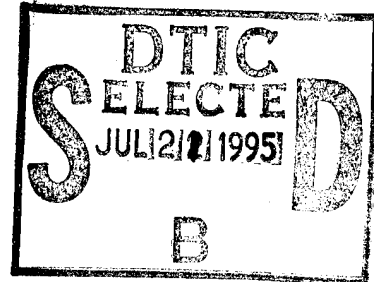


OFFICE OF NAVAL RESEARCH  
END-OF-THE-YEAR REPORT  
PUBLICATIONS/PATENTS/PRESENTATIONS/HONORS/STUDENTS REPORT

for

GRANT OR CONTRACT: N00014-93-1-0780  
N00014-93-1-1282

R&T Code 4132091ess03



Pollution Minimization

Charles L. McCormick

Department of Polymer Science  
University of Southern Mississippi  
Hattiesburg, MS 39401-0076

19950630 156

June 26, 1995

Reproduction in whole, or in part, is permitted for any purpose of the United States Government.

This document has been approved for public release and sale, its distribution is unlimited.

DTIC QUALITY INSPECTED 5

OFFICE OF NAVAL RESEARCH  
PUBLICATIONS/PATENTS/PRESENTATIONS/HONORS REPORT

R&T Code: 4132091ess03

Contract/Grant Number: N00014-93-1-0780/N00014-93-1-1282

Contract/grant Title: Pollution Minimization

Principal Investigator: Dr. Charles L. McCormick

Mailing Address: Box 10076 Southern Station, Hattiesburg MS 39406-0076

Phone Number: (601) 266-4872 or (601) 266-4868 Fax Number: (601) 266-5504

E-mail Address: cmccormi@whale.st.usm.edu

WWW Homepage:

- a. Number of papers submitted to refereed journals, but not published: 5
- b. Number of papers published in refereed journals (provide complete citations): 6
- c. Number of books or chapters submitted, but not yet published: 3
- d. Number of books or chapters published (provide complete citations): 0
- e. Number of printed technical reports/non-refereed papers(provide completed citations): 7
- f. Number of patents filed: 0
- g. Number of patents granted (for each, provide a complete citation): 4
- h. Number of invited presentations (for each, provide a complete citation): 3
- i. Number of submitted presentations (for each, provide a complete citation): 37
- j. Honors/Awards/Prizes for contract/grant employees (list attached): 5
- k. Total number of Full-time equivalent Graduate Students and Post-Doctoral associates supported during this period, under this R&T project number: 13
  - Graduate Students: 11
  - Post-Doctoral Associates: 2
  - Female Graduate Students: 5
  - Female Post-Doctoral Associates: 0
  - Minority Graduate Students: 0
  - Minority Post-Doctoral Associates: 0
  - Asian Graduate Students: 0
  - Asian Post-Doctoral Associates: 2

1. + Other funding

Accession For	
ERIC GRANT	<input checked="" type="checkbox"/>
ERIC TAB	<input type="checkbox"/>
Unannounced	<input type="checkbox"/>
Justification	
By	
Distribution/	
Availability Codes	
Dist	Avail and/or Special
A-1	

## A. Technical Papers Published

"Water-Soluble Copolymers 52:  $^{23}\text{Na}$  NMR Studies of Ion-Binding to Anionic Polyelectrolytes: Poly(sodium 2-acrylamido-2-methylpropanesulfonate), Poly(sodium 3-acrylamido-3-methylbutanoate), Poly(sodium acrylate) and Poly(sodium galacturonate)" J. Kent Newman and C. L. McCormick, *Macromolecules*, 29, 5123-5128 (1994).

"Water-Soluble Copolymers 53:  $^{23}\text{Na}$  NMR Studies of Hydrophobically-Modified Polyacids: Copolymers of 2-(1-Naphthylacetamido)-ethylacrylamide with Acrylic acid and Methacrylic Acid" J. Kent Newman and C. L. McCormick, *Macromolecules*, 29, 5114-5122 (1994).

"Water-Soluble Copolymers 54: N-isopropylacrylamide-co-acrylamide Copolymers in Drag Reduction: Synthesis, Characterization and Dilute Solution Behavior" Pavneet S. Mumick and Charles L. McCormick, *Polymer Engineering and Science*, Vol. 34, 18, 1419-1427 (1994).

"Water-Soluble Copolymers 55: N-isopropylacrylamide-co-acrylamide Copolymers in Drag Reduction: Effect of Molecular Structure, Hydration and Flow Geometry on Drag Reduction, Performance" Pavneet S. Mumick, Roger D. Hester and Charles L. McCormick, *Polymer Engineering and Science*, Vol. 34, 18, 1429-1440 (1994).

"Water-Soluble Copolymers 57: Amphiphilic Cyclocopolymers of Diallylalkoxybenzylmethylammonium Chloride and Diallyldimethyl-Ammonium Chloride" Yihua Chang and Charles L. McCormick, *Polymer*, 35, 3503-3512 (1994).

"Water-Soluble Copolymers 59: Investigation of the Effects of Polymer Microstructure on the Associative Behavior of Amphiphilic Terpolymers of Acrylamide, Acrylic Acid and N-[(4-decyl)phenyl]acrylamide" K. D. Branham, D. L. Davis, J. C. Middleton and Charles L. McCormick, *Polymer*, 35, 4429-4436 (1994).

"Photophysical and Rheological Studies of Amphiphilic Polyelectrolytes: Correlation of Polymer Microstructure with Associative-Thickening Behavior" Kelly D. Branham and Charles L. McCormick, *American Chemical Society Symposium Series*, January 1995.

"Fluorescence Studies of Pyrene-Labeled, Water-Soluble Polymeric Surfactants" Michael C. Kramer, Jamie R. Steger, and Charles L. McCormick, *American Chemical Society Symposium Series*, January 1995.

"Polyampholytes" *The Polymeric Materials Encyclopedia: Synthesis, Properties, and Applications*, CRC Press, Inc. E. E. Kathmann and C. L. McCormick.

## B. Technical Papers Submitted

"Water-Soluble Copolymers 61: Microstructural Investigation of Pyrenesulfonamide-Labeled Polyelectrolytes; Variation of Label Proximity Utilizing Micellar Polymerization" Kelly D. Branham, Charles L. McCormick, Georgia S. Shafer and Charles E. Hoyle, accepted for publication in *Macromolecules* (Dec 95).

"Water-Soluble Copolymers 62: Nonradiative Energy Transfer Studies of Fluorescently Labeled, Hydrophobically Modified Poly(Sodium Maleate-*alt*-Ethyl Vinyl Ether)s in Aqueous Media" Yuxin Hu, Michael C. Kramer, Chase J. Boudreaux, and Charles L. McCormick, submitted to *Macromolecules* (May 95).

"Water-Soluble Copolymers 63: Rheological and Photophysical Studies of the Associative Properties of Pyrene-Labeled Poly[acrylamide-*co*-sodium 11-(acrylamido)undecanoate]" Michael C. Kramer, Cynthia G. Welch, Jamie R. Steger, and Charles L. McCormick, accepted for publication in *Macromolecules* (July 95).

"Water-Soluble Copolymers 64: Effects of pH and Acrylic Acid Content on Associative Properties of Amphiphilic Acrylamide/Acrylic Acid-Based Terpolymers" Kelly D. Branham, H. Scott Snowden, and Charles L. McCormick, submitted to *Macromolecules* (June 95).

"Novel Nafion/ORMOSIL Hydrate via in situ Sol-Gel Reaction: 3. Pyrene Fluorescence Probe Investigations of Nanoscale Environment" Qin Deng, Yuxin Hu, R.B. Moore, C.L. McCormick and K.A. Mauritz. submitted to *Chemistry of Materials* (June 1995).

## C. Preprints

"The Synthesis and Characterization of Novel Hydrophobically Modified Zwitterionic Copolymers," K. M. Johnson and C. L. McCormick, *Polymer Preprints*, 35(2), 637 (1994).

"Fluorescence Spectroscopy Studies of Amphiphilic Polyelectrolytes," K. D. Branham, C. L. McCormick, and G. S. Shafer, *Proceedings PMSE*, 71, 423 (1994).

"An Investigation of the Conformation and Interaction of Apolipoprotein-III from *Manduca sexta* and Oleosin from *Glycine max* in Water in the Presence of Hydrophobic Materials," M. F. Richardson and C. L. McCormick, *Polymer Preprints*, 35(2) 775 (1994).

"Controlled Activity Polymers: Acrylic Acid Copolymers of *b*-Naphthyl Acrylate, 2-Acrylamido(*b*-Naphthyl)Valerate, 3-Acrylamido-3-Methyl(*b*-Naphthyl)Butanoate, and 6-Acrylamido(*b*-Naphthyl)-Caproate: Release Behavior," C. Boudreaux, C. Bunyard, and C. L. McCormick, *Polymer Preprints*, 35(2) 639 (1994).

"Cloning, Expression, and Purification of Recombinant Apolipoprotein-III: A Biopolymer for Phase Transfer of Hydrocarbons from Aqueous Environments," J. Kahalley, Gordon Cannon, and C. L. McCormick, *Proceedings PMSE*, 71, 500 (1994).

"Synthesis and Solution Behavior of pH Responsive Polyampholytes Based on a Novel Carboxybetaine Monomer," E. E. Kathmann and C. L. McCormick, *Polymer Preprints*, 35(2) 641 (1994).

"Fluorescence Studies of Pyrene-Labeled Polymeric Surfactants," M.C. Kramer, J. R. Steger, and C. L. McCormick, *Proceedings PMSE*, 71, 413 (1994).

#### D. Presentations

"An Investigation of Plant Oleosins as Polymeric Emulsifiers," Monica E. Tisack, Robert Y. Lochhead, and Charles L. McCormick, ACS Division of Colloid and Surface Chemistry, 68th ACS Colloid and Surface Science Symposium, San Francisco, CA, June 1994.

"The Synthesis and Characterization of Novel Hydrophobically Modified Zwitterionic Copolymers," K. M. Johnson and C. L. McCormick, National ACS Meeting, 208th ACS National meeting, Washington, DC, August 21-25, 1994.

"Fluorescence Spectroscopy Studies of Amphiphilic Polyelectrolytes," K. D. Branham, C. L. McCormick, and G. S. Shafer, 208th ACS National meeting, Washington, DC, August 21-25, 1994.

"An Investigation of the Conformation and Interaction of Apolipoprotein-III from *Manduca sexta* and Oleosin from *Glycine max* in Water in the Presence of Hydrophobic Materials," M. F. Richardson and C. L. McCormick, 208th ACS National meeting, Washington, DC, August 21-25, 1994.

"Controlled Activity Polymers: Acrylic Acid Copolymers of *o*-Naphthyl Acrylate, 2-Acrylamido(*o*-Naphthyl)Valerate, 3-Acrylamido-3-Methyl(*o*-Naphthyl)Butanoate, and 6-Acrylamido(*o*-Naphthyl)-Caproate: Release Behavior," C. Boudreaux, C. Bunyard, and C. L. McCormick, 208th ACS National meeting, Washington, DC, August 21-25, 1994.

"Cloning, Expression, and Purification of Recombinant Apolipoprotein-III: A Biopolymer for Phase Transfer of Hydrocarbons from Aqueous Environments," J. Kahalley, Gordon Cannon, and C. L. McCormick, 208th ACS National meeting, Washington, DC, August 21-25, 1994.

"Synthesis and Solution Behavior of pH Responsive Polyampholytes Based on a Novel Carboxybetaine Monomer," E. E. Kathmann and C. L. McCormick, 208th ACS National meeting, Washington, DC, August 21-25, 1994.

"Fluorescence Studies of Pyrene-Labeled Polymeric Surfactants," M.C. Kramer, J. R. Steger, and C. L. McCormick, National ACS Meeting, 208th ACS National meeting, Washington, DC, August 21-25, 1994.

"An Investigation of Plant Oleosins as Polymeric Emulsifiers," Monica E. Tisack, Robert Y. Lochhead, and Charles L. McCormick, ACS Division of Colloid and Surface Chemistry, 208th ACS National meeting, Washington, DC, August 21-25, 1994.

"Comparison of Expression and Mutagenesis Strategies for *Manduca sexta* Apolipoprotein-III," Johanna Kahalley, Gordon C. Cannon, and Charles L. McCormick, Southeastern Regional ACS Meeting, Birmingham, AL, October 1994.

"Hydrophobically Associating Polypeptides as Polymeric Micelles," Mark J. Logan, Gordon C. Cannon, and Charles L. McCormick, Southeastern Regional ACS Meeting, Birmingham, AL, October 1994.

"Studies of the Mechanism of Associative Thickening Utilizing Labeled Acrylamide Copolymers Prepared via Micellar Polymerization," Kelly D. Branham, H. Scott Snowden, and Charles L. McCormick, Industrial Advisory Committee Meeting, University of Southern Mississippi, October 1994.

"Effects of pH and Polyelectrolyte Charge Density on Associative Properties of Amphiphilic Polyelectrolytes," H. Scott Snowden, Kelly D. Branham, and Charles L. McCormick, Industrial Advisory Committee Meeting, University of Southern Mississippi, October 1994.

"Fluorescence Studies of the Associative Properties of Pyrene-Labeled Polymeric Micelles," Michael C. Kramer, Jamie R. Steger, and Charles L. McCormick, Industrial Advisory Committee Meeting, University of Southern Mississippi, October 1994.

"Synthesis and Solution Behavior of pH and Electrolyte Responsive Water Soluble Polyampholytes," Erich E. Kathmann, Leslie A. White, and Charles L. McCormick, Industrial Advisory Committee Meeting, University of Southern Mississippi, October 1994.

"Novel Zwitterionic Copolymers for Application in Aqueous Electrolyte Solutions," Kathryn M. Johnson and Charles McCormick, Industrial Advisory Committee Meeting, University of Southern Mississippi, October 1994.

"Novel Amphiphilic Copolymers Via Microemulsion Polymerization Techniques," Geoffrey L. Smith and Charles L. McCormick, Industrial Advisory Committee Meeting, University of Southern Mississippi, October 1994.

"The Use of *De Novo* Designed Responsive Polymers for the Remediation of Hydrocarbons: Polypeptide Emulsifiers," Mark Logan, Gordon C. Cannon, and Charles L.

McCormick, Industrial Advisory Committee Meeting, University of Southern Mississippi, October 1994.

Recombinantly Modified Apolipoproteins for pH Responsive Transport and Sequestration of Hydrophobes in Water," Johanna Kahalley and Charles L. McCormick, Industrial Advisory Committee Meeting, University of Southern Mississippi, October 1994.

"Studies of the Interactions of Amphipathic Proteins with Hydrophobic Materials in an Aqueous Environment: Potential Bioremediation Agents," Michael F. Richardson and Charles L. McCormick, Industrial Advisory Committee Meeting, University of Southern Mississippi, October 1994.

"Isolation and Characterization of a Hydrophobic Polypeptide for Potential Application in Emulsification, Controlled Release and Water Remediation," Gregory G. Martin, Gordon C. Cannon, and Charles L. McCormick, Industrial Advisory Committee Meeting, University of Southern Mississippi, October 1994.

"Synthesis and Characterization of pH Responsive Hydrogels for Water Remediation and Transport," R. Scott Armentrout and Charles L. McCormick, Industrial Advisory Committee Meeting, University of Southern Mississippi, October 1994.

"Chitin and Cellulose Derivatives Utilizing the LiCl/N,N-Dimethylacetamide Solvent System," Sheila Williamson and Charles L. McCormick, Industrial Advisory Committee Meeting, University of Southern Mississippi, October 1994.

"Bioactive Copolymers for Controlled Release of Model Compounds, Herbicides, and Allelopathic Agents," Chase J. Boudreaux, Clay Bunyard, and Charles L. McCormick, Industrial Advisory Committee Meeting, University of Southern Mississippi, October 1994.

"Amphiphilic Copolymers Containing Pendent Menthol Esters: Synthesis, Structural Analysis, and Aqueous Solution Behavior," Clay Bunyard, Chase J. Boudreaux, and Charles L. McCormick, Industrial Advisory Committee Meeting, University of Southern Mississippi, October 1994.

"Chitin and Cellulose Derivatives Utilizing the LiCl/N,N-Dimethylacetamide Solvent System," Sheila Williamson and Charles L. McCormick, 1995 Mid-Winter Symposium, Millsaps College, January, 1995.

"Synthesis and Solution Behavior of pH and Electrolyte Responsive Water Soluble Polyampholytes," Erich E. Kathmann, Leslie A. White, and Charles L. McCormick, 1995 Mid-Winter Symposium, Millsaps College, January, 1995.

"Recombinant Production of Manduca sexta Apolipoprotein-III: A Biopolymer for Phase Transfer of Hydrocarbons From Aqueous Solutions," Johanna Kahalley, Gordon Cannon,

and Charles L. McCormick, 1995 Mid-Winter Symposium, Millsaps College, January, 1995.

"Purification of Soybean 34kDa Oleosin: An Amphiphilic Protein with the Potential to be Recombinantly Tailored to a pH Responsive Biosurfactant," Jianbin Xue, Charles L. McCormick and Gordon C. Cannon, Mississippi Academy of Sciences, Biloxi, MS, February 9, 1995.

"The Study of Proteins from Plants and Insects as Candidates for Oil Recovery," Monica Tisack, Robert Lochhead and Charles L. McCormick, Mississippi Academy of Sciences, Biloxi, MS, February 9, 1995.

"Recombinant Production of *Manduca sexta* Apolipoprotein-III: A Biopolymer for Phase Transfer of Hydrocarbons From Aqueous Solutions," Johanna Kahalley, Gordon Cannon, and Charles L. McCormick, Mississippi Academy of Sciences, Biloxi, MS, February 9, 1995.

"The Use of *De Novo* Designed Responsive Polymers for the Remediation of Hydrocarbons: Polypeptide Emulsifiers," Mark Logan, Gordon C. Cannon, and Charles L. McCormick, Mississippi Academy of Sciences, Biloxi, MS, February 9, 1995.

"Purification of Soybean 34kDa Oleosin: An Amphiphilic Protein with Potential to be Recombinantly Tailored to a Phase Transfer Biosurfactant," Jianbin Xue, Charles L. McCormick, Gordon C. Cannon, Southeast Region Meeting for the Association of Plant Physiologists, Knoxville, TN, February 1995.

"Purification and Characterization of Hydrophobins and Schizophyllin From *Schizophyllum commune* for Potential Use In Controlled Release And/Or Waste-Water Remediation," Gordon C. Cannon, Gregory Martin, and Charles McCormick, Current Topics in Plant Biochemistry, Physiology and Molecular Biology, University of Missouri-Columbia, April 19-22, 1995.

"Expression and Characterization of Recombinant Apolipoprotein-III From *Manduca sexta*," Johanna M. Kahalley, Gordon C. Cannon, and Charles L. McCormick, Current Topics in Plant Biochemistry, Physiology and Molecular Biology, University of Missouri-Columbia, April 19-22, 1995.

"Remediation of Wastewater Through the Use of Two Naturally Occurring Proteins: Apolipoprotein-III from *Manduca sexta* and Oleosin from *Glycine max*," Michael F. Richardson and Charles L. McCormick, Current Topics in Plant Biochemistry, Physiology and Molecular Biology, University of Missouri-Columbia, April 19-22, 1995.

"The Behavior Of Soybean Oleosins and *Manduca sexta* Apolipoprotein III Proteins at the Cyclohexane/Water Interface," Monica Tisack, Robert Y. Lochhead, Charles L.

McCormick and Gordon Cannon, ACS Division of Colloid and Surface Chemistry, 69th ACS Colloid and Surface Science Symposium, Salt Lake City, Utah, June 11-14, 1995.

"Isolation, Synthesis, and Characterization of the Proteins, Apolipoprotein-III and Oleosin, for Use in the Bioremediation of Contaminated Waters," Charles L. McCormick, Gordon C. Cannon, Johanna Kahalley, Greg Martin, Michael Richardson, submitted to 1995 International Chemical Congress of Pacific Basin Societies, Pacificchem '95, Hawaii to be held December, 1995.

"Photophysical Studies of the Associative Properties of pH and Salt-Responsive Microdomains in Hydrophobically Modified Water-Soluble Copolymers," Charles L. McCormick, Michael C. Kramer, Yuxin Hu, and Kelly D. Branham, submitted to 1995 International Chemical Congress of Pacific Basin Societies, Pacificchem '95, Hawaii to be held December, 1995.

"Synthetic and Biosynthetic Polymers with Responsive Microdomains for Phase Transfer/Remediation," Charles L. McCormick, Michael C. Kramer, Johanna Kahalley, and Michael F. Richardson, submitted to 1995 International Chemical Congress of Pacific Basin Societies, Pacificchem '95, Hawaii to be held December, 1995.

"Synthesis and Characterization of Phase Transfer Proteins with Responsive Microdomains for Water Remediation," Charles L. McCormick, Gordon C. Cannon, Johanna Kahalley, Michael F. Richardson, and Greg Martin, submitted to 1995 International Chemical Congress of Pacific Basin Societies, Pacificchem '95, Hawaii to be held December, 1995.

#### E. Awards

"Expression and Characterization of Recombinant Apolipoprotein-III from *Manduca sexta*,"

Johanna M. Kahalley, Gordon C. Cannon, and Charles L. McCormick

*Department of Polymer Science and Department of Chemistry and Biochemistry, the University of Southern Mississippi, Hattiesburg, MS 39406-0076*

Best Graduate Poster, 1995 Fourteenth Annual Bioremediation Symposium, Columbia, MO, April 20, 1995

"Chitin and Cellulose Derivatives Utilizing the LiCl/N,N-Dimethylacetamide Solvent System,"

Sheila Williamson and Charles L. McCormick

*Department of Polymer Science, University of Southern Mississippi Hattiesburg, Mississippi 39406-0076*

Best Paper in Polymer Science, 1995 Mid-Winter Symposium, Millsaps College, Jackson, MS, January, 1995.

"The Study of Proteins from Plants and Insects as Candidates for Oil Recovery,"

Monica Tisack, Robert Lochhead and Charles L. McCormick

*Department of Polymer Science, University of Southern Mississippi*

*Hattiesburg, Mississippi 39406-0076*

Best Paper in Chemistry, 1995 Mid-Winter Symposium, Millsaps College, Jackson, MS, January, 1995.

"The Use of *De Novo* Designed Responsive Polymers for the Remediation of Hydrocarbons: Polypeptide Emulsifiers,"

Mark Logan, Gordon C. Cannon, and Charles L. McCormick

*Department of Polymer Science, University of Southern Mississippi*

*Hattiesburg, Mississippi 39406-0076*

Mississippi Academy of Science, February 1995, Fisher Biotechnology Award for Best Graduate Presentation in the Division of Cellular and Molecular Biology.

"Controlled Release of the Allelochemical, Naphthol, from Pendently Substituted Acrylic Acid Copolymers: Structural Effects on Release Kinetics in Aqueous Media,"

W. Clayton Bunyard, Chase J. Boudreaux, Charles L. McCormick

*Department of Polymer Science, University of Southern Mississippi*

*Hattiesburg, Mississippi 39406-0076*

Waldo Semon Undergraduate Research Award in Polymer Science and Polymer Engineering for the paper and presentation of "Controlled Release of the Allelochemical, Naphthol, from Pendently Substituted Acrylic Acid Copolymers: Structural Effects on Release Kinetics in Aqueous Media" at the Waldo Semon Undergraduate Research Symposium (sponsored by BFGoodrich) at the University of Akron on April 21, 1995. Received a \$2,000 cash prize.

Five undergraduates in the U.S. conducting research in polymer science were selected on the basis of their papers submitted. The five finalists presented a seminar at the U of Akron and were judged by the University of Akron polymer science faculty.

## **F. Other Funding**

“Responsive Copolymers for Enhanced Oil Recovery, “ Department of Energy, \$295,002 (1994).

Exxon Chemical Company, \$10,000 (1993-1994).

Gillette Research Institute, \$30,000 (1994).

Mobil Oil Company, \$10,000 (1993-1994).

Biopolymer Development, USM, \$84,000 (1993-1994).

Principal Investigator  
C. L. McCormick  
(601)-266-4872/4868

Co-Investigators  
R.Y. Lochhead  
G.C. Cannon

Cognizant ONR Scientific Officer  
Kenneth J. Wynne

#### Brief Description of Project

The overall goal of this research is to develop pH responsive phase transfer polymers capable of removal of water borne contaminants. The phase transfer efficiency of these 'smart' systems is enhanced by maximum interfacial surface area contact between microheterogeneous domains and foulant species. Therefore, this chemistry is amenable for use in microphase separated, polymeric surfactant solutions (liquid membranes), supported hydrogel membranes, grafted and interpenetrating polymer networks, and nanocomposites. For the ESS program, hydrophobic organic and amphiphilic compounds in confined grey water are our targets for remediation.

Major project objectives involve: preparation of precisely tailored synthetic and biosynthetic polymers with domain structures responsive to changes in pH, electrolyte, temperature and shear; study of the extent of domain formation and reversibility utilizing photophysical techniques; examination of the extent and nature of transfer, sequestration, and phase stability with model grey water contaminants; and optimization of the efficiency of polymer and model pollutant separation and recovery. An often overlooked but important goal of this work is the interdisciplinary training and education of young scientists in this vital environmental area.

#### Significant Results During the Last Year

During the last year our research has continued with the synthesis and physical characterization of several microphase-separated synthetic and biosynthetic polymers. A new method of investigating the interaction of these polymers with model foulants has been developed using micellar enhanced ultrafiltration techniques. This technique should provide not only a means of laboratory characterization but potentially a scaleable method that could be employed for large scale remediation.

We have prepared a series of hydrophobically modified poly(sodium maleate-alt-ethylvinyl ether copolymers). These polymers show a polyelectrolyte-to-polysoap transition favored by increasing hydrophobe content. Aromatic hydrocarbon uptake studies have begun on the C-8 and C-12 polymers containing 10-50 mol% over the range of the polyelectrolyte-to-polysoap transition.

Copolymers of acrylamide with sodium 11-acrylamidoundecanoate have been synthesized and show interesting effects in water as a function of polymer concentration, pH and salt. Pyrene probe studies show enhanced hydrophobic domain character ( $I_1/I_3$ ) with association. Currently, we are evaluating these polymers for hydrocarbon and cationic surfactant uptake.

Hydrophobically-modified, cationic DAMAB copolymers have been prepared which exhibit both intramolecular and intermolecular association based on copolymer content, alkyl chain length, and environmental conditions such as pH and ionic strength. These copolymers can bind very strongly to anionic surfactants. We have studied binding isotherms for these systems which offer immense potential for surfactant remediation from aqueous media. Additionally, we are preparing salt-tolerant zwitterionic polymers.

We have concentrated our biosynthetic efforts on isolating and/or preparing recombinantly major transport proteins, apo-III and oleosin. These polymeric biosurfactants play critical roles in stabilizing lipid aggregates for transport in animal and plant species. Importantly, these biopolymers have precise molecular weights and microstructures and undergo reversible conformational changes affecting adsorption to and stabilization of hydrophobic interfaces. Moreover, these systems are non-toxic and break down to simple peptides and amino acid by-products in the environment.

#### Summary of plans for next years work.

During the next year, we plan to continue the study of the synthetic polymers and biopolymers mentioned above. Our work will focus on the interaction of these polymers with model hydrophobic and amphipathic foulants. Incorporation of these target remediation agents into supported liquid membranes and membranes that may be used with existing ultrafiltration methods will be pursued. Temperature or pH triggered phase separation mechanisms will also be a vital part of these new technologies. We feel that the use of polymers that form intermolecular and intramolecular micelles will provide an advantage over the currently used micellar ultrafiltration techniques in that the materials may be contained in the filtration loop and will provide no threat to contamination by diffusion across the membranes to the free effluent stream.

### **Graduate Student Investigators**

Kelly Branham  
Erich Kathmann  
Michael Kramer  
Mark Logan  
Chase Boudreaux  
Sheila Williamson  
Johanna Kahalley  
Kathy Johnson  
Michael F. Richardson  
Monica Tisack  
Jian Bin Xue

### **Post Doctoral Associates**

Yuxin Hu  
Zhang-bei Zhang

### **Undergraduate Assistants**

Jamie Steger  
Leslie White  
Clay Bunyard  
Scott Snowden