

All provisions are subject to addition, elimination, or revision by either party. All communications and discussions are tentative until execution of a written agreement by both parties.

**CARNEGIE MELLON UNIVERSITY
RESEARCH CONSORTIUM AGREEMENT
CRP CONSORTIUM**

A NEW CONSORTIUM RELATED TO THE RESEARCH PROGRAM IN CONTROLLED RADICAL
POLYMERIZATION ("CRP") AT CMU'S CENTER FOR MACROMOLECULAR ENGINEERING
("CME")

This Research Consortium Agreement (hereinafter referred to as "this **Agreement**"), made by and between Carnegie Mellon University, a non-profit Pennsylvania corporation located at 5000 Forbes Avenue, Pittsburgh, PA 15213-3890 ("**CMU**") and _____, a for-profit corporation existing under the laws of _____ with its principal address at _____ ("**MEMBER**");

WITNESSETH

WHEREAS, the purpose of the research program contemplated by this Agreement is of mutual interest and benefit to CMU and to the MEMBER, and will further the instruction and research objectives of CMU in a manner consistent with its status as a non-profit, tax exempt, educational institution,

NOW, THEREFORE, CMU and MEMBER agree as follows:

1.0 Definitions

1.1 "CRP" shall mean CRP, a term broader than but including ATRP.

1.2 "ATRP" shall mean Atom Transfer Radical Polymerization -- a process for the controlled polymerization of vinyl monomers initially developed at CMU to bring about dramatic changes in the range of products attainable through free radical polymerization.

1.3 "CRP Consortium" or "Consortium" shall mean the CMU CRP Consortium.

1.4 "ATRP Consortium" shall mean the CMU ATRP Consortium in existence from 1/1/96 to 12/31/00.

1.5 "CRP Research Program" shall mean a research program focused on expanding the understanding of CRP and provision of assistance in the commercial development of materials based on CRP processes.

1.6 "MEMBER" shall mean a MEMBER of the CRP Consortium.

1.7 "CRP Patents" shall mean CMU patents issued prior to the commencement of the CRP Consortium, from prior work on several aspects of CRP, including the ATRP Consortium Patents that evolved from the ATRP Consortium. The four published and issued patents are enumerated below.

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“ATRP Basic Patents” shall mean Patent No. 5,763,548, entitled “Novel (Co) Polymers and A Novel Polymerization Process Based on Atom (or Group) Transfer Radical Polymerization” (ATRP Basic Patent 1), and Patent No. 5,807,937, entitled “Processes Based on Atom (or Group) Transfer Radical Polymerization and Novel (Co) Polymers Having Useful Structures and Properties” (ATRP Basic Patent 2), (Collectively referred to as the “Basic Patents,”) together with any continuation, continuation-in-part, re-examination, divisional, or re-issue of such patent in the U.S or any other country.

“ATRP Consortium Patents” shall mean Patent No. 5,789,487, and 5,945,491 both entitled “Preparation of Novel Homo- and Copolymers Using Atom Transfer Radical Polymerization” (ATRP Consortium Patent 1, and CP#1 divisional no. 1), Patent Application No. 09/018,554 entitled “Improvements in Atom Transfer Radical Polymerization” (ATRP Consortium Patent 4), Patent Application No. 09/126,765 entitled “Controlled/‘Living’ Radical Polymerization Applied to Water-Borne Systems” (ATRP Consortium Patent 5), and Patent Application No. 09/534,827 entitled “Catalytic Processes for the Controlled Polymerization of Free Radically (Co)Polymerizable monomers and Functional Polymeric Systems Prepared Thereby” (ATRP Consortium Patent 6) together, with any continuation, continuation-in-part, re-examination divisional, or re-issue of such patent in the U.S or any other country, and any additional ATRP patents which result from the research funded by the ATRP Research Consortium and arising out of applications made prior to 01/01/01.

“ATRP Special Patents” shall mean more, specialized patents which resulted from Contracts with CMU by ATRP Consortium Members.

“Other Patents” shall mean CRP patents based on Patent No. 5,910,549 “ Method for Preparation of Alkoxyamines from Nitroxyl Radicals,” together with any continuation, continuation-in-part, re-examination, divisional, or re-issue of such patent in the U.S. or any other country.

1.8 “New CRP Patents” shall mean patents that may arise from the research funded by the CRP Consortium and during the Term of the CRP Consortium at CME.

1.9 “New Special Patents” shall mean specialized patents which result from contracts with CMU by CRP Consortium MEMBERS.

1.10 “Technology” shall mean the technology, patent(s), know-how, trade secrets, trademarks, and copyrights, if any, related to the particular patent(s) in question.

1.11 “ATRP Basic Technologies” shall mean Technologies incorporating one or both of the ATRP Basic Patents.

1.12 “ATRP Consortium Technologies” shall mean Technologies incorporating any of the ATRP Consortium Patents.

1.13 “Other Technologies” shall mean Technologies incorporating any of the Other Patents.

1.14 “New CRP Technologies” shall mean Technologies incorporating any of the New CRP Patents.

1.15 “ATRP Special Technologies” shall mean Technologies incorporating any of the ATRP Special Patents.

1.16 “New Special Technologies” shall mean Technologies incorporating any of the New Special Patents.

2.0 Purpose of the Consortium

The purpose of the Consortium is to create a vehicle for —

- a. conducting additional research and development in CRP, including ATRP technology, at the CME in CMU, to expand the scope and to develop and define the limits of CRP technologies, including but not limited to polymerizable monomers, comonomers, polymer functionality and polymer topology, catalysts including metals and ligands, and process conditions including catalyst recovery;
- b. providing a set of rights and benefits to the MEMBERS;
- c. training scientists in CRP for industry.

3.0 Statement of Work

CMU will use its best efforts to conduct a program of research and development in CRP Technology with the purpose of expanding the scope and to develop and define the limits of CRP Technology, including but not limited to polymerizable monomers, comonomers and polymer topology, catalysts including metals and ligands, process conditions including catalyst recovery as well as the development of new CRP methodologies as more specifically described in Attachment A ("CRP Research Program").

Specific CRP Research Program directions and projects may be modified from time to time under the direction of the Consortium Director to address interests and concerns of the MEMBERS on basic technology.

4.0 Research Team

The Consortium Director will be Professor Krzysztof Matyjaszewski (hereinafter referred to as "Program Director"). Research and development may be conducted in collaboration with other researchers who may join the Research Team as deemed appropriate by the Program Director. It is agreed that if the Program Director becomes unwilling or unable to carry out the CRP Research Program during the Term hereof then a MEMBER shall be entitled to terminate its participation in the Consortium upon giving sixty (60) days written notice to CMU. If a MEMBER elects to terminate its participation in accordance with this paragraph, the portion of such MEMBER's contribution which has not been spent and which is not

needed to pay non-cancelable commitments incurred in the course of the Research Program prior to termination will be returned to the MEMBER.

5.0 Advisory Board

One representative of each MEMBER, along with the Program Director, shall constitute the Consortium Advisory Board.

6.0 Membership Participation, Rights and Benefits

MEMBERS in Good Standing will, for the Term of the Consortium (see Section 9.0), have the following Rights which (except as otherwise specified below) shall not be available to the public during the five-year term of the consortium:

- 6.1 Each MEMBER will have access to ATRP Consortium and CRP Consortium information and participation in CRP Consortium Activities and Events, including the following:
 - a. Each MEMBER will have the right to participate in annual or semi-annual CRP meetings and presentations.
 - b. Each MEMBER may have one representative on the Advisory Board.
 - c. Each MEMBER will have the right to visit and interact with the CME lab (Note: Exploratory visits to the lab by Non-MEMBERS who are potential new MEMBERS will also be allowed).
 - d. Each MEMBER will have access to new CRP information prior to the submission of a publication.
- 6.2 Each MEMBER will have the right to negotiate commercial licenses with CMU for New CRP Technologies. MEMBERS may negotiate commercial licenses with CMU for the ATRP Basic Technologies, ATRP Consortium Technologies, and Other Technologies.
- 6.3 Each MEMBER will have the right to negotiate with CMU Individual Research Contracts (“Contracts”) for specific aspects and/or applications of CRP Technology which are more specialized than the fundamental CRP Consortium work.
- 6.4 Each MEMBER which funds such a Contract will have the right of first refusal to negotiate commercial licenses with CMU for New Special Technologies which result from the Contract which it funds, for defined fields of use.
- 6.5 Each MEMBER will be able to send a researcher from their corporate laboratories to CMU for a short period of time (less than three months) to learn various CRP techniques. All intellectual property resulting from such efforts will be the property of CMU. Conversely, a researcher from CMU can be sent to a corporate research laboratory to teach CRP techniques.
- 6.6 The rights of a MEMBER enumerated under Sections 6.1 through 6.5 continue during the five year Term of the Agreement which the MEMBER remains a

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MEMBER in Good Standing (see Section 12.1). The rights of a MEMBER whose Membership has terminated prior to 12/31/2005 are defined in Section 12.2.

7.0 Consulting Agreements

Each MEMBER will have the right to negotiate individual, specific consulting agreements on CRP matters with CMU personnel (Note: Exploratory consulting with potential new MEMBERS will also be permitted).

8.0 Membership Term

MEMBERS are requested to commit to Membership for the entire Term of the Consortium, but withdrawal from Membership is permitted with one hundred and eighty (180) days prior notice.

9.0 Term of the Consortium

The Consortium will start January 1, 2001 and will be in effect for five years ending December 31, 2005.

10.0 Duties of CMU

CMU agrees to furnish such available laboratory facilities and equipment it shall consider necessary for the work to be done on this Project except that which may be awarded by MEMBERS as part of this Agreement.

11.0 Consortium Costs and Payments

11.1 Membership Fee

The MEMBER, as its share of the Consortium funding, will pay to CMU the Membership Fee of \$20,000 per year for the Term of the CRP Consortium due September 1, prior to the start of each Year (e.g. a MEMBER's first \$20,000 payment will be due on September 1, 2000). The Membership Year or Year is defined as the calendar year during the Term of the Consortium.

Payments are to be sent by either wire transfer or check, as follows:

Wire Transfers:	Mellon Bank NA Oakland Office 5th and Oakland Avenues Carnegie Mellon University Account Number 197-003 ABA Number 043000261
Checks:	Carnegie Mellon University Technology Transfer Office 5000 Forbes Avenue

Pittsburgh, PA 15213-3890

12.0 Membership "In Good Standing"

- 12.1 The Rights of MEMBERS "in good standing" (Section 6) will be contingent on the timely payment of Membership Fees as provided for in Section 11. MEMBERS whose payments are overdue will receive notice by CMU and, if payment of the amount due is not received within 30 days, will, after that date, automatically cease to have the Rights described in Section 6 and Membership will be considered to have terminated.
- 12.2 If a MEMBER ceases to be a MEMBER in Good Standing during the Term of the Consortium, i.e. prior to 12/31/2005, the following rules will apply with regard to Research Contracts and License Agreements:
 - a. **Individual Research Contracts** entered pursuant to Paragraph 6.3 may not continue and will be subject to automatic termination as of the date when MEMBER ceases to be a MEMBER in Good Standing.
 - b. Licenses for **New Special Technologies** which were negotiated while the MEMBER was a MEMBER in Good Standing will remain in effect; additional licenses for New Special Technologies may be negotiated by the MEMBER in accordance with Section 6.4 (during the Term of the Consortium) for Technologies which were disclosed while the MEMBER was still a MEMBER in Good Standing (but with no rights to underlying ATRP Basic Technologies).
 - c. Regarding **New CRP Technologies** which were disclosed while a MEMBER was (during the Term of the Consortium) still a MEMBER in Good Standing, the MEMBER will retain the right to negotiate a license (per Section 6.2) for such.

13.0 Intellectual Property; Licensing Rights; Patenting

- 13.1 Any intellectual property developed pursuant to this Consortium, including but not limited to patents, copyrights, know-how, or trade secrets, (hereby defined as "Intellectual Property"), ATRP Basic Technologies, ATRP Consortium Technologies, Other ATRP Technologies, ATRP Special Technologies, New CRP Technologies, and New Special Technologies shall be owned by CMU regardless of whether MEMBERS or their employees have participated in the creation thereof, and MEMBERS hereby assign all ownership and other Intellectual Property rights therein to CMU.
- 13.2 International Patenting: CMU intends to apply for patent coverage of CRP Patents in certain major industrial countries. CMU will apply for coverage in any additional country at the MEMBER's cost. If CMU should consider dropping during the Term of the Consortium, maintenance fees on granted CRP Patents, CMU will first poll the MEMBERS on the value of such coverage to each MEMBER and, if interest is expressed, will offer those MEMBERS continuation of such international coverage if MEMBERS will pay for any further maintenance fees and expenses. MEMBERS may notify CMU of the countries in which they would like to see international filings

for Basic and Consortium Patents. With regard to countries desired by one or more MEMBERS for which CMU declines to file for patent coverage at CMU's expense, a MEMBER (or MEMBERS) may request that CMU file for such coverage at that MEMBER's or MEMBERS' expense; that MEMBER or MEMBERS may later deduct the full out-of-pocket costs of such a filing (and subsequent fees) from royalty payments which are based on licensed revenues in that country.

- 13.3 Grant-Back of Improvements: Improvements by MEMBERS to Licensed ATRP Technologies ("Improvements") licensed to them shall be made available on a perpetual royalty-free basis to CMU for research, educational, and/or academic purposes.

14.0 Confidential Information

- 14.1 All MEMBERS will be required to sign Confidentiality Agreements with regard to all confidential information related to the CRP Consortium.
- 14.2 All documents, materials and know-how which may be furnished to CMU by MEMBER pursuant to the work to be performed hereunder shall be, if suitably marked as Confidential or designated in tangible form, deemed MEMBER'S Proprietary Information and therefore considered as Confidential and shall not be used by CMU other than for the work under this Agreement. CMU shall use the same degree of care as it uses in protecting and preserving its own proprietary/confidential information of like kind to avoid disclosure or dissemination thereof.
- 14.3 Information which is disclosed orally or otherwise than in tangible form by MEMBER shall be considered MEMBER'S Proprietary Information if (a) the information is identified as confidential at the time of disclosure and a written summary is provided to CMU within twenty (20) days thereafter or (b) the information is identified as confidential in a writing provided to CMU prior to or at the time of disclosure by MEMBER.
- 14.4 Neither party shall be liable for the inadvertent or accidental disclosure of Proprietary or Confidential Information if such disclosure occurs despite the exercise of the same degree of care as such party normally takes to preserve its own such data or information.
- 14.5 The Proprietary Information designation and any confidentiality obligation shall not apply to information if the information --
- (a) is publicly known to CMU for which it has documentary records which establish knowledge prior to this disclosure;
 - (b) subsequently becomes public knowledge and/or published through no fault of CMU;
 - (c) is independently developed by employees of CMU who have no access thereto; or

(d) is or was brought to CMU's attention by a third party who has a legal right to do so.

- 14.6 It is understood that if CMU submits any confidential information it owns to MEMBER then MEMBER will be obligated to treat and protect CMU's confidential information as if its own.
- 14.7 Confidentiality obligations shall remain in force for a period of five (5) years after termination of this Agreement.
- 14.8 CMU will use a good faith effort to have each employee or student who has access to MEMBER's proprietary information in performance of the work execute a Confidential Disclosure Agreement attached to this Agreement.
- 14.9 In addition to the provisions of this Section 14, specific mutual Confidential Disclosure Agreements shall be completed between CMU and the MEMBER.

15.0 Publications

- 15.1 Subject to the non-disclosure obligations created by or pursuant to this Agreement, all reports and papers of research and other activities conducted under the CRP Research Program may be published by CMU in accordance with its publication policies. Any such reports or papers shall refer to the fact that the project was conducted pursuant to a grant from MEMBER if such reference is desired by the MEMBER.
- 15.2 In order that information concerning scientific, software or technical developments conceived or first actually reduced to practice in the performance of the CRP Research Program is not prematurely published so as to adversely affect a patent, copyright or proprietary interests of the MEMBER in any information it has conveyed to CMU, CMU agrees to submit to MEMBER a copy of any such reports or papers for review and comment prior to submission for publication. MEMBER can then request deletion from the publication of any MEMBER Confidential Information or can request a delay in publication for sixty (60) days to allow time for filing of patent/copyright protection of MEMBER Confidential or Proprietary Information. Such delay shall not, however, be imposed on the filing of any student thesis or dissertation.

16.0 Use of the Name of CMU or MEMBER

Each party agrees not to use the name of the other party or any persons or its staff in sales promotion work or advertising, or in any other form of publicity without the written permission of the other party.

17.0 Excusable Delay

- 17.1 Neither party shall be liable for delay in performance due to fire, flood, strike, or other labor difficulty, act of God, act of any governmental authority, acts or omissions of the other party, riot, fuel or energy shortage, or due to any other cause beyond the party's reasonable control.

17.2 In the event of delays in performance due to any such cause, the dates for performance will be postponed by a period of time equal to the delay period.

18.0 Warranty

ANY INFORMATION, MATERIALS OR SERVICES, INTELLECTUAL PROPERTY OR OTHER PROPERTY OR RIGHTS GRANTED OR PROVIDED BY CMU PURSUANT TO THIS AGREEMENT (HEREINAFTER THE "DELIVERABLES") ARE ON AN "AS IS" BASIS. CMU MAKES NO WARRANTIES OF ANY KIND, EITHER EXPRESSED OR IMPLIED AS TO ANY MATTER INCLUDING, BUT NOT LIMITED TO, WARRANTY OF FITNESS FOR PURPOSE, OR MERCHANTABILITY, EXCLUSIVITY OR RESULTS OBTAINED FROM MEMBER'S USE OF ANY INTELLECTUAL PROPERTY DEVELOPED UNDER THIS AGREEMENT, NOR SHALL EITHER PARTY HERETO BE LIABLE TO THE OTHER FOR INDIRECT, SPECIAL, OR CONSEQUENTIAL DAMAGES SUCH AS LOSS OF PROFITS OR INABILITY TO USE SAID INTELLECTUAL PROPERTY OR ANY APPLICATIONS AND DERIVATIONS THEREOF. CMU DOES NOT MAKE ANY WARRANTY OF ANY KIND WITH RESPECT TO FREEDOM FROM PATENT, TRADEMARK, OR THEFT OF TRADE SECRETS AND DOES NOT ASSUME ANY LIABILITY HEREUNDER FOR ANY INFRINGEMENT OF ANY PATENT, TRADEMARK, OR COPYRIGHT ARISING FROM THE USE OF THE DELIVERABLES, INFORMATION, INTELLECTUAL PROPERTY OR OTHER PROPERTY OR RIGHTS GRANTED OR PROVIDED TO IT HEREUNDER. MEMBER AGREES THAT IT WILL NOT MAKE ANY WARRANTY ON BEHALF OF CMU, EXPRESSED OR IMPLIED, TO ANY PERSON CONCERNING THE APPLICATION OF OR THE RESULTS TO BE OBTAINED WITH THE DELIVERABLES UNDER THIS AGREEMENT.

19.0 Indemnification

MEMBER hereby agrees to defend, indemnify and hold harmless CMU, its trustees, officers, employees and agents from all claims or demands made against them (and any related losses, expenses or attorneys' costs) arising out of or relating to MEMBER's use of or conduct regarding the Deliverables, information, Intellectual Property or other property or rights granted or provided to it by CMU under this Agreement, including, but not limited to, any claims of product liability, personal injury (including, but not limited to, death), damage to property or violation of any laws or regulations, including but not limited to claims of active or passive negligence.

20.0 Notice and Other Addresses

20.1 Any notice to either party hereunder must be in writing signed by the party giving it, and shall be served either personally or by registered or certified mail addressed as follows:

(The balance of this page intentionally left blank.)

Carnegie Mellon University

MEMBER

Associate Provost - Research

Carnegie Mellon University

5000 Forbes Avenue

Pittsburgh, Pennsylvania 15213

Fax : 412-268-6247

Fax : _____

20.2 Other key addresses are as follows:

Program Director:

Prof. Krzysztof Matyjaszewski,
Department of Chemistry

Mellon Institute, Carnegie Mellon University
4400 Fifth Avenue, Pittsburgh, PA 15213-2683
Telephone : (412) 268-3209; Fax : (412) 268-6897
email : km3b@andrew.cmu.edu

Program Consultant :

Dr. James Spanswick
Consultant, Polymeric Materials

Bridges TIC
2365 Albright Lane, Wheaton, IL 60187
Telephone / Fax : (630) 690-5132
email : Jspanswick@aol.com

21.0 Academic Collaboration; Government Sponsored Research

- 21.1 Nothing contained in this Agreement shall prevent either MEMBER or CMU from entering into research projects with third parties which are similar to the activities under this Agreement ("Consortium Activities"), or from independently developing (either through third parties or through the use of its own personnel), or from acquiring from third parties, technologies or products which are similar to and competitive with intellectual property resulting from Consortium Activities.
- 21.2 Nothing herein shall be construed to grant either party any rights in any such technologies or products so developed or acquired as described in subparagraph 21.1, or any rights to the revenues or any portion thereof derived by the other from the use, sale, lease, license or other disposal of any such technologies or products. Furthermore, nothing herein shall preclude either party from transferring any such technologies or products to others including to users of the intellectual property resulting from said Consortium Activities.

21.3 CMU may collaborate with other academic institutions when researchers at such institutions can assist the CRP Consortium. Intellectual Property will be protected, when possible, in these collaborations.

21.4 CMU may continue to seek funding from Government-related organizations which may result in additional CRP Technologies available to MEMBERS.

22.0 Validity

If any portion of this Agreement shall be finally determined by any court or governmental agency of competent jurisdiction to violate applicable law or otherwise not to conform to requirements of law then the remainder of this Agreement shall not be affected thereby; provided, however, that if any provision hereof is invalid or unenforceable, then a suitable and equitable provision shall be substituted therefor in order to carry out, so far as may be valid and enforceable, the intent and purpose of this Agreement including the invalid or unenforceable provision.

23.0 Paragraph Headings

The paragraph headings herein are inserted for convenience only and shall not be construed to limit or modify the scope of any provision of this Agreement.

24.0 Benefit, Entire Agreement

24.1 This Agreement is binding upon and shall inure to the benefit of the parties hereto, their representatives, successors and assigns. No failure or successive failures on the part of either party, its successors or assigns, to enforce any covenant or agreement, and no waiver or successive waivers on its or their part of any condition of this Agreement, shall operate as a discharge of such covenant, agreement, or condition, or render the same invalid, or impair the right of either party, its successors and assigns, to enforce the same in the event of any subsequent breach or breaches by the other party, its successors or assigns.

24.2 This Agreement constitutes the entire agreement between the parties and supersedes all previous agreements and understandings relating to the subject matter hereof. This Agreement may not be altered, amended, or modified except by a written instrument signed by the duly authorized representatives of both parties.

25.0 Disputes

This Agreement shall be governed by the laws of the Commonwealth of Pennsylvania excluding its choice of law principles. Any dispute or claim arising out of or relating to this Agreement will be settled by arbitration in Pittsburgh, Pennsylvania in accordance with the rules of the American Arbitration Association and judgment upon award rendered by the arbitrator(s) may be entered in any court having jurisdiction.

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IN WITNESS WHEREOF, the parties hereto have caused this Agreement to be executed by their duly authorized representatives to be in effect as of the last date and year written below.

The undersigned verify subject to the penalties of Pa. C.S. § 4904 relating to unsworn falsification to authorities that they have the authority to bind to this Agreement the party on behalf of which they are executing below.

Carnegie Mellon University

MEMBER

(Signature)

Susan Burkett, Associate Provost

(Date)

(Signature)

(Name)

(Title)

(Date)

(Signature)

(Name)

(Title)

(Date)

Attachment A

(June 2000 Version.)

Controlled Radical Polymerization Consortium

Long Range Research Plans

Mission: to explore and define the scope of different Controlled/Living Radical Polymerization (CRP) techniques in order to demonstrate preparation of a broad spectrum of new materials, under commercially viable conditions, from an expanded range of available monomers.

Vision: to empower the polymer chemist with a library of CRP techniques to expedite development of new materials with desired properties for any targeted application utilizing radically (co)polymerizable monomers under non-demanding conditions.

Scope: primarily ATRP, competitive evaluation of nitroxide mediated polymerization, chain transfer agents, reversible C-Mt bond formation, reversible addition fragmentation.

Methodology:

- - explore and define mechanistic and synthetic aspects of various CRPs;
- - expand limits of CRP by defining conditions for controlled polymerization of a larger range of monomers through development and evaluation of a spectrum of initiators / catalysts / transfer agents to prepare macromolecules with novel architectures, compositions, micro- and macro-functionalities;
- - incorporate polymers prepared by non-radical processes into materials development;
- - prepare organic/inorganic hybrids, composites, and tethered functional materials;
- - collaborate with expert research groups to establish a comprehensive structure-property correlation for new (co)polymers;
- - identify, define and optimize new controlled radical polymerization processes that will either expand capability for preparation of new materials or allow development of the lowest cost, lowest environmental impact process, for each target material;
- - facilitate commercialization of CRP processes by identifying, defining and explaining process fundamentals of each CRP;
- - provide technology transfer through training/consulting for industry.

Tools:

- *Synthesis* - detailed mechanistic, and preparative studies to optimize criteria for rapid and facile preparation of (co)polymers with precise control over MW, MWD, functionality, topology and composition.
- *Processing* – collaborate on, and pursue internally, development of rapid accurate processing of small samples, evaluation of thermal, mechanical and environmental (solvent) histories on properties, effect of additives including reactive processing, structure property correlation of interactions of inherent physical properties, fabrication conditions, and resulting mechanical properties of polymeric materials.
- *Characterization* – collaborate on, and pursue internally, rapid and facile characterization of materials; MW, MWD (SEC MS MALDI...), microstructure (NMR IR MS...), thermal and mechanical (DSC DMA...), morphology (SAXS SANS...), surface (AMF ellipsometry...), and specialized (CMC blending adhesion...).
- *Simulations* – collaborate on rapid and precise prediction of macroscopic structure and properties in dense and dilute media, combination of methodologies for various size and time scales, simulation of complete routes: synthesis, processing characterization, semiempirical approach (data input and testing from processing and characterization of well defined systems e.g. stars, combs, blocks, gradients, bottle brush, (hyper)branched...).

Targets:

- - expand and define limits of CRP;
- - understand fundamentals of all CRP processes;
- - correlate structure with reactivity for all components of each CRP process;
- - train students and postdocs to expedite technology transfer;
- - teach industrial chemists to utilize latest improvements and interact to accelerate identification of optimum process/product/application chain.

Mechanisms:

Structure-reactivity relationships for ATRP systems and some other CRP processes

1. Absolute and relative K_{eq} for various complexes and initiators.
2. Absolute k_{act} and k_{deact} .
3. Effect of temperature and solvent.
4. Structural characterization of metal complexes (X-ray, EXAFS, EPR, UV, IR, NMR, ENDOR, CV...).
5. Correlation of reactivities with structure of catalyst complexes and initiators.
6. Rational design of new catalysts, initiating systems and transfer systems for various monomers allowing for optimization of catalyst, persistent radical or chain transfer agent for each (co)monomer.

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7. Defining limits of polymerization rates and MW for each system under various conditions.
8. Expansion of number of monomers polymerizable by each process.
9. Polymerization process transformation.
10. Critical comparison of ATRP with other CRP systems.

Structure-property relationships for materials prepared by CRP processes

1. Synthesis of (co)polymers with tailored properties by controlling composition, functionality, architecture.
2. Synthesis and characterization of various pure and tapered di-, tri, and multiblock copolymers.
3. Evaluation of copolymers with controlled compositional gradient.
4. Homo- and copolymers with controlled topologies (linear, star, graft, bottle-brush, (hyper)branched and core/shell).
5. Homo and copolymers with various site specific and end functionalities.
6. Hybrid materials, including inorganic and natural polymers.
7. Incorporation of polymers prepared by non-CRP routes.
8. Transformation and/or stabilization of end groups for downstream reactive fabrication and/or applications.
9. Development of a rational process for the design of new materials, conceptual applications include polar TPE's, solventless coatings, new adhesives, additives, compatibilizers, lubricants, separation media, hydrogels, personal care products...
10. Correlation of structure with properties, including structural imperfections.

Some special cases for ATRP:

1. Immobilization/reclamation/recycling/regeneration of the catalyst system.
2. Development of alternatives to halogen based initiators and catalyst complexes.
3. Heterogeneous (water, ionic liquids, CO₂, other supercritical fluids) polymerization systems.
4. Aqueous homogeneous systems.
5. Attempts to combine coordination and radical polymerization