Polymer Reference List

Transition Metal Coupling Polymerizations

   - Professor R.B. Grubbs, Center for Functional Nanomaterials, Brookhaven National Laboratory, Upton, NY
   - Polymer could be synthesized in a microwave through ipso arylative, Stille coupling or Suzuki coupling polymerization
   - Polymers absorb light of longer wavelengths in comparison to the thiophene analog

   - Professor Jian Pei at Beijing National Laboratory for Molecular Sciences, College of Chemistry and Molecular Engineering, Peking University
   - Rapid electron transport in a polymer under ambient conditions
   - By incorporating electron withdrawing groups into poly(p-phenylene vinylene) they were able to increase electron mobility
   - Palladium catalyzed Stille coupling polymerization

   - Professor Guillermo Bazan, Center for Polymers and Organic Solids and Department of Chemistry and Biochemistry, UCSB, Santa Barbara
   - Microwave-assisted Stille coupling polymerization for the synthesis of highly thermally stable semiconductors
   - Polymer was synthesized in under an hour using a step-wise heating process
   - Substitution of fluorine into the backbone produced controllable thermal stability and phase transition temperatures

   - Professor Martin Heeney, Department of Chemistry and Centre for Plastic Electronics, Imperial College London
   - Microwave-assisted Stille coupling polymerization
   - Three polymers differing only in side chain synthesized reveal significant changes in optoelectronic and aggregation properties

   - Professor Wei You, Department of Chemistry, University of North Carolina at Chapel Hill
   - Using a CEM Discover® , researchers performed the synthesis of a number of fluorinated BnDT-DTBT polymers via microwave-assisted Stille coupling polymerization
   - The electrical properties of varied fluorine substituted polymers were investigated

   - Professors Hon Hang Fong, Zhenan Bao, and Mingqian He - Polymerization reactions were completed using a CEM Discover® or CEM MARS
   - Up to 100 g quantities of the title polymer were synthesized by a Pd catalyzed Stille coupling polymerization
   - This polymer was incorporated into a thin film transistor with hole mobilities in excess of 2 cm²/V·s

   - Doctors ShaoFeng Lu and Antonio Facchetti, Polyera Corporation
   - A number of 3,6-dithiophen-2-yl-diketopyrrolo[3,2-b]pyrrole (isoDPPT) copolymers were synthesized by microwave irradiation
   - These new polymers hole mobility of up to 0.03 cm²/(Vs) and solar cell power conversion efficiency (PCE) of 5.1%

   - Professor Zhenan Bao, Department of Chemical Engineering, Stanford University
   - Synthesized isoindigio based polymers with siloxane-terminated side chain utilizing the CEM Discover® “power cycling” method
   - As compared to a reference polymer, the synthesized polymer exhibited almost a ten-fold increase in average hole mobility when incorporated into a thin film transistor
   - The more efficient average conductivity is attributed to a shorter π-π stacking distance
   - Professor Ulrich Scherf, Max-Planck-Institute for Polymer Research
   - Substituted chiral 9-alkyl-9-alkylfluorene monomers were heated for 12 min at 120 °C in a CEM Discover® to furnish either atactic or isotactic polymers
   - Physical and chemical properties of each sample were investigated, displaying characteristics consistent with each type of polymer.

   - Professor Wei You, Department of Chemistry, University of North Carolina at Chapel Hill
   - Using previously established methodologies (see 10.1021/ja1112595), a parallel-like bulk heterojunction (PBHJ) cell was synthesized which mimicked the efficacy of polymer tandem cells but offers the low cost of single junction cells
   - PBHJ devices demonstrate improvements of up to 40% in Jsc and 30% in overall efficiency.

   - Professor Avelino Corma, Instituto de Tecnología Química, UPV-CSIC
   - Researchers synthesized a porous polymeric aromatic framework (PPAF) through a Pd catalyzed Suzuki coupling
   - The (PPAF) was functionalized with acid and base active sites and used as a bifunctional catalyst.

   - Professor Christophe Detrembleur, Department of Chemistry, University of Liège
   - Poly(thiophene)-based multiblock copolymers were synthesized using a Ni catalyst and Grignard metathesis polymerization (GRIM)
   - Reaction was complete in a few hours at 80 °C conventionally, or in only 10 minutes at 120 °C in a CEM Discover®.

   - Professor Klaus Müllen, Max-Planck-Institute for Polymer Research
   - Researchers detail a bottom-up organic synthesis of defect-free graphene nanoribbons
   - Microwave-assisted Suzuki reaction was used to construct polymers which were efficiently converted to graphene nanoribbons by an intramolecular Scholl reaction.

   - Professor Wei You, Department of Chemistry, University of North Carolina at Chapel Hill
   - The CEM Discover® was used to polymerize benzotriazole(HTAZ/FTAZ)/benzodithiophene(BnDT) monomers and form two medium band gap copolymers
   - Resulting fluorinated polymer PBNDT-FTAZ exhibited efficiencies above 7% when combined with fullerences in a heterojunction
   - Synthesized polymers in a layer of 1 μm outperformed current polymers used for solar cells through high photovoltaic efficiency and a low band gap.

   - Professor J. Seixas de Melo, Department of Chemistry, University of Coimbra
   - Alternating binaphthyl-oligothiophene copolymers were synthesized by microwave-assisted Stille-type polymerizations
   - Spectral and photophysical properties investigations were carried out on four novel copolymers.

   - Researchers detail the synthesis of two low-band-gap polythiophenes, PCPDTTBTT and PCPDTQ
   - After preparation of the monomers, polymerization reaction are carried out in a CEM Discover® at 150 °C for only 15 min
   - While the PCPDTQ polymer did not produce efficient solar cells, a high power efficiency of 2.1% was found for a mixture of PCPDTTBTT and fullerene
   - The power efficiency was achieved through addition of a solvent additive which altered the phase mixing ratios.
   - Professor Klaus Müllen, Max-Planck-Institute for Polymer Research
   - Triphenylene derived monomers and polymers all synthesized using microwave irradiation
   - Novel co- and homopolymers formed through Suzuki-Miyaura and Yamamoto polycondensation reactions in a CEM Discover®
   - Emission spectrum of synthesized compounds show promising use in blue polymeric light emitting diodes

   - Drs. Jens Weber and Arne Thomas, Max Planck Institute of Colloids and Interfaces
   - Polymers based on spirobifluorene were synthesized in about 5 min at 145 °C using microwave irradiation
   - Conventional heating methods were plagued by long reaction times, lower yields, and specific surface area
   - The microporous, conjugated polymer networks have great potential for applications in organic electronics

   - Professor Wei You, Department of Chemistry, University of North Carolina at Chapel Hill
   - Utilizing a quinoid strategy, a series of polymers using thienothiophene (TT) monomers with various comonomers were synthesized using microwave irradiation and Stille coupling polymerizations
   - Polymerizations complete in only 20 min at 150 °C using a CEM Discover®
   - Incorporation of TT with any comonomer results in a small-band-gap polymer with applications in solar cells

   - Dr. Martin Baumgarten, Max Planck Institute for Polymer Research
   - Conjugated copolymers PPTQT and PTTQT were synthesized from thiadiazoloquinoxalines and thiophenes connected by ethynylene spacers; a Sonogashira cross-coupling strategy was used to combine monomers
   - Microwave heating PTQ and TTQ monomers at a low temperature resulted in polymer formation after only 100 min
   - Copolymers displayed electron and hole mobilities of 0.042 and 0.028 cm²/V s respectively, making them the first example of a triple bond containing polymer with ambipolar characteristics

Cationic Polymerizations

   - Professor Schacher, Organic and Macromolecular Chemistry, Friedrich Schiller University, Humboldtstr, Germany
   - Cationic ring opening polymerization and copolymerization of several oxazolines
   - Successful formation of block copolymers despite being insoluble in organic solvents

   - Professor Chen Department of Chemistry, Colorado State University, Fort Collins, CO
   - Polymerization of dimethacrylates to unsaturated polyesters
   - Termed proton(H) transfer polymerization (HTP)

   - Professors Marija R. Gizdavic-Nikolaidis and Zoran D. Zujovic, Department of Chemistry, University of Auckland
   - Copolymers of aniline and 2-aminobenzoic acid and 2-aminothiobenzoic acid were synthesized comparing conventional and microwave methods
   - Nanostructured functionalized copolymers synthesized by microwave were produced in a 2.5-3 times higher yield and exhibited a 2.1-2.4 times better radical scavenger ability than conventionally synthesized counterparts
   - Polymerization reactions were performed at room temperature in as little as 5 min
Acrylamido and acrylate monomers were used for microwave-assisted reversible addition-fragmentation chain transfer (RAFT) polymerizations. Using the CEM Discover® with camera accessory, researchers synthesized porous organic polymers (POPs) in 30 min. The products are predominantly microporous with surface areas of up to 1904 m$^2$/g. Microwave heated reactions proceeded much faster (as little as 2 min) than conventional reactions (50 min) with up to an apparent six-fold increase in reaction rate.

Low polydispersity and high molecular weights seen for all samples. Polymerizations formed block polymers after 3-4 h of heating at 120 ºC in toluene.

Polyphenylene ribbons were converted to large polyaromatic hydrocarbon (PAH) graphene-like sheets through a single cyclodehydrogenation. Successful chain extension under microwave irradiation revealed an ATRP mechanism. Polymerization proceeds much faster under microwave irradiation. Conventional reaction procedure requires an overnight reaction.


- Professor Dong-Pyo Kim, Department of Fine Chem. Eng. & Chemistry and Graduate School of Analytical Science and Technology, Chungnam National University
- Using a CEM MARS, scientists synthesized high molecular weight, low polydispersity polyvinylsilazane (PVSZ) by reversible addition-fragmentation chain transfer (RAFT) polymerization
- Microwave reactions resulted in higher molecular weight and higher yield than comparable conventional reactions
- Polymerizations formed block polymers after 3-4 h of heating at 120 ºC in toluene

Polymers of hypercrosslinked poly(vinyl-benzyl chloride) (HCPVBC) and dichloroxylene (DCX) were synthesized using microwave irradiation in 1 h. Researchers demonstrated a significant (100 fold) microwave time reduction as compared to conventional heating.

The electronic properties of these sheets make them candidates for future applications in electronic devices.
   - Professor Albert Demonceau, Laboratory of Macromolecular Chemistry and Organic Catalysis, University of Liège
   - Methyl methacrylate was polymerized by an atom transfer radical polymerization (ATRP) using microwave irradiation
   - At 120 ºC, a three-fold rate increase was seen as compared to the conventionally heated protocols
   - Higher temperatures resulted in an uncontrolled reaction, while under ideal conditions polymers of up to 30 kDa with a low polydispersity were synthesized in 3 h or less

   - Professor Zoran D. Zujovic at the School of Chemical Sciences, the University of Auckland
   - Synthesis of polyaniline by oxidative polymerization revealed relationships between conditions and molecular weight
   - Higher power levels resulted in higher molecular weight polymers in the same amount of time
   - Microwave-synthesized samples displayed higher conductivity and areas as compared to those made conventionally
   - Demonstrated use of microwaves to fine tune thermal and mechanical characteristics of polymers

   - Professor Derek Patton, University of Southern Mississippi, School of Polymers and High Performance Materials
   - Researchers synthesized N,N-dimethylacrylamide (DMA) and 2-hydroxyethyl acrylate (HEA) polymer brush surfaces on a functionalized silicon/glass wafer
   - Microwave reaction were complete in as short as 2 minutes with as much as a 39-fold increase in brush thickness over a direct temperature comparison to conventional methods

   - Professor Ying-Ji Zhu at the State Key Laboratory of high Performance Ceramics and superfine Microstructures and Shanghai Institute of Ceramics, Chinese Academy of Sciences
   - Fast, microwave-assisted synthesis of polyacrylamide metal sulfides using metal salt, sulfur powder, and acrylamide monomer
   - Heated in ethylene glycol, which acted as solvent and reducing agent. Created low-cost preparation of polymeric metal sulfide nanoparticles without additional need for initiator or surfactant
   - Reaction run in open vessel format, samples heated to 125 ºC or 190 ºC for 15 – 60 min
   - Took over 2 h to complete in oil bath
   - Overall, variable heating times, temperatures resulted in monodispersed, size control synthesis of metal sulfide nanoparticles

Step-Growth/Condensation Polymerizations

   - Professor Kanbara at Tsukuba Research Center for Interdisciplinary Materials Science (TIMS), University of Tsukuba, Japan
   - Polymer formation through direct arylation of C-H bonds providing high molecular weights of up to 147 000
   - High purity polymer obtained only through microwave methods
   - Synthesized using CEM Discover® SP and Explorer

   - Professor Takaki Kanbara, Tsukuba Research Center for Interdisciplinary Materials Science (TIMS), Graduate School of Pure and Applied Sciences, University of Tsukuba, Japan
   - Faster reaction times and increased molecular weights with microwave heating vs. conventional
   - 1 mol % loading of Pd catalyst under microwave irradiation provided comparable results to 5 mol % loading under conventional reaction conditions
   - Professor Ulrich Ziener, University of Ulm
   - A combination of synthetic methods (Stille-type polycondensation, ultrasound-assisted dispersion, and microwave-assisted thionation and condensation) were used to create unsubstituted polythiophenes with defined high molecular weights
   - Microwave reaction complete in 2 h at 190 ºC
   - This method allows precise control of high molecular weight polymers and has potential applications in the production of semiconducting materials

   - Dr. Kazuhiro Takeuchi, National Institute of Advanced Industrial Science and Technology, Japan
   - Researchers note a drastic rate enhancement of microwave heating versus conventional methods of PLA formation
   - Polymers with high molecular weights were obtained by irradiating at 200 ºC for 30 min under vacuum

   - Professors Christopher Bray and Bien Tan, Department of Chemistry and Centre for Materials Discovery, University of Liverpool
   - CEM Discover® used for high-throughput synthesis (300+ compounds) of alkyl polyester library
   - All synthetically difficult reactions required use of the microwave over conventional methods

   - Professors Vitaliy V. Khutoryanskiy, Reading School of Pharmacy, School of Chemistry, University of Reading
   - Microwave irradiation used to crosslink PVA and PAA polymers, forming hydrogels in as little as 15 min at 150 ºC
   - This method of hydrogel synthesis eliminates the need for removal of unreacted monomers and yielded gels with equilibrium swelling degrees of 500-1000 g/g
   - One-pot synthetic strategy proved to be efficient, simple, and reproducible

Reviews


