Nano Reference List

Quantum Dots


- Professor Hui-Li Li, Engineering Research Center for Nanophotonics & Advanced Instrument, Ministry of Education, Department of Physics, East China Normal University, Shanghai, China
- Synthesized via a green microwave method
- Quantum dots absorbed strongly in the blue light region and emitted in the red light region with a maximum quantum yield of 40%


- Matthew C. Beard at the National Renewable Energy Laboratory, Chemical and Materials Sciences Center, Golden, CO
- Quantum-dot dimers synthesized in a CEM Discover S-class microwave
- Synthesized by oriented attachment of quantum dot monomers
- Able to correlate dimer splitting with quantum dot monomer size


- Professor Dirk M. Guldi, Department of Chemistry and Pharmacy & Interdisciplinary Center for Molecular Materials (ICMM), Friedrich-Alexander-Universitat Erlangen-Nurnberg, Germany
- Synthesis of carbon nanodots in a microwave reactor
- Formation of carbon nanodots with consistent optical properties


- Professors Delmar S. Larsen and Susan M. Kauzlarich, Department of Chemistry, University of California, Davis
- Researchers synthesized silicon quantum dots (QDs) in as little as 12 minutes under microwave conditions as opposed to conventional syntheses which take days
- Methodology proved to be efficient and reproducible
- Si QDs could be tuned to optimize the charge-transfer process, alluding to possible applications in multicomponent systems and optoelectronics


- CdSe core shell dots were synthesized in a Discover microwave at 60 - 180 °C for only two minutes
- Cd(CIO4)2, MeNCSeNH2, Zn(CIO4)2, MeCSNH2 were used as core and shell sources with water as the solvent
- Higher temperatures produced bigger dots with a higher quantum yield. \( \lambda_{\text{abs}} \) from 490 - 580 nm, depending on [Cd]:[Se] ratio
- Quantum yield drastically improved from shelling


- Scientist from IBM Almaden Research Center and The National Nanotechnology Center and the Petrochemicals Research Institute in Riyadh Saudi Arabia prepared monodispersed CdTe quantum dots
- CdO and TeTBP (tributylphosphine) were combined in the presence of tetradecylphosphonic acid in octadecene.
- The contents were heated in a CEM Discover® microwave with 300 W fixed power to temperatures ranging from 180-280 °C for 1-90 min
- The high quality crystals were monodispersed with a size distribution of less than 5%
- Tunable emission spectra (516 nm to 650 nm) by varying reaction time and temperature
- Highly reproducible microwave assisted method for preparing CdTe nanocrystals


- Professor Danzhen Li at the Research Institute of Photocatalysis, State Key Laboratory Breeding Base of Photocatalysis, Fuzhou University
- TEM showed MW method gave a more homogeneous nanorod compared to conventional heating
- Precursors heated to 140 - 160 °C for only 10 min
- Nanorods were monodispersed with diameters of 10 nm
- MW sample had higher surface area and faster conversion of methy orange degradation
   - Professor Prabir Dutta, Department of Chemistry and Pathology, The Ohio State University
   - One-pot synthesis of CdSe/ZnS core/shell quantum dots using readily available and cheap starting material in water
   - CdSe nanocrystals from NaHse and Cd-MPA (3-mercaptopropionic acid) were heated in a MARS digestion vessel with Zn(NH3)2+ solutions at 140 - 170 °C for 45 - 120 min to give 5 nm particles
   - MW synthesized QDs at 20 nM were readily detected within the macrophages after 20 min of incubation

   - Professor Geoffrey Strouse, Department of Chemistry and Biochemistry, Florida State University
   - Through selective microwave absorption, they demonstrate the ability to activate TOPS as an efficient sulfur donor, allowing the rapid (18 m growth of highly emissive (PLQY=33%), Zn blended CdS quantum dots (QDs) passivated by TOP/TOPS in the 4-6 nm size regime (5% size dispersity)
   - The CdS QDs exhibited sharp absorption features and band edge photoluminescence even for the largest CdS sample
   - The use of MW chemistry for QD formation allows a highly reproducible synthetic protocol that is fully adaptable to industrial applications

    - Professor Geoffrey Strouse, Department of Chemistry and Biochemistry, Florida State University
    - The selectivity of the MW reactions is demonstrated by the ability to generate multiple, different sized QDs in the same reaction, where each QD component exhibits 6-7% size dispersity
    - The number of QDs in solution translates to color saturation (intensity), and the size of the QD translated to color index and is completely controlled by temperature and concentration in the MW reaction
    - This approach offered a great deal of control of particle size and particles were very monodispersed shorter reaction times when compared to conventional reactions

    - Professor Geoffrey Strouse, Florida State University, Department of Chemistry
    - Manganese doping used to probe efficiency of CdSe quantum dot micro-environments
    - Quantum dots were synthesized in only 30s at 220 °C under an increased pressure

    - Professor Wei Huang and Lian-Hui Wang at the Institute of Advanced Materials, Fudan University
    - Synthesized CdTe/CdS/ZnS (this is a QD with a CdTe center, encased in a layer of CdS, followed by an outer layer of ZnS) QDs using MW irradiation
      - CdTe MW, 100 °C, 1 min
      - CdTe/CdS MW, 100 °C, 5 min
      - CdTe/CdS/ZnS, MW, 60 °C, 5 min. Final size of 3.4 - 4.5 nm.
      - Quantum Yield increased drastically from CdTe (30%) to CdTe/CdS/ZnS (80%)
      - This was the first example of water dispersed QDs that are made in water -which was assisted by MW irradiation

    - Dr. Matthew Becker Polymers Division and Surface and Microanalysis Science Division, National Institute of Standards and Technology
    - Water soluble CdSe/ZnS nanoparticles with emission maxima from 511 nm to 596 nm and quantum efficiencies ranging from 11% to 28% were synthesized using MW irradiation
    - Particle size controlled by heating times. Reactions were run at lower temperatures (145 - 150 °C) under ambient atmosphere with shorter reaction times when compared to conventional reactions
    - This approach offered a great deal of control of particle size and particles were very monodispersed

    - Professor Geoffrey Strouse, Florida State University, Department of Chemistry
    - Used MW irradiation and fluorinated ionic liquids to etch InP nanoparticles. Conventional procedure required HF. This technique eliminates the need for HF, making it much safer and more practical
    - 280 °C, 300 W, times of 70 s to 20 min

    - Professor Geoffrey Strouse, Florida State University, Department of Chemistry
    - Synthesis of CdSe and CdTe quantum dots
      - Were found to be temperature, time, and power dependent in the presence of an Ionic Liquid and minohexadecane (strong MW absorbing solvents)
      - Temperature and time dependent in non MW absorbing solvents
      - By varying the reaction temperature, time, power, or a combination of both, Strouse and co-workers were successful in controlling particles size and quantum yields
      - Typical diameters were 2.3 - 5 nm, depending on power, temperature, and time
      - Typical Temperatures were 180 - 280 °C, time ranging from 30 - 600 sec, power 67 - 400 W
Higher temperatures and longer reaction times lead to larger particles with lower quantum yields. The higher the power the faster the ramp to temperature which resulted in a higher quality QD. Cooling at the end of this reaction played a crucial role in QD size. Slow cooling from the reaction temperature to ambient conditions resulted in larger size dispersity.


Inorganic Nanomaterial


   - Professor Mathew M. Maye, Department of Chemistry, Syracuse University
   - Researchers used a CEM Discover to rapidly synthesize core/ally nanoparticles with subnanometer precision
   - Microwave heating allowed for precise and reproducible control of particle size

   - Professor Simon M. Humphrey, Department of Chemistry and Biochemistry, The University of Texas at Austin
   - Thorough study compared conventional and microwave syntheses of Rh, Pd, and Pt nanoparticles by a new one-pot method
   - When compared to conventional heating methods, the microwave methodology was completed at lower temperatures and in shorter times

   - Professor Susan Kauzlarich, Department of Chemistry, The University of California Davis
   - In a CEM Discover, researchers developed a simple and safe way to synthesize Ge nanoparticles
   - Unique top-down synthesis forms particles smaller in less than 5 minutes using a CEM Discover microwave

   - Dr. Rajender Varma, National Risk Management Research Laboratory, U.S. Environmental Protection Agency
   - Novel approach to nanoparticles uses beet juice as a reducing agent to form AgCl/Ag nanoparticles
   - The material was incorporated into a novel solid-state battery architecture capable of reversible, four electron storage

   - Professor Se-Hee Lee, Department of Mechanical Engineering, University of Colorado at Boulder
   - Pyrite (FeS2) was synthesized using a CEM Discover SP
   - The material was incorporated into a novel solid-state battery architecture capable of reversible, four electron storage

   - Professor John B. Goodenough, Texas Materials Institute, University of Texas at Austin
   - LifePO4 was synthesized in only 15 minutes in a CEM MARS
   - The sample was used to probe the chemical bonding surface features

   - Drs. Giorgia Brancolini and Stefano Corni, Center S3, CNR Institute Nanoscience
   - Gold nanoparticles for this study were synthesized by Turkevich method, using the open vessel feature of the CEM Discover
   - Ubiquitin binding was studied using ab initio calculations and experimental data to construct a model for nanoparticle/protein interaction

   - Professor Miao Yu, Department of Chemical and Biological Engineering, University of Colorado
   - Using a CEM MARS with Teflon vessels, SAPO-34 zeolite seed crystals were prepared for membrane synthesis
   - Composite membranes showed much higher ability to separate H2 from N2 and CO2 than conventional SAPO-34 membranes

   - Dr. Tuyang Sun, Center for Nanoscale Materials, Argonne National Laboratory
   - Using a CEM Discover, scientists synthesized a varied of MnO2 nanostructures with possible applications in batteries
   - Further investigation revealed the role of the two-step Ostwald ripening process in the transitions between morphologies

   - Professor Marc Armbrüster, Max-Planck Institute, Germany
   - BiRh nanoparticles were synthesized using a CEM MARS with Teflon vessels after 1 hour of heating at 220 °C
   - Unsupported BiRh nanoparticles displayed excellent selectivity for the semi-hydrogenation of acetylene

- Professor Shu-Hong Yu, Division of Materials & Chemistry, Hefei National Laboratory for Physical Sciences at Microscale, The School of Chemistry & Materials, University of Science and Technology of China
- Silver nanoparticles were synthesized by microwave irradiation in 10 s at 150 °C
- Resultant particles were dimerized then incorporated into poly vinyl alcohol polymer, which was electrospun and cast into a film
- Superior performance as compared to other conventional surface-enhanced Raman scattering (SERS) substrates makes material perfect choice for practical SERS detection


- Professor Sumanta Kumar Meher, Department of Chemistry, Indian Institute of Technology Madras
- Co3O4 nanowires were synthesized comparing conventional-reflux and microwave assisted methods
- Reflux samples required 12 h at 120 °C to reach completion while the microwave nanowires were synthesized in only 15 minutes at the same temperature
- Lower-dimensional Co3O4 nanowires which displayed superior surface properties were created using the conventional method while the higher-dimension order of the microwave nanowires showed better high rate cyclic stability


- Professor Angelique Y. Louie, Department of Chemistry, University of California, Davis
- Dextran coated, iron oxide nanoparticles were synthesized and doped with Cu or 64Cu
- Microwave synthesis was complete in as little as 5 minutes, using both time and power controls to tune the size of the particles
- Conventional methods normally require 2 hours of heating at reflux, and can often lead to significant decay of radiolabeled products


- Dr. Luigi Calzolai, European Commission, Joint Research Centre
- Gold nanoparticles synthesized by Turkevich method in 20 min / silver nanoparticles were synthesized in only 5 min
- Nanoparticles used to probe structure and stability changes to proteins interacting with the particles
- Synchrotron radiation circular dichroism (SRCD) used to acquire experimental data about nanotoxicology for key biological proteins


- Professor Ganpati Ramanath, Rensselaer Polytechnic Institute
- Microwave synthesis was used to create sulfur doped, antimony telluride nanostructures
- Sulfur doping resulted in a thermoelectric figure of merit (2T) three times higher than non-doped materials


- Dr. Charlotte Martineau, Tectospin · Institut Lavoisier de Versailles
- Aluminum cloverite compound LUIH-2 was synthesized by microwave irradiation at 160 °C for 1 hour
- Nonperiodic subnetworks of the cloverite were characterized using novel NMR crystallography techniques
- Combination of PXRD and NMR crystallography approaches provided insight into the key steps for crystal formation for porous solids


- Professors Juan Antonio Zapien and Igor Bello, Department of Physics and Materials Science and Center of Super-Diamond and Advanced Films (COSDAF), City University of Hong Kong
- Porous TiO2 nanospheres constructed in only 10 minutes by microwave synthesis in a CEM Discover
- Products displayed good morphology and better electrochemical efficiency than commercially available nanopowders


- Professor Kenneth H. Sandhage, School of Materials Science and Engineering, Georgia Institute of Technology
- A layer-by-layer surface sol-gel process was used to convert the structure of Morpho helenor butterfly wings to BiTiO3 replicas
- CEM MARS used for the final step, microwave hydrothermal conversion of anatase TiO2 to BiTiO3
- The general process can be applied to microscale nanostructured bioorganic or synthetic organic templates


- Professor Ganpati Ramanath, Rensselaer Polytechnic Institute, Department of Materials Science and Engineering
- One-dimensional nanocrystals of sulfurized antimony selenide were synthesized in a rapid and scalable manner
- 1010-1012 times higher electrical conductivity than non-nanostructured bulk or thin film forms
- Control of microwave heating times showed changes in wire morphology


- Professor Yushan Yan, Department of Chemical and Environmental Engineering, University of California Riverside
- CEM MARS used to heat dry gel precursor (DGP) in an ionic liquid

   - Method combines benefits of ionothermal synthesis, dry-gel conversion, and microwave irradiation to produce MFI zeolite crystals in a fast and efficient manner


   - Professor Thomas Nann, School of Chemistry, University of East Anglia, Norwich
   - Nanocrystals consisting of different ratios of Na, Er, Y, and Li were synthesized
   - A microwave assisted synthesis approach allows for the synthesis of such monodisperse and luminescent upconverting nanocrystals within 5 min in a closed reaction vessel (even though the same reactants and solvents as with classical conductive heating reactions were used)
   - Microwave-assisted synthesis resulted in differently sized and shaped particles and provided superior reaction control. The nucleation and growth mechanism follows a La Mer scheme and can be controlled extremely accurately

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   - Professor Geoffrey F. Strouse, Department of Chemistry and Biochemistry, Florida State University
   - Eu(III) - doped Y2O3 nanocrystals were synthesized in only 15 minutes at 240 °C, drastically more efficient than conventional hydrothermal methods (1-12h)
   - Excitation of surface passivated acetylacetone (acac) led to a strong white light emission, competitive with current commercial lighting
   - Provides a novel method to use acac as a molecular antenna for efficient energy transfer


   - Professor Sridhar Komarneni, Materials Research Institute, The Pennsylvania State University
   - Common biomolecule templates (amino acids, peptides, proteins, etc.) used as templates for complex and varied CdS nanorod based structures
   - Using a CEM MARS, reactions were completed at 160 °C in only 1 hour while conventional methods required 15 hours at the same temperature
   - Varied 3-D and 2-D morphologies were seen to correspond to the used biomolecules' type and structure


   - Varma at the EPA developed rapid, green synthesis of Ag, Pt, Pd, and Cu nanoparticles in Glutathione (benign antioxidant)
   - Reaction time of 30 - 60 sec at 50 W for Ag, and 45 - 60 sec at 75 W for Pt, Pd, and Cu
   - Completed at very low temperatures: 40 - 60 °C. Conventional temperatures > 150 °C
   - Monodispersed particles of 5 - 10 nm


   - Professor Narayanan Ravishankar, Materials Research Centre and Department of Chemical Engineering, Indian Institute of Science
   - This paper studies the thermodynamic and kinetic aspects of metal salt reduction to identify optimal conditions for homogeneous metal nucleation using a CEM MARS
   - Metal particles undergo selective nucleation to solid support surfaces using microwave irradiation with a uniform distribution of Pt on CeO2 and TiO2 supports
   - Microwave synthesized catalysts showed greater reactivity than previously synthesized supported catalysts


   - Professor Henk Bolink, Institute of Molecular Science at the University of Valencia
   - The title compound was prepared in a CEM Discover in only 5 minutes with a yield of 89% as compared to conventional reactions which can take days and generate <5% desired product
   - Ru(dpp)2+ incorporated into electrochemical cells demonstrating a high power efficiency of 1.9 Lum/W and luminous brightness of 390 cd/m²


   - Professor Jung-Kun Lee, Department of Mechanical Engineering and Materials Science, University of Pittsburgh
   - In a CEM MARS, microwave heating was used in conjunction with hydrothermal methods to synthesize TiO2 nanorods
   - Combination of methods resulted in longer nanorods in less time (100 minutes) than conventional hydrothermal methods (>20 hours)


   - Professor Markus Niederberger, Laboratory for Multifunctional Materials, Department of Materials, ETH Zurich
Comparison of the microwave mediated route with conventional heating showed that microwave irradiation greatly accelerates nanoparticle formation by:
- facilitating the dissolution of the precursor in the solvent
- increasing the rate constants for the esterification reaction by 1 order of magnitude, resulting in faster production of monomer and consequently in an earlier nucleation event
- increasing the rate constants k growth for the crystal growth from 3.9 nm/min (conventional heating) to 15.4 nm/min (microwave heating)

- Professor Jun Lin at the State Key Laboratory of Rare Earth Resource Utilization, Changchun Institute of Applied Chemistry, Academy of Sciences in collaboration with Graduate University of the Chinese Academy of Sciences
- One step route to colloidal KMgF3 nanocrystals via thermolysis using MW irradiation.
- Shape of nanocrystals readily controlled resulting in the well defined near-spherical nanoparticles and nano-plates of cubic-phased KMgF3 and nanorods of tetragonal-phased MgF2.
- Substrates heated in MW at 100 °C for 10 min under inert atmosphere, then 290 °C for 30 min.
- Morphology and size were controlled by changing the heating temperature, time, and by altering the ratio of surfactants

- Xianluo Hu and Professor Jimmy Yu. Key Laboratory of Pesticide and Chemical Biology of Ministry of Education, College of Chemistry Central China Normal University with the Department of Chemistry, The Chinese University of Hong Kong
- Reaction is run under open vessel conditions - the NP size is directly controlled by the amount of Zn Acetate stock solution added
- Open vessel allows Zn solution to be added during the reaction-this was crucial for monodispersed nanoparticle formation
- Small ZnO nuclei are generated by the rapid MW induced hydrolysis of Zn2+ and dehydration of resulting Zn complexes at 180 deg C. This is achieved by the polar, and thus strong microwave absorbing, characteristic of Zn and ZnO, creating a super hot surface speeding up nanocrystal growth

- Raj Varma at EPA synthesized Ag and Fe nanorods and nanoparticles using MW.
- Also synthesized Ag supported Pt nanocubes
- 100 °C for 1 h. Same conditions with conventional heating yielded no product at all
- Morphology controlled by ratio of solvent (PEG) to metal precursor

- Professor Yu, Division of Nanomaterials and Chemistry and Hefei National Laboratory for Physical Sciences at Microscale, the School of Chemistry and Materials, University of Science and Technology of China
- Synthesized uniform Ag nanoparticles using water, soluble starch (dextrin) as a protecting agent, and basic amino acids L-lysine and L-arginine as mild, renewable, and nontoxic reducing agents.
- The reaction was heated using microwave irradiation to 150 deg C and held for 10 s. The authors noted that higher power settings lead to smaller nanoparticles. This could be due to faster ramp times, therefore decreasing the total crystal growth time, or that the higher energy could promote he generation of more nuclei
- Using MW irradiation shortened the reaction time by 2-3 orders of magnitude when compared to conventional hydrothermal methods.
- Recovered nanoparticles were more uniform in dimension than their conventional partners

- Professor Steven Suib, Department of Chemistry and Department of Chemical, Materials and Biomolecular Engineering. University of Connecticut
- Typical reaction conditions using an oil bath require anywhere from hours to days, multiple procedures under hydrothermal and refluxing conditions, and generally have no direct control of nanoparticle size and surface area-which play a crucial role in determining the catalytic properties of the material
- Developed a systematic approach to control particle size by using MW irradiation and varying the amount of co-solvent (DMSO) from 0 - 50% v/v in water
- Microwave irradiation formed nanofibers, ranging from 4 - 12.2 nm. These results could not be duplicated using an oil bath. No ordered nanoparticles were recovered after 90 min of reflux using conventional heating methods and poorly ordered manganese oxide with particle diameter of around 100 nm formed at room temperature. Well-formed needle-like fibers were only formed with the addition of microwave irradiation. The needle diameter was varied by changing the ratio of solvent to co-solvent

- Professor Ganpati Ramanath, Materials Science and Engineering Department, Rensselaer Nanotechnology Center, Rensselaer Polytechnic Institute
- ZnO nanocrystals doped with aluminum were synthesized using the CEM Discover
- These crystals display enhanced thermoelectric properties and can be prepared in a rapid and scalable fashion using microwave irradiation
- Pressed and sintered nanocrystals possess a high ZT for possible applications in low-cost waste heat harvesting

- Professor Thierry Liseau, Unité Catalyse et Chimie du Solide (UCCs), Université de Lille Nord de France
Magnetic Metal Materials


Organic Nanostructures


- Professors Marcelo O. Rodrigues and Severino A. Júnior, Instituto de Química, Universidade de Brasília
- A Tb/Eu organic framework was synthesized in 10 min using the CEM Discover
- Experimental and theoretical data from this study contributed to a more complete understanding of Tb → Eu energy transfer


- Professor Laurence D. Melton, Riddet Institute and School of Chemical Sciences, University of Auckland
- Researchers performed identical conventional heating and microwave reactions to induce the self-assembly of B-lg nanofibrils
- After only 2 h, microwave heating furnished yields that required 16 h of conventional heating
- Microwave synthesized nanofibrils were composited into secondary organization into β-sheets with higher surface hydrophobicity than their conventionally synthesized counterparts


- Professor Andrew Cooper, University of Liverpool, Department of Chemistry and Centre for Materials
- Using the CEM Discover with camera accessory, researchers synthesized porous organic polymers (POPs) in 30 min
- Conventional reaction procedure requires an overnight reaction
- Materials exhibit BET surfaces exceeding 1100 m²g⁻¹ and exceptional CO₂ capacities up to 4.17 mmol g⁻¹


- Professor Pascal Van Der Voort, Center for Ordered Materials, Organometallics and Catalysis, Department of Inorganic and Physical Chemistry, Ghent University
- Researchers synthesized a vanadium based metal organic framework (MOF) capable of controllable pore deformation at different temperatures
- The “breathing” effect of pore shape changes predictably alters the sorption behavior towards gases such as CO₂ and CH₄
- The flexibility of the MOF was dependent on the ratio of VIV to V⁰ found in the framework


- Professor Huixin He, Chemistry Department, Rutgers University
- Simply method uses nitronium ions generated from 1:1 nitric acid:sulfuric acid and microwave irradiation to produce large, highly conductive graphene sheets from graphite powder
- Sheets are produced in only 30 seconds in the microwave, while conventional methods result in over oxidation to graphene oxide
- Dispersions are clean and well separated as opposed to established Hummer’s method


- Professor Timothy M. Swager, Department of Chemistry, Massachusetts Institute of Technology
- Silver/poly(aryl ether) (PAE) nanoparticles were synthesized using varied microwave pulses
- Resultant structures showed good uniformity and could be synthesized in as quickly as 5 minutes
- Ag/PAE particles were then incorporated into an insulating polymer matrix resulting in a “relatively uniform polymer-ion thin film”


- Professor Andre E. Nel, Division of NanoMedicine, Department of Medicine, and California NanoSystems Institute, UCLA
- CEM MARS used for purification and functionalization of multiwalled carbon nanotubes (MWCNT)
- Modified nanotubes used to assay dispersion of MWCNT in tissue culture media
- It was determined that hydrophobicity is the major factor determining agglomeration


- Professor Klaus Müller, Max-Planck-Institut für Polymerforschung
- Researchers detail a bottom-up organic synthesis of defect-free graphene nanoribbons
- Microwave irradiation was used to construct polymer precursors which were efficiently converted to graphene nanoribbons by an intramolecular Scholl reaction


- Scientist at MIT synthesized metal organic frameworks (MOFs) directly on polyacrylonitrile using microwave irradiation
- Growth of MOF was studied by varying microwave irradiation time
- Reagents were heated in DI water to 200 °C for 5 s to 30 min
- MOF agglomerates formed on the polymer after just 5 s of MW irradiation. The MOFs were only found on the polymer and not in the bulk solution
- Provides rapid, reproducible method to coat polymer fibers with MOFs

- Prof. V. Maisonneuve and Dr. M. Bujoli-Doeuff, Faculté des Sciences et Techniques, Université du Maine and IMN, France
- A unique UV absorber with the structure [Hgua]2•(Ti5O5F12) was synthesized using microwave hydrothermal synthesis
- Heating materials in a CEM MARS with Teflon vessels to 190 °C for 1 hour generated the desired product efficiently
- Investigations of the atomic, optical, and electrical properties show that this hybrid may have unique applications for UV shielding


- Scientist at MIT presented a microwave synthesis of MIL-47 and 6 new vanadium MOF’s
- Precursors were heated to 200 °C for only 10 min
- Represents a very fast and reproducible method for MOF’s


- Doctor Jeffrey Blackburn, National Renewable Energy Laboratory, Colorado
- Only two minutes of microwave irradiation at 250 W were required to deposit Ru nanoparticles on a high surface area carbon monolith
- Ru decorated carbon and spectroscopic methods were used experimentally confirm hydrogen spillover phenomena responsible for reversible hydrogen storage in fuel cells


- Professor Jeffrey Long, Department of Chemistry, University of California, Berkeley
- Researchers created two new Zn and Mg metal organic frameworks (MOFs) using a combination of solvothermal and microwave assisted methods, related to MOF-74
- The microwave synthesis of Mg2(dobpdc)(DEF)2•DEF•H2O (DEF-2) was complete in only 30 minutes
- DEF-2 was functionalized with N,N-dimethylhexaniamine to afford a material with exceptional CO2 capture properties


- Dr. Nikos Tagmatarchis at the Theoretical and Physical Chemistry Institute- National Hellenic Research Foundation (Athens, Greece) and in collaboration with the Nanotube Research Center, National Institute of Advanced Industrial Science and Technology(Higashi, Japan) and NEC Corporation(Ibaraki, Japan)
- Functionalized carbon nano-horns with fluorine-containing linkers through Bingel reaction without solvent
- MW irradiation provided a high degree of functionalization
- Pulse method: 5 - 45 second of MW irradiation was used. Total reaction time of 5 min with a max temp of 120 - 140 °C
- Conventional synthesis: 60 °C for 20 h


- Professor Makoto Fujita, Department of Applied Chemistry, School of Engineering, The University of Tokyo, and CREST, Japan Science and Technology Agency
- Researchers used solvent conditions and metal ion selection to control geometry and self-assembly of spherical complexes
- Previous syntheses of complexes required 4h or more of reaction time under conventional conditions; microwave reactions complete in 30 minutes or less


- Professor Jim Yang Lee, Department of Chemical and Biomolecular Engineering, National University of Singapore
- SnO2 nanoparticles prepared with microwave heating showed uniform dispersion and no agglomeration on carbon hollow sphere surface as compared to conventional heating methods
- Microwave synthesis completed in only 3 minutes; conventional heating required 3 hours
- Electrochemical testing of different products demonstrated potential applications of tin composite nanostructures in Li-ion storage


- Professor Chio-Liang Sun, Department of Chemical and Materials Engineering, Chang Gung University
- Microwave irradiation used to “unzip” multiwalled carbon nanotubes (MWCNTs) upon treatment with strong acids and KMnO4, forming graphene oxide nanoribbons
- Reactions were completed in only 6 minutes, much shorter than previously reported literature examples
- Composite core-shell MWCNT/GONR materials exhibited electrochemical properties exceeding the efficiency of MWCNTs and graphene alone


- Professor Andrew Cooper at University of Liverpool - Dept of Chemistry and materials discovery
- MW irradiation offered a convenient and rapid synthesis of covalent organic frameworks.
- 200 times faster than conventional methods
- Reactions were run in closed vessel and open vessel format at 100 °C, 200W
- Reaction times as low as 20 min
   - Dr. Nikos Tagmatarchis, Theoretical and Physical Chemistry Institute, National Hellenic Research Foundation
   - Used MW to multi-functionalize graphene
   - Series of electrochemical, spectroscopic, gravimetric, and thermal experiments performed to fully characterize new material

   - Professor Maurizio Prato and Professor Ester Vazquez. Universita degli Studi di Trieste and Universidad de Castilla-La Mancha
   - Used MW to multi-functionalize CNTs
   - Conventional conditions generally require high temperatures and/or pressures, long reaction times, and organic solvents or mineral acids
   - MW reduced amount of organic waste, and reduced the reaction time from 5 days to 2.5 hours.
   - Typical temperatures for [3+2] cycloaddition step was 160 oC for 90 min (100 W), and no solvent, the reaction was done under neat conditions. Ame addition step: 80 oC,90 min (100 W) and in water

   - See previous reference

   - Professor Wei Zhang, Department of Chemistry and Biochemistry, University of Colorado, Boulder
   - CEM Discover used to perform Sonogashira couplings of three dimensional cage building blocks
   - After microwave irradiation at 100 °C for 1 h, resulted in novel organic framework useful in gas separation
   - Material demonstrated high (213/1) selectivity for adsorption of CO2 over N2

Reviews