

We report a dithiol-protected silver cluster, $Ag_{14}(BDT)_6(PPh_3)_8$ (BDT = 1,2-benzene dithiol), abbreviated as Ag14DT, which exhibits distinctly different optical properties than the analogous monothiol-protected $Ag_{14}(SC_6H_3F_2)_{12}(PPh_3)_8$, abbreviated as Ag14MT. Replacement of monothiol by dithiol, keeping the composition constant, has not been possible so far. The inner cores of both Ag_{14}DT and Ag_{14}MT are composed of octahedral Ag_6, but because of the presence of dithiol, the outer cubic Ag_8 shell became distorted in the former. Consequently, Ag_{14}DT showed a unique absorption in the near-infrared (NIR) region, which is mainly due to transitions derived from ligands. It exhibits dual visible/NIR emission, at around 680 and 997 nm. The cluster with NIR



absorption and emission open up a possibility for their application in solar thermal conversion and medical imaging. NIR luminescence in the range of 1000 nm in ultrasmall clusters is very new.

Co-crystals of Atomically Precise Noble Metal Nanocluster

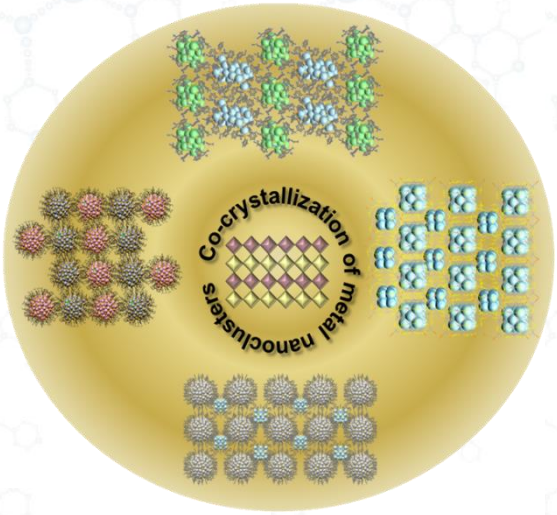
Mohammad Bodiuzzaman, Wakeel Ahmed Dar and Thalappil Pradeep

Small, (2020), 2003981 (DOI: 10.1002/smll.202003981) (Article ASAP)

Abstract:

Co-crystallization is a phenomenon involving the assembly of two or more different chemical entities in a lattice, occurring typically through supramolecular interactions. It encompasses the study of multi-component crystalline solids as well as their design principles. In the last decade, co-crystals have become popular as a potential new solid form in pharmaceuticals. However, the study of co-crystals in nanomaterials is extremely limited. In this Concept, we present recent advancements in the co-crystallization of atomically precise noble metal cluster systems and their potential directions for future. In the beginning, we briefly introduce atomically precise clusters, their crystals, and importance of thiolate-protected nanoclusters. In the subsequent sections, we explain different strategies to create co-assembly of thiolate-protected noble metal nanoclusters. In the subsequent sections, we explain different strategies to create co-assembly of thiolate-protected noble metal nanoclusters.First approach introduced in this regard is the simultaneous synthesis, and co-crystallization of two clusters having similar structures, such as the same shell but different metal cores, as in a unique pair of clusters found recently, namely Ag_{40} and Ag_{46}. In

another category, there is the same core, namely Ag_{116} with different shells, as in a mixture of Ag_{210} and Ag_{211} nanoclusters. Next, we present an intercluster reaction to create mixed solids through selective crystallization of the reaction products. The co-existence of competing effects, magic sizes, and magic electron shells in a co-assembly of alloy nanoclusters is discussed next. Finally, an assembly strategy for metal nanoclusters using electrostatic interactions is described. We conclude this Concept with a future perspective on the emerging possibilities of mixed solids of atomically precise clusters of noble metals. Advancements in this field will certainly help the development of novel materials with potential



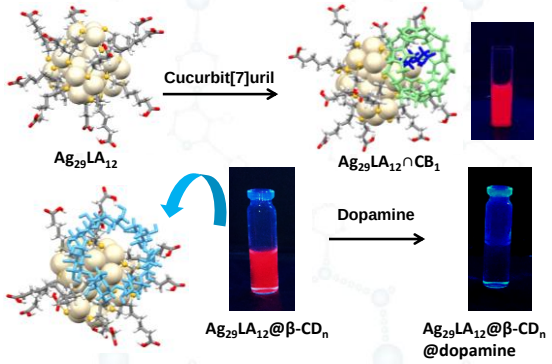
optical, electrical, magnetic, and mechanical properties.

Atomically Precise Noble Metal Cluster-Assembled Superstructures in Water: Luminescence Enhancement and Sensing

Abhijit Nag, Papri Chakraborty, Athira Thacharon, Ganesan Paramasivam, Biswajit Mondal, Mohammad Bodiuzzaman and Thalappil Pradeep

J. Phys. Chem. C, 124 (2020) 23426–23432 (DOI: 10.1021/acs.jpcc.0c07140)

Abstract:



We present an example of host–guest complexes of atomically precise noble metal nanoparticles with cucurbit[7]uril (CB) in water, specifically concentrating on $Ag_{29}(LA)_{12}$ (where LA is α-lipoic acid), a well-known red luminescent silver cluster. Such host–guest interactions resulted in enhanced luminescence of about 1.25 times for the modified system, compared to the parent cluster. We extended our study to cyclodextrins (CDs), where about 1.5 times enhanced luminescence was estimated compared to the parent cluster. The formation of supramolecular complexes was confirmed using high-resolution electrospray ionization mass spectrometry (HRESI MS) and nuclear magnetic resonance spectroscopy. Molecular docking and density functional theory calculations supported our experimental results and showed that while CB formed inclusion complexes by encapsulation of one of the LA ligands of the cluster, CD formed supramolecular adducts by interaction with the cavity built by the ligands on the cluster surface. The complexation was favored by geometrical compatibility. Consequently, these superstructures are labeled as $Ag_{29}LA_{12}\cap CB_n$ and $Ag_{29}LA_{12}@CD_n$ (n = 1–3), where ∩ and @ indicate the inclusion complex and supramolecular adduct, respectively. Solution-phase $Ag_{29}LA_{12}@CD_n$ complexes were employed to detect dopamine (10 nM). Luminescent $Ag_{29}LA_{12}@CD_n$ and $Ag_{29}LA_{12}\cap CB_n$ complexes in water could be potential candidates for organic pollutant sensing and biomedical applications.

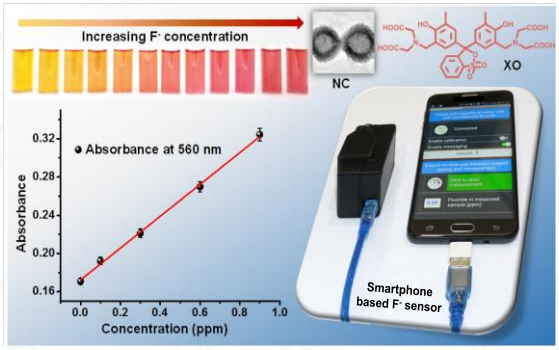
A Smartphone-Based Fluoride-Specific Sensor for Rapid and Affordable Colorimetric Detection and Precise Quantification at Sub-ppm Levels for Field Applications

Sritama Mukherjee, Manav Shah, Kamalesh Chaudhari, Arijit Jana, Chennu Sudhakar, Pillalamarri Srikrishnarka, Md Rabiul Islam, Ligy Philip and Thalappil Pradeep

ACS Omega, 5 (2020) 25253–25263 (DOI: 10.1021/acsomega.0c03465)

Abstract:

Higher levels of fluoride (F-) in groundwater constitute a severe problem that affects more than 200 million people spread over 25 countries. It is not only essential to detect but also accurately quantify aqueous F- to ensure safety. Need of the hour is to develop smart water quality testing systems that would be effective in location-based real-time water quality data collection, devoid of professional expertise for handling. We report a cheap, handheld, portable mobile device for colorimetric detection and rapid estimation of F- in water by the application of the synthesized core-shell nanoparticles (near-cubic ceria@zirconia nanocages) and a chemoresponsive dye (xylenol orange). The nanomaterial has been characterized thoroughly and the mechanism of sensing has been studied in detail. The sensor system is highly selective towards F- and shows unprecedented sensitivity in the range of 0.1 to 5 ppm of F-, in field water samples, which is the transition regime where remedial measures may be needed. It addresses multiple issues expressed by indicator based metal complexes used to determine F- previously. Consistency in the performance of the sensing material has



been tested with synthetic F- standards, water samples from F- affected regions, and dental care products like toothpastes and mouthwash using a smartphone attachment and by naked eye. The sensor performs better than prior reports on aqueous F- sensing.

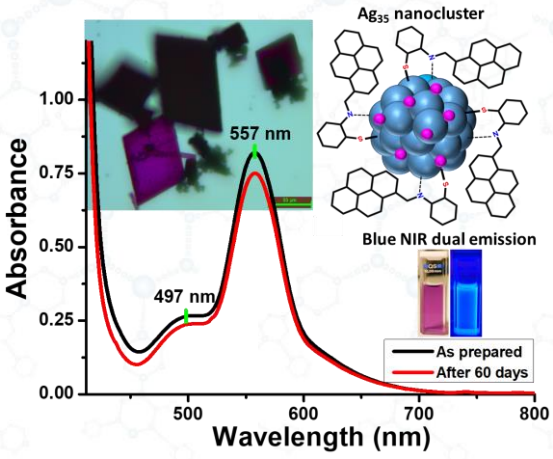
Dual Emitting Ag_{35} Nanocluster Protected by 2-Pyrene Imine Thiol

Arijit Jana, Papri Chakraborty, Wakeel Ahmed Dar, Sourov Chandra, Esma Khatun, M. P. Kannan, Robin H. A. Ras, Thalappil Pradeep

Chem. Commun., 56 (2020) 12550-12553 (DOI: 10.1039/d0cc03983g)

Abstract:

In this communication, we present the synthesis of 2-pyrene imine thiol (2-PIT)-protected Ag_{35} nanoclusters using a ligand exchange-induced structural transformation reaction. The formation of the nanocluster and its composition were confirmed through several spectroscopic and electron microscopic studies. UV-vis absorption spectrum showed a set of characteristic features for the nanocluster. This nanocluster showed blue emission under UV light due to pyrene to metal core charge-transfer, and a NIR emission due to charge-transfer within the metal core. This is the first report of dual emitting pyrene protected atomically precise silver nanocluster.



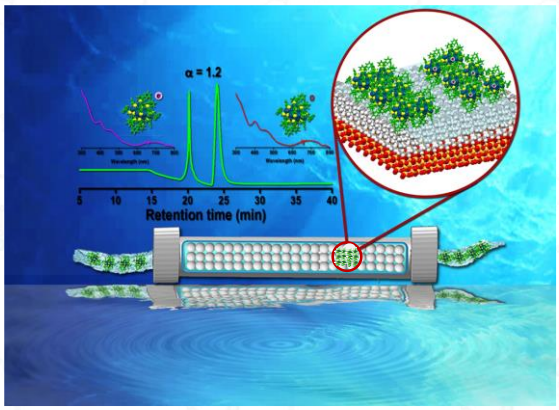
Ligand structure and charge state-dependent separation of monolayer protected Au25 clusters using non-aqueous reversed-phase HPLC

Korath Shivan Sugi, Shridevi Bhat, Abhijit Nag, Ganesan Paramasivam, Ananthu Mahendranath, and Thalappil Pradeep

Analyst, 145 (2020) 1337-1345 (DOI: 10.1039/c9an02043h)

Abstract:

The synthesis of atomically precise noble metal clusters using various protocols often results in a mixture of clusters with different cores. Hence, it is important to isolate such clusters in their pure form in terms of composition especially for crystallization. High-performance liquid chromatography (HPLC) is a powerful tool to achieve this. The interaction of ligands with column functionalities determine the extent of separation and their stability under conditions used. We demonstrate a systematic flow rate dependent study of three different aliphatic ligand protected Au_{25} clusters, with three commercially available alkyl and aryl functionalized reversed-phase HPLC columns, as they represent the variations encountered commonly. Molecular docking simulations were carried out to understand the interactions between the stationary phase and the cluster surface. These investigations enabled the selection of an appropriate column for better separation of structurally different ligand protected clusters. High-resolution separation of anionic and neutral Au_{25} clusters was acheived with a selectivity (α) of 1.2 by tuning the chromatographic conditions. This study would provide new insights in developing better methods for the efficient separation of monolayer protected clusters.



Manifestation of Structural Differences of Atomically Precise Cluster-Assembled Solids in Their Mechanical Properties

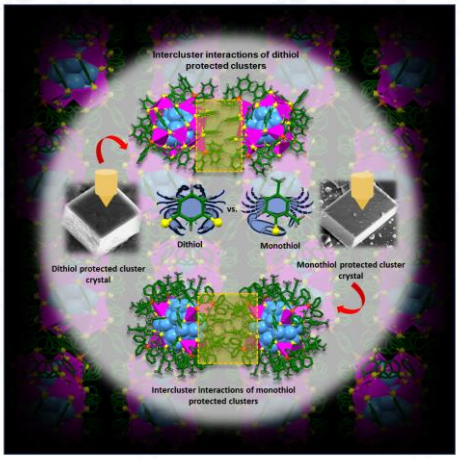
Korath Shivan Sugi, Payel Bandyopadhyay, Mohammad Bodiuzzaman, Abhijit Nag, Manjapoyil Hridya, Wakeel Ahmed Dar, Pijush Ghosh, and Thalappil Pradeep

Chem. Mater., 32 (2020) 7973–7984 (DOI: 10.1021/acs.chemmater.0c02905)

Abstract:

Cluster-assembled solids (CASs) formed by the self-assembly of monodispersed atomically precise monolayer-protected noble metal clusters are attractive due to their collective properties. The physical stability and mechanical response of these materials remain largely unexplored. We have investigated the mechanical response of single crystals of atomically precise dithiol-protected Ag_{29} polymorphs, monothiol-protected Ag_{46}, and a cocrystal of the latter with Ag_{40} (formulas of the clusters have been simplified merely with the number of metal atoms). The Ag_{29} polymorphs crystallize in cubic and trigonal lattices (Ag_{29} C and Ag_{29} T, respectively), and Ag_{46} and its cocrystal with Ag_{40} crystallize in trigonal and monoclinic lattices (Ag_{46} T and Ag40/46 M, respectively). The time and loading-rate-dependent mechanical properties of the CASs are elucidated by measuring nanoindentation creep and stress relaxation. The obtained Young's modulus (E_r) values of the CASs were similar to those of zeolitic imidazolate frameworks (ZIFs) and show the trend Ag_{29} T > Ag_{29} C > $Ag_{40/46}$ M > Ag_{46} T. We have also studied the viscoelastic properties of all of the four CASs and found that the value of tan δ/damping factor of monothiol-protected Ag_{46} T

was higher than that of other CASs. The unusual mechanical response of CASs was attributed to the supramolecular interactions at the surface of nanoclusters. This observation implies that the stiffness and damping characteristics of the materials can be modulated by ligand and surface engineering. These studies suggest the possibility of distinguishing between the crystal structures using mechanical properties. This work provides an understanding that is critical for designing nanocluster devices capable of withstanding mechanical deformations.



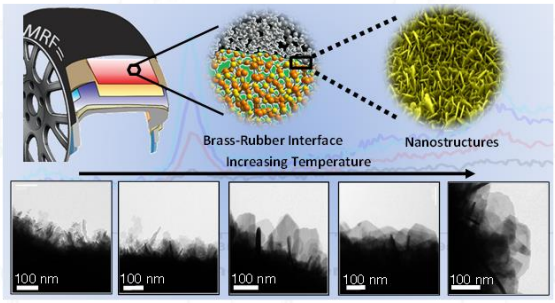
Nonstoichiometric Copper Sulfide Nanostructures at the Brass−Rubber Interface: Implications for Rubber Vulcanization Temperature in the Tire Industry

M. P. Kannan, Anirban Som, Tripti Ahuja, Vidhya Subramanian A. Sreekumaran Nair, and Thalappil Pradeep

ACS Appl. Nano Mater., 3 (2020) 7685–7694 (DOI: 10.1021/acsanm.0c01298)

Abstract:

Brass (which is an alloy of copper and zinc)-coated steel cords (BCSCs) in the form of belts are embedded in rubber compound in radial tires (beneath the tread) to give stability and strength to the tread region of the tires. The life of the tires also depends on the strength and durability of the bond between the BCSCs and rubber. During the vulcanization process with sulphur, a series of sulfide and oxide nanostructures of copper and zinc are formed at the brass-rubber. These nanostructures have a dendritic morphology that can reinforce rubber primarily through mechanical interlocking created through the flow of rubber chains into the dendritic cavities followed by formation of crosslinks between rubber chains during vulcanization. The strength and durability of the bonding depend on a number of parameters such as rubber compound formulation, vulcanization temperature (VT) and time, nanostructure thickness (height) and chemical composition of the nanostructures, etc. (the so-called adhesion interface). A few methods have been stated in literature for assessing the chemical composition and thickness of the adhesion interface. However, simple, reliable and newer methodologies are needed for a better understanding of the same. The present manuscript details a new approach called “brass mesh experiment” to assess the thickness of the adhesion interface formed under particular vulcanization conditions using microscopy. Raman imaging and spectroscopy were employed to determine the chemical composition of the interface with complementary data from X-ray photoelectron spectroscopy and X-ray diffraction. Using the methodologies, VT optimization was done for a tire compound formulation and this was verified by the generally accepted pull-out force method. We believe that the methodologies outlined in the can trigger further research for a better understanding of the adhesion interface in radial tires.



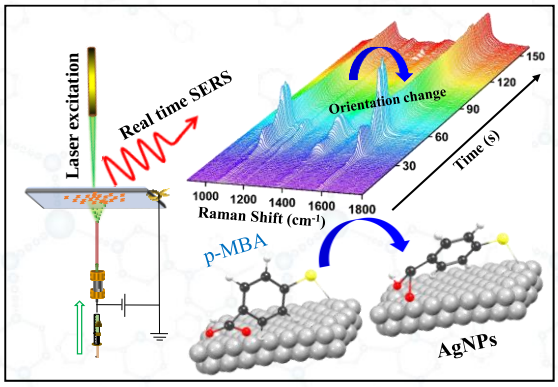
Probing Subtle Changes in Molecular Orientations Using Ambient Electrospray Deposition Raman Spectroscopy (AESD RS)

Atanu Ghosh†, Tripti Ahuja†, Kamalesh Chaudhari and Thalappil Pradeep (†equal contribution)

J. Phys. Chem. C, 124 (2020) 16644–16651 (DOI: 10.1021/acs.jpcc.0c04116)

Abstract:

Herein, subtle changes in the molecular orientations of different thiols upon interaction with soft-landed silver nanoparticles (AgNPs) have been probed using the technique called ambient electrospray deposition Raman spectroscopy (AESD RS). The method collects real-time surface-enhanced Raman scattering (SERS) spectra of analytes as Raman-active AgNPs were electrodeposited on a substrate. We have used p-mercaptobenzoic acid (pMBA), benzenethiol (BT), and cyclohexanethiol (CHT) as proof-of-concept ligands for understanding variations in molecular orientations as a function of time, immediately after 30-40 s of electrospray of AgNPs. During timedependent SERS measurements, we observed that the carboxylate (COO^-) group of p-MBA preferred a flat orientation on the NP surface upon interaction with the electrosprayed AgNPs, which later transformed into a tilted two-legged standing-up orientation. We also observed a concomitant change in the orientation of the phenyl ring, which transformed from tilted to a flat orientation with respect to the NP surface. We have found that the time of tilting depends on the concentration of the analyte used for analysis. Additional information on the orientation flipping of thiols was achieved by performing real-time SERS experiments on other thiol derivatives such as CHT and BT. In the case of BT, SERS intensity variations were similar to p-MBA, which were attributed to the



changes in orientation. However, in the case of CHT, such SERS intensity variations were absent. Time-dependent SERS spectra of p-MBA, BT, and CHT suggested that the interaction between the π-cloud of the phenyl ring and AgNPs could be one of the triggering factors for such orientation flipping of thiols on NP surfaces.

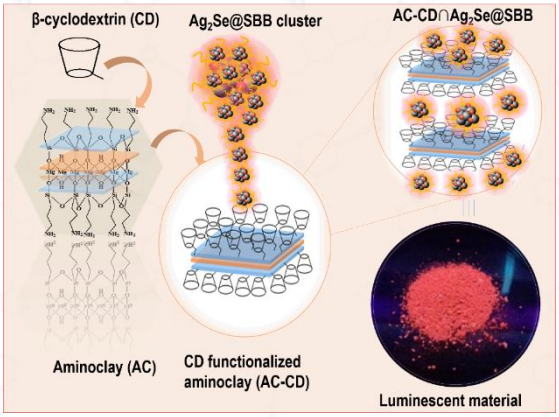
Entrapping Atomically Precise Clusters in Cyclodextrin-Functionalized Aminoclay Sheets: Synthesis and Enhanced Luminescence

Mohd Azhardin Ganayee, C. K. Manju, Wakeel Ahmed Dar, Biswajit Mondal, and Thalappil Pradeep

ACS Ind. Eng. Chem. Res., 2020, 59, 12737–12744. (DOI: 10.1021/acs.iecr.9b07018)

Abstract:

In this article, a unique covalently-linked aminoclay substrate, grafted with *β*-cyclodextrin (AC-CD), was prepared to entrap luminescent silver nanocluster. Chemically synthesized aminoclay (AC) sheets grafted with *β*-cyclodextrins (*β*-CD) were used to develop a supramolecular entity. Here, we have grafted *β*-CD onto aminoclays using cyanuric chloride as a linker. AC-CD material was thoroughly characterized using fourier transform infrared spectroscopy (FTIR), powder X-ray diffraction (PXRD) and transmission electron microscopy (TEM). The grafting ratio of *β*-CD onto AC-CD



was determined using the phenolphthalein inclusion protocol. The as-prepared functionalized clay (AC-CD) is an effective and attractive material for entrapping a luminescent silver chalcogenide cluster stabilized by 4-(*t*-butyl)benzyl mercaptan ($Ag_{56}Se_{13}S_{15}$@SBB_{28} shortened as Ag_2Se@SBB). The cluster AC-CD (AC-CD∩Ag_2Se@SBB) supramolecular nanocomposite is based on specific host-guest interactions involving *β*-CD of AC-CD and SBB of silver cluster. Entrapment of the cluster into the *β*-CD cavity was verified using optical absorption, luminescence spectroscopy, XRD and TEM. The entrapment results in the enhanced luminescence and stability of the cluster. Such a dispersible nanocomposite system exhibiting intense luminescence will be useful in creating novel materials for various applications such as sensors, optoelectronic devices, etc.

Clean Water through Nanotechnology: Needs, Gaps, and Fulfillment

Ankit Nagar and Thalappil Pradeep

ACS Nano, 14 (2020) 6420–6435 (DOI: 10.1021/acsnano.9b01730)

Abstract:

Sustainable nanotechnology has made substantial contributions in providing contaminant-free water to humanity. In this

review, we present the compelling need for providing access to clean water through nano-technology-enabled solutions and the large disparities in ensuring their implementation. We also discuss the current nanotechnology frontiers in diverse areas of the clean water space with an emphasis on applications in the field and provide suggestions for future research. Extending the vision of sustainable and affordable clean water to environment in general, we note that cities can live and breathe well by adopting such technologies. By understanding the global environmental challenges and exploring remedies from emerging nanotechnologies, sustainability in clean water can be realized. We suggest specific pointers and quantify the impact of such technologies.

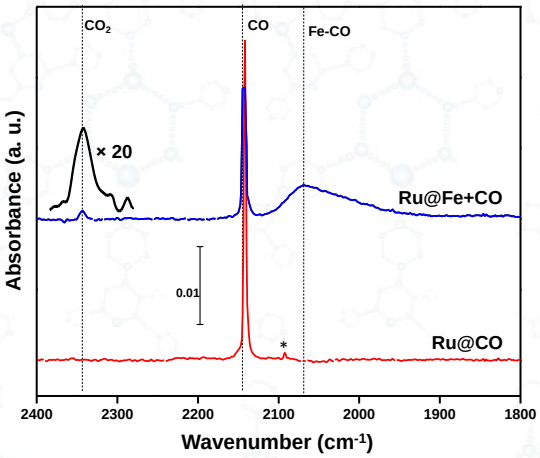
Iron Assisted Formation of CO_2 over Condensed CO and Its Relevance to Interstellar Chemistry

Rabin Rajan J. Methikkalam,† Jyotirmoy Ghosh,† Radha Gobinda Bhuin, Soumabha Bag, Gopi Ragupathy, and Thalappil Pradeep (†equal contribution)

Phys. Chem. Chem. Phys., 22 (2020) 8491-8498 (DOI: 10.1039/c9cp06983f)

Abstract:

Catalytic conversion of CO to CO_2 has been investigated in ultrahigh vacuum (UHV) under cryogenic conditions (10 K). This cryogenic oxidation is assisted by iron upon its co-deposition with CO, on a substrate. The study shows that the interaction of Fe and CO results in a Fe-CO complex that reacts in the presence of excess CO at cryogenic conditions leading to CO_2. Here, the presence of CO on the surface is a prerequisite for the reaction to occur. Different control experiments confirm that the reaction takes place in the condensed phase and not in the gas phase. Surface sensitive reflection absorption infrared spectroscopy (RAIRS), temperature programmed desorption (TPD), and Cs^+ based low energy ion scattering are utilized for this study. The iron assisted formation of CO_2 may be proposed as another pathway relevant in interstellar ices, containing CO. This direct oxidation process, which occurs at extremely low temperatures and pressures, in the presence of a reactive metal species like



iron (the most abundant metal in the interstellar medium) may have astrochemical importance. It does not require any external energy in the form of photo-irradiation or thermal processing. Such reactions are highly relevant in cold dense molecular clouds where interactions between neutral species are more favoured.

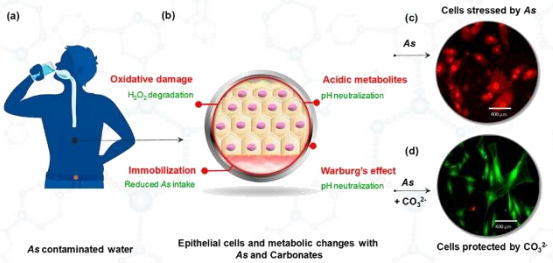
Arsenic Toxicity: Carbonate's Counteraction Revealed

Swathy Jakka Ravindran, Shantha Kumar Jenifer, Jayashree Balasubramanyam, Sourav Kanti Jana, Subramanian Krishnakumar, Sailaja Elchuri, Ligy Philip, and Thalappil Pradeep

ACS Sustainable Chem. Eng. 2020, 8, 13, 5067–5075 (DOI: 10.1021/acssuschemeng.9b06850)

Abstract:

Well-known purification technologies built for arsenic (As) removal from drinking water are not sustainable, either being unaffordable or inefficient in the elimination of traces of As. In our experiments, we observed that carbonate ion can counteract the effects of As exposure as it efficiently prevented As induced cytotoxicity on epithelial cell lines of the small intestine (IEC-6). The cotreatment of IEC-6 cells with 40 ppm of carbonates and As (≥3 ppm) showed substantial remissions in the As-induced cytotoxicity and increased the viability from 50% to 75%. The production of intracellular reactive oxygen species (ROS) and cellular acidification were also reduced in this process (pH increase from 5 to 6.5). Thus, the present study suggests that the cytoprotective effect of carbonate can involve multiple pathways, such as reduction of extracellular/intracellular acidosis, H2O2 decomposition, balancing mitochondrial potential, and immobilization of As. We show that As-contaminated drinking water enriched with carbonates up to 40 ppm has a reduced toxic effect on cells in comparison to that of an As-alone sample. Therefore, carbonates can act as an adjunct in addition to the prevailing approaches to tackle mass poisoning by As.



We believe that this study is initial evidence for developing an alternative method to tackle the prevailing mass environmental poisoning by As, using locally available, affordable, safe, and sustainable solutions.

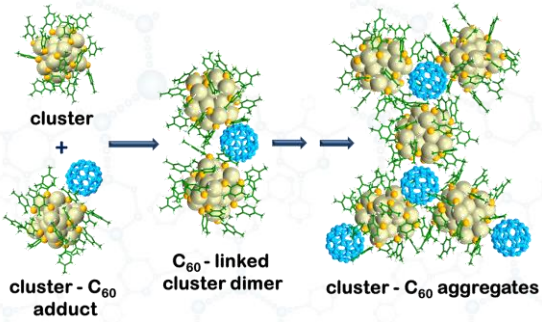
Fullerene-Mediated Aggregation of $M_{25}(SR)_{18}^-$ (M = Ag, Au) Nanoclusters

Papri Chakraborty, Abhijit Nag, Biswajit Mondal, Esma Khatun, Ganesan Paramasivam, and Thalappil Pradeep

J. Phys. Chem. C, 124 (2020) 14891–14900 (DOI: 10.1021/acs.jpcc.0c03383)

Abstract:

We report fullerene (C_{60} and C_{70})-induced aggregation of atomically precise clusters, taking $M_{25}(SR)_{18}^-$ (M = Ag, Au and −SR is a thiolate ligand) clusters as an example. We show that dimers, trimers, tetramers, and even higher aggregates of the clusters can be created by supramolecular interaction with



fullerenes. Adducts such as $[\{M_{25}(SR)_{18}\}_n(C_{60})]^{n-}$ (n = 1–5), $[\{M_{25}(SR)_{18}\}_n(C_{60})_{n-1}]^{n-}$ (n = 2–5), and $[\{M_{25}(SR)_{18}\}_n(C_{60})_n]^{n-}$ (n = 1, 2, 3, ..., etc.) were formed, which were studied by electrospray ionization mass spectrometry. Similar adducts with C_{70} were also observed. Structural insights were obtained from molecular docking and density functional theory calculations. Computational studies predicted the possibility of isomerism in some of these adducts. Fullerenes linked multiple clusters, causing aggregation. Fullerenes and clusters formed host–guest complexes in such assemblies. The possibilities of coassembly between the clusters and the fullerenes were also studied in the solid state. The nature of adducts observed in the case of $M_{25}(SR)_{18}^-$ was completely different compared to the previously reported fullerene adducts of $[Ag_{29}(BDT)_{12}]^{3-}$ (where BDT is 1,3-benzene dithiol), in which multiple fullerenes were attached on the surface of a single cluster. Supramolecular aggregates formed in the case of $M_{25}(SR)_{18}^-$ were independent of the nature of the metal atoms (Ag or Au). This implied that for an appropriate geometry of the cluster weak interactions with the ligands and ion-induced dipole interactions were more important in controlling the complexation compared to the metallophilic interactions. Exploring the interaction of atomically precise clusters with fullerenes is important, as the resulting adducts can show new properties such as isomerism, chirality, charge transfer, or enhanced optical properties.

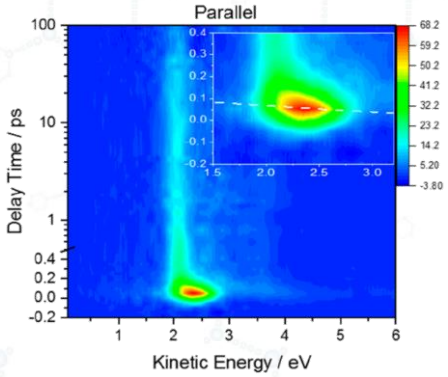
Ultrafast Intersystem Crossing in Isolated Ag29(BDT)123- Probed by Time-Resolved Pump-Probe Photoelectron Spectroscopy

Aron P. Veenstra, Laurenz Monzel, Ananya Baksi, Joseph Czekner, Sergei Lebedkin, Erik K. Schneider, Thalappil Pradeep, Andreas-Neil Unterreiner, and Manfred M. Kappes

J. Phys. Chem. Lett. 11, (2020), 2675−2681, (DOI: 10.1021/acs.jpclett.0c00482)

Abstract:

The photophysics of the isolated trianion $Ag_{29}(BDT)^{123-}$ (BDT = benzenedithiolate), a ligand-protected cluster comprising BDT-based ligands, terminating a shell of silver thiolates and a core of silver atoms, was studied in the gas phase by femtosecond time-resolved, pump-probe photoelectron spectroscopy. UV excitation at 490 nm populates one or more singlet excited states with significant charge transfer (CT) character in which electron



density is shifted from shell to core. These CT states relax on an average time scale of several hundred femtoseconds by charge recombination to yield either the vibrationally excited singlet ground state (internal conversion) or a long-lived triplet (intersystem crossing). Our study is the first ultrafast spectroscopic probe of a ligand-protected coinage metal cluster in isolation. In the future, it will be interesting to study how cluster size, overall charge state, or heteroatom doping can be used to tune the corresponding relaxation dynamics in the absence of solvent

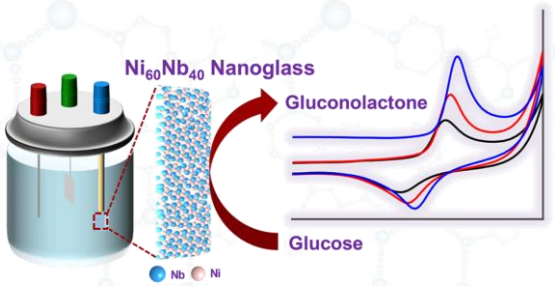
Nonenzymatic Glucose Sensing Using $Ni_{60}Nb_{40}$ Nanoglass

Soumabha Bag, Ananya Baksi, Sree Harsha Nandam, Di Wang, Xinglong Ye, Jyotirmoy Ghosh, Thalappil Pradeep, and Horst Hahn

ACS Nano, 14, (2020), 5543-5552, (DOI: 10.1021/acsnano.9b09778)

Abstract:

Despite being researched for nearly five decades, chemical application of metallic glass is scarcely explored. Here we show electrochemical nonenzymatic glucose-sensing ability of nickel-niobium ($Ni_{60}Nb_{40}$) amorphous alloys in alkaline medium. Three different $Ni_{60}Nb_{40}$ systems with the same elemental composition, but varying microstructures are created following different synthetic routes and tested for their glucosesensing performance. Among melt-spun ribbon, nanoglass, and amorphous crystalline nanocomposite materials, nanoglass showed the best performance in terms of high anodic current density, sensitivity (20 mA cm^{-2} mM^{-1}), limit of detection (100 nM glucose), stability, reproducibility,(above 5000 cycles), and sensing accuracy among nonenzymatic glucose sensors involving amorphous alloys. When annealed under vacuum, only the heat-



treated nanoglass retained a similar electrochemical sensing property, while the other materials failed to yield desired results. In nanoglass, a network of glassy interfaces, compared to melt-spun ribbon, is plausibly responsible for the enhanced sensitivity.

Ferrofluid Microdroplet Splitting for Population-Based Microfluidics and Interfacial Tensiometry

Mika Latikka, Matilda Backholm, Avijit Baidya, Alberto Ballesio, Amandine Serve, Grégory Beaune, Jaakko V. I. Timonen, Thalappil Pradeep, and Robin H. A. Ras

Adv. Sci., 7, (2020), 2000359 (DOI: 10.1002/advs.202000359)

Abstract:

Ferrofluids exhibit a unique combination of liquid properties and strong magnetic response, which leads to a rich variety of interesting functional properties. Here, the magnetic-field-induced splitting of ferrofluid droplets immersed in an immiscible liquid is presented, and related fascinating dynamics and applications are discussed. A magnetic field created by a permanent magnet induces instability on a mother droplet, which divides into two daughter droplets in less than 0.1 s. During the splitting process, the droplet undergoes a Plateau–Rayleigh-like instability, which is investigated using high-speed imaging further increasing the field results in additional splitting events and self-assembly of microdroplet populations. The dynamics of the resulting satellite droplet formation is shown to depend on the roughness of the supporting surface. , which can be magnetically actuated. The effects of magnetization and interfacial tension are systematically investigated by varying magnetic

nanoparticles and surfactant concentrations, and a variety of outcomes from labyrinthine patterns to discrete droplets are observed. As the splitting process depends on interfacial tension, the droplet splitting can be used as a measure for interfacial tension as low as 0.1 mN m−1. Finally, a population-based digital microfluidics concept based on the self-assembled microdroplets is presented.

Phosphorylated Cellulose Nanofibers Exhibit Exceptional Capacity For Uranium Capture

Janika Lehtonen, Jukka Hassinen, Avula Anil Kumar, Leena-Sisko Johansson, Roni Ma¨enpa¨a¨, Nikolaos Pahimanolis, Thalappil Pradeep, Olli Ikkala, Orlando J. Rojas

Cellulose, 27, (2020), 10719–10732 (DOI: 10.1007/s10570-020-02971-8)

Abstract:

We investigate the adsorption of hexavalent uranium, U(VI), on phosphorylated cellulose nanofibers (PHO-CNF) and compare the results with those for native and TEMPO oxidized nanocelluloses. Batch adsorption experiments in aqueous media show that PHO CNF is highly efficient in removing U(VI) in the pH range between 3 and 6. Gelling of nanofiber hydrogels is observed at U(VI) concentration of 500 mg/L. Structural changes in the nanofiber network (scanning and transmission electron microscopies) and the surface chemical composition (Xray photoelectron spectroscopy) gave insights on the mechanism of adsorption. The results from batch adsorption experiments are fitted to Langmuir, Freundlich, and Sips isotherm models, which indicate a maximum adsorption capacity of 1550 mg/g, the highest value reported so far for any bioadsorbent. Compared to other metals (Zn, Mn, and Cu) and typical ions present in natural aqueous matrices the phosphorylated nanofibers are shown to be remarkably selective to U(VI). The results suggest a solution for the capture of uranium, which is of interest given its health and toxic impacts when present in aqueous matrices.

Association of co accumulation of arsenic and organophosphate insecticides with diabetes and atherosclerosis in a rural agricultural community: KMCH NNCD I study

Ganesan Velmurugan, Krishnan Swaminathan, Sundaresan Mohanraj, Mani Dhivakar, Ganesh Veerasekar, Thomas Alexander, Mathew Cherian, Nalla G. Palaniswami, Thalappil Pradeep

Acta Diabetologica, 57, (2020), 1159–1168 (DOI: 10.1007/s00592-020-01516-6)

Abstract:

In last few decades, the prevalence of diabetes and vascular diseases has intensified concurrently with increased use of synthetic chemicals in agriculture. This study is aimed to evaluate the association of co accumulation of arsenic and organophosphate (OP) insecticides with diabetes and atherosclerosis prevalence in a rural Indian population. This study included observations from KMCH-NNCD-I (2015) cross-sectional study (n = 865) from an Indian farming village. The participants had assessment of clinical parameters including HbA1c and carotid intima–media thickness and urinary heavy metals. Serum OP residues were extracted and quantified by GC–MS. Statistical analyses were performed to unravel the co-association of arsenic and OPs on prevalence of diabetes and atherosclerosis. Results On multivariate regression analyses, total organophosphate level and arsenic accumulation showed association with diabetes and atherosclerosis. Higher odds ratio with significant trends were observed for the sub-quartiles formed by the combination of higher quartiles of arsenic and total organophosphates in association with diabetes and atherosclerosis. Conclusions We observed evidence of possible synergism between arsenic and OPs in association with prevalence of diabetes, pre-diabetes and atherosclerosis in

the study population. Our findings highlight the importance of understanding health effects of mixed exposures and raises vital questions on the role of these agrochemicals in the etiology of diabetes and vascular diseases.

Acknowledgements

We thank our collaborators and students for their hard work.

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Department of Science and Technology,

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