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Abstract booklet

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Inorganic Graphene Analogues

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Graphene has been a sensational discovery of recent years. In the last two to three years, there has been effort to prepare graphene-like layered inorganic materials such as MoS_2, WS_2, GaS and BN. Several methods of synthesis of such nanosheets have been developed.[1] In the last two years MoS2 and related dichalcogenides have gained considerable importance because of the many novel properties and phenomena exhibited by them.[2] Transistors and devices have been fabricated with some of these layered inorganic materials. A new family of graphene-like materials is the borocarbonitrides, ($B_xC_yN_z$). These materials exhibit unusual gas adsorptive properties including high-surface areas.[3] Open-framework materials incorporating graphene and BN have been synthesized and characterized. The graphene-like 2D materials have potential applications specially in energy devices.[4]

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Biographical sketch

Prof. C.N.R. Rao is the National Research Professor as well as Linus Pauling Research Professor and Honorary President of the Jawaharlal Nehru Centre for Advanced Scientific Research, Bangalore. He is also an Honorary Professor at the Indian Institute of Science. His main research interests are in solid state and materials chemistry, surface phenomena, spectroscopy and molecular structure. He is an author of over 1,600 research papers and 50 books. He received the M.Sc. degree from Banaras, Ph.D. from Purdue, D.Sc. from Mysore universities and has received Honoris Causa doctorate degrees from 62 universities.

He is a member of many science academies. He was President of the International Union of Pure and Applied Chemistry and also President of the Third World Academy of Sciences (TWAS). Prof. Rao is a Fellow of 25 science academies which include the Indian National Science Academy, the Indian Academy of Sciences, the Royal Society, London, U.S. National Academy of Sciences, the Russian Academy of Sciences, French Academy of Sciences, Pontifical Academy of Sciences and Japan Academy as well as the American Philosophical Society.

He was the Director of the Indian Institute of Science (1984-94), Chairman of the Science Advisory Council to Prime Minister Rajiv Gandhi (1985-89) and Chairman, Scientific Advisory Committee to the Union Cabinet (1997-98). He is the Chairman of the National Nano Initiative. He is currently the Chairman of the Science Advisory Council to the Prime Minister.

Synthesis and Properties of Heterostructures with Designed Nanoarchitecture

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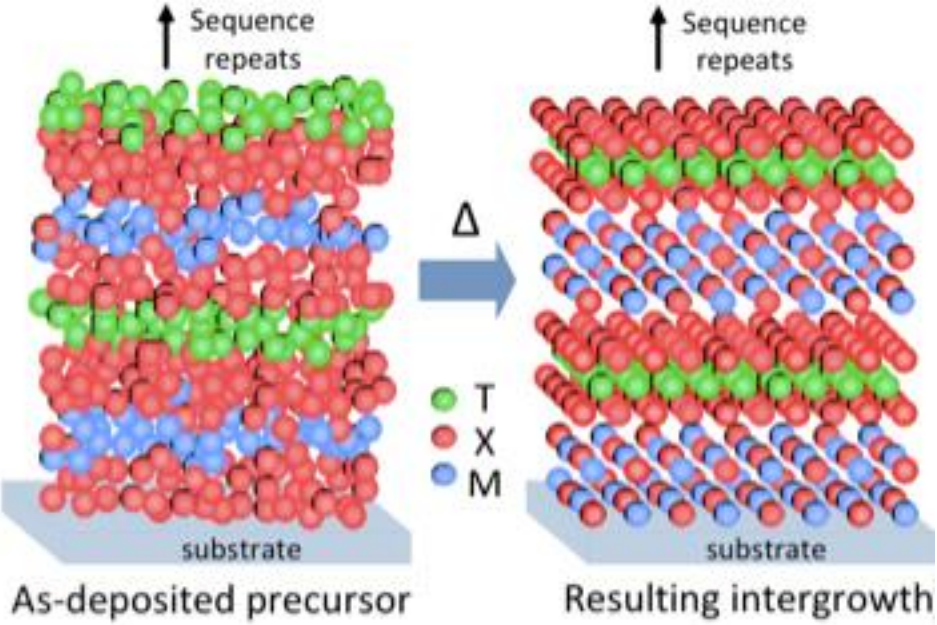
By controlling the composition of an amorphous intermediate on the nanoscale it is possible to kinetically control the self-assembly of new nanostructured compounds consisting of two or more compounds with different crystal structures that are precisely interleaved on the nanoscale. We have used this approach to synthesize hundreds of new metastable compounds with designed nanostructure, including structural isomers. Many of these materials have unprecedented physical properties, including the lowest thermal conductivities ever reported for a fully dense solid, systematic structural changes dependent on nanostructure, and charge density wave transitions. The ability to prepare entire families of new nanostructured compounds and equilibrating them to control carrier concentrations permits a new "thin film metallurgy" or “nanochemistry” in which nanostructure and composition can both be used to tailor physical properties, interfacial structures can be determined for precisely defined constituent thicknesses, and interfacial phenomena and modulation doping can be systematically exploited.



Biographical sketch

David C. Johnson is the Rosaria Haugland Foundation Chair in Pure and Applied Chemistry at the University of Oregon. He is the creator of the Graduate Internship program and the Center for Advanced Materials Characterization in Oregon (CAMCOR) – the state of Oregon's 'high tech' extension service, Johnson is also the co-director of the Center for Sustainable Materials Chemistry, an NSF Chemical Innovation Center and the director of ONAMI's Nanoarchitectures for Enhanced Performance Center.

Johnson's research is at the interface of chemistry and physics focused on controlling materials properties using nanoarchitecture. His non-traditional approach to chemical synthesis has led to many new materials with unprecedented physical properties. A recent example is the discovery of a new class of materials material with the lowest thermal conductivity ever reported for a fully dense solid.

Johnson received his Ph.D. from Cornell in 1983 and worked as a research chemist for DuPont before coming to Oregon in 1986, received the Oregon Academy of Science's Outstanding Scientist Award in 2006. He has served as a Board Member for the International Thermoelectric Society and is a founding academic member of the Oregon Nanoscience and Microtechnology Institute.- ONAMI. He was a Mercator Fellow of the DFG (the German Research Foundation) in 2013 at the University of Freiburg.

High Spin-orbit Group 14 Graphane Analogues and Layered Zintl Phases as Novel Topological and Magnetic Materials

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The group 14 graphane analogues represent a unique class of covalently modifiable 2D materials, as there have been many recent exciting predictions of the existence of 2D quantum spin Hall behavior at room temperature in these materials. Here, we will describe our recent efforts in the creation and properties of hydrogen and organic-terminated group IV graphane analogues, from the topochemical deintercalation of precursor Zintl phases in order to create these topological phases. First, through the synthesis and characterization of a wide array of ligand terminated germanane analogues we have established experimental limits to which the electronic structure can be manipulated via surface chemistry. Second, we will discuss our recent efforts on the synthesis and properties of ligand-terminated Sn-contain graphane analogues to create systems that span from trivial insulators to 2D topological phases depending on the surface functionalization group. Finally, we will describe emerging discoveries on the existence of topological insulating phenomena in our Sn-containing layered Zintl phase precursor materials.

Biographical sketch

Josh Goldberger received his B.S. in chemistry from The Ohio State University in 2001. He received his Ph.D. in chemistry from the University of California at Berkeley with Professor Peidong Yang in 2006, as an NSF graduate fellow. He then did his postdoctoral research with Professor Sam Stupp at Northwestern University as part of the Institute for BioNanotechnology in Medicine, as an NIH-NRSA postdoctoral fellow (2007-2010). He has received many awards, including an MRS Graduate Student Finalist Award in 2003, an IUPAC Prize for Young Chemists in 2007, and a Camille Dreyfus Teacher-Scholar Award in 2015. He joined The Ohio State University Chemistry Department in August of 2010, and was promoted to Associate Professor in 2016.

Liquid-exfoliated transition metal dichalcogenides: a story of excitons, spectroscopic metrics and functionalisation

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Liquid exfoliation has become an important production technique to give access to large quantities of two-dimensional nanosheets in colloidal dispersion.[1] Importantly, this is a highly versatile technique that can be applied to numerous layered materials beyond graphene such as transition metal dichalcogenides, III-VI semiconductors, black phosphorus, layered oxides to name just a few. These can be cast into films and composites and have proven useful in a number of application areas. However, as produced dispersions contain a nanosheets of various sizes and thicknesses making post-exfoliation size selection extremely important to tap the full potential in the future.

We have previously developed a universal and efficient size selection technique termed liquid cascade centrifugation.[2] Optimisation of this centrifugation procedure allowed us to produce monolayer-rich dispersions with monolayer volume fractions up to 75%. This was made possible because we have realised that nanosheet size and thickness, as well as monolayer content can be quantitatively extracted from for example optical extinction spectra due to edge and confinement effects greatly facilitating and accelerating the characterisation.[2,3] We now use this basic understanding and these improvements in sample quality to systematically investigate the effect of the chemical environment on the optical properties of the liquid-exfoliated nanosheets. For example, we observe solvatochromic shifts of the A-exciton in response to the solvent or stabiliser system[4] suggesting that the A-exciton is ideal to study chemical doping. These investigations lay the foundation for a more comprehensive understanding of the interfacial interaction of these materials which will allow for fine-tuning of the materials' properties in the future.

Last but not least, we will show that the ability to dramatically increase the surface area of the layered materials on exfoliation can be used to explore new chemistry and to controllably functionalise either basal plane [5,6] or edge sites.

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Biographical sketch

Claudia Backes has received her Ph.D with honors in 2011 from the University of Erlangen, Germany. From 2011-2012, she supported the Erlangen Cluster of Excellence “Engineering of Advanced Materials” as deputy executive director and scientific coordinator. After receiving a fellowship grant from the German Research Foundation (DFG) in 2012, she subsequently moved to Jonathan Coleman’s groups at Trinity College Dublin, Ireland. In 2015, she returned to Germany and started her independent junior research group at the Chair of Applied Physical Chemistry at the University of Heidelberg. In 2016, she received the highly prestigious Emmy-Noether funding from the DFG. To date, she has published more than 45 papers in peer-reviewed journals, a book chapter and a book.

Synthetic Two-Dimensional Materials: A New Paradigm for Optoelectronics and Energy Technologies

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In the past decade, as inspired by the discovery of graphene, two-dimensional (2D) materials which possess a periodic network structure and with a topographical thickness of atomic/molecular level, have emerged as the new paradigm of materials with enormous potentials, ranging from electronics and optoelectronics to energy technology, membrane, sensing and biomedical applications. Various fabrication strategies have been developed to attain high quality 2D materials. Among of them, mechanical exfoliation remains the most popular protocol to isolate single-layer high quality 2D materials for fundamental physical studies. In contrast to the tremendous exploration of graphene and 2D inorganic materials such as metal dichalcogenides, metal oxides and nitrides, the study on 2D soft material systems including the bottom-up organic synthesis of graphene, 2D metal-organic frameworks, 2D polymers/supramolecular polymers as well as supramolecular approach to 2D organic nanostructures remains under development.

In this lecture, we will present our recent efforts on the bottom-up synthetic approaches towards novel 2D conducting polymers and supramolecular polymers with structural control at the atomic/molecular-level or at the meso-scale. First, we will briefly discuss the latest development on the synthesis of graphene nanostructures (nanoribbons) with atomically precise structures. Both solution and on-surface synthesis approaches have been established to fabricate planar graphene nanoribbons upon intramolecular cyclodehydrogenation of corresponding dendritic polyphenylene precursors. Second, we will demonstrate the synthetic 2D conjugated polymers including 2D Schiff-base type polymers and 2D metal-dithienene/diamine coordination supramolecular polymers at air-water and liquid-liquid interfaces. The resulting 2D conjugated polymers exhibit single-layer feature, good local structural ordering and with a size of cm^2. The functional exploration of such 2D single-layer conjugated polymers for the electrical and mechanical properties, as well as serving as efficient electrocatalytic water splitting catalysts will be demonstrated. Third, we will introduce the self-assembly of a host–guest enhanced donor–acceptor interaction, consisting of a tris(methoxynaphthyl)-substituted truxene spacer, and a naphthalene diimide substituted with N-methyl viologenyl moieties as donor and acceptor monomers, respectively, in combination with cucurbit[8]uril as host monomer toward monolayers of an unprecedented 2D supramolecular polymers at liquid-liquid interface. Finally, we will present the supramolecular approaches to 2D conducting polymers, such as polypyrrole and

polyaniline nanosheets featuring 2D structures and with adjustable mesopores with/without on various functional free-standing surfaces. The unique structure with adjustable pore sizes (5–20 nm) and thickness (35–45 nm), enlarged specific surface area as well as high electrical conductivity make 2D conducting polymers promising for a number of applications.

Nature. **2016**, 531, 489-492; Angew. Chem. Int. Ed. **2016**, DOI: 10.1002/anie.201606988R1; Adv. Mater. **2016**, online; J. Am. Chem. Soc. **2015**, 137, 14525-14532 ; Nature Comm. **2015**, 6, 8817 ; Angew. Chem. Int. Ed. **2015**, 54, 12058-12063; Chem. Soc. Rev. **2015**, 2015, 44, 6616-6643 ; Adv. Mater. **2015**, 27, 403-427.

Biographical sketch

Xinliang Feng is a full professor at Technical University of Dresden. He received his Bachelor's degree in analytic chemistry in 2001 and Master's degree in organic chemistry in 2004. Then he joined Prof. Klaus Müllen's group at the Max Planck Institute for Polymer Research for PhD thesis, where he obtained his PhD degree in April 2008. In December 2007 he was appointed as a group leader at the Max-Planck Institute for Polymer Research, and in 2012 he became a distinguished group leader at the Max-Planck Institute for Polymer Research.

His current scientific interests include graphene, synthetic two-dimensional materials, organic conjugated materials, and carbon-rich molecules and materials for electronic and energy-related applications. He has published more than 280 research articles which have attracted more than 14000 citations with H-index of 60.

He has been awarded several prestigious prizes such as IUPAC Prize for Young Chemists (2009), Finalist of 3rd European Young Chemist Award, European Research Council (ERC) Starting Grant Award (2012), Journal of Materials Chemistry Lectureship Award (2013), ChemComm Emerging Investigator Lectureship (2014), Highly Cited Researcher (Thomson Reuters, 2014, 2015), Fellow of the Royal Society of Chemistry (FRSC, 2014).

He is an Advisory Board Member for Advanced Materials, Journal of Materials Chemistry A, and Chemistry -An Asian Journal. He is also one of the Working Package Leaders for European commission's pilot project Graphene Flagship.

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