



# CONTENTS

THE THERMODYNAMIC FORCES IN AN INTERFACE	1
<i>By Ronald Lovett and Marc Baus</i>	
MOLECULAR SELF-ASSEMBLY INTO CRYSTALS AT AIR-LIQUID INTERFACES	39
<i>By Isabelle Weissbuch, Ronit Popovitz-Biro, Meir Lahav, Leslie Leiserowitz, Kristian Kjaer, and Jens Als-Nielsen</i>	
SOME APPLICATIONS OF FRACTIONAL CALCULUS TO POLYMER SCIENCE	121
<i>By Jack F. Douglas</i>	
THE NEWTONIAN VISCOSITY OF A MODERATELY DENSE SUSPENSION	193
<i>By Eligiusz Wajnryb and John S. Dahler</i>	
A REVIEW OF FOAM DRAINAGE	315
<i>By D. Weaire, S. Hutzler, G. Verbist, and E. Peters</i>	
AUTHOR INDEX	375
SUBJECT INDEX	383



# **THE THERMODYNAMIC FORCES IN AN INTERFACE**

**RONALD LOVETT**

*Department of Chemistry, Washington University, St. Louis, MO 63130*

**MARC BAUS**

*Faculté des Sciences, C.P. 231, Université Libre de Bruxelles,  
B-1050 Brussels, Belgium*

## **CONTENTS**

- I. Introduction**
  - II. The Force Problem**
  - III. The Solution**
  - IV. Density Functional Theory**
  - V. Thermodynamics**
  - VI. Molecular Realizations**
  - VII. The Cylindrical Interface**
  - VIII. Young's Model and the Surface Tension**
  - IX. The Free Energy Density**
  - X. The Stress Tensor Exposed**
  - XI. Conclusions**
- Acknowledgments**
- References**



# MOLECULAR SELF-ASSEMBLY INTO CRYSTALS AT AIR-LIQUID INTERFACES

ISABELLE WEISSBUCH, RONIT POPOVITZ-BIRO,  
MEIR LAHAV, AND LESLIE LEISEROWITZ

*Department of Materials and Interfaces, The Weizmann Institute of Science,  
Rehovot, 76100 Israel*

KRISTIAN KJAER

*Department of Solid State Physics, Risø National Laboratory, DK-4000  
Roskilde, Denmark*

JENS ALS-NIELSEN

*H.C. Ørsted Laboratory, Niels Bohr Institute, DK2100  
Copenhagen, Denmark*

## CONTENTS

- I. Introduction
- II. Packing properties of self-assembled crystalline monolayers
  - A. Introduction
  - B. Crystalline Self-Assembly of Amphiphilic Molecules
  - C. Correlation between Crystal Domain Anisotropy and Lattice Energy
- III. Effect of solute, solvent, and ions on growth, dissolution and structure of amphiphilic monolayers
  - A. Effect of Glycine and  $\beta$ -Alanine Solutes in the Aqueous Subphase on  $\alpha$ -Amino Acid Monolayers
  - B. Effect of Formamide and Formic Acid Cosolvents on Crystallinity and Structure of Amphiphilic Monolayers
  - C. Ion Binding and Growth of Amphiphilic Monolayers
- IV. Crystalline multilayers of chain-like molecules on Liquid Surfaces

- A. Aliphatic Primary Amides on Water, Formamide, and Water–Formamide Mixtures
  - B. Aliphatic Secondary Amides on Formamide and Water–Formamide Mixtures
  - C. Direction of Interlayer Growth of Primary and Secondary Aliphatic Amides at the Air–Formamide Interface
  - D. Multilayer Formation of Bolaform Amphiphiles on Water
  - E. Self-Assembled Crystalline Films of *n*-Alkanes on Water
  - V. Tailor-made surfaces composed of amphiphilic monolayers for promotion of crystal nucleation
    - A. Introduction
    - B. Crystal Nucleation of 4-Methoxycinnamic Acid at the Air–Solution Interface
    - C. Transfer of Structural Information from  $\alpha$ -Amino Acid Monolayers to Underlying Nucleated Crystals of  $\alpha$ -Glycine
    - D. Two-Dimensional Crystals of Heterochiral Arrangement from Racemic  $\alpha$ -Amino Acid Amphiphiles on Aqueous Solutions
    - E. Spontaneous Separation of Racemic Mixtures of  $\alpha$ -Amino Acid Monolayers into Enantiomorphous Domains
    - F. Crystallization of NaCl Under Amphiphilic Monolayers
    - G. Oriented Nucleation of 4-Hydroxybenzoic Acid Monohydrate
    - H. Structured Surfaces of Mixed Monolayers for Induced Three-Dimensional Crystallization
    - I. Induced Nucleation of Ice by Monolayers of Long-Chain Alcohols
  - VI. Conclusions
- Appendix  
References







# **SOME APPLICATIONS OF FRACTIONAL CALCULUS TO POLYMER SCIENCE**

**JACK F. DOUGLAS**

*Polymers Division, National Institute of Standards and Technology,  
Gaithersburg, MD 20899*

## **CONTENTS**

- I. Introduction**
- II. Path-Integration and Fractional Calculus**
  - A. The Wiener Path-Integral Model of Flexible Polymers**
  - B. Fractional Calculus Treatment of Surface-Interacting Polymers**
- III. Translational Friction and Capacity of Polymer Chains**
- IV. Virial Coefficients, the Wiener Sausage, and Shape Recognition**
- V. Conclusion.**
- Appendix A. Stable Processes and Subordination**
- Appendix B. Smoothing and Mechanical Similarity**
- Acknowledgements**
- References**



# THE NEWTONIAN VISCOSITY OF A MODERATELY DENSE SUSPENSION

ELIGIUSZ WAJNRYB\* AND JOHN S. DAHLER

*Department of Chemical Engineering and Materials Science,  
University of Minnesota, Minneapolis, MN 55455*

## CONTENTS

- I. Introduction
  - A. Synopsis of the Theory
- II. The Formal Theory
  - A. Friction and Mobility Tensors
  - B. The Smoluchowski Equation
  - C. The Construction of  $\langle F \rangle$
  - D. Cluster, Virial Expansion of the Operator  $B$
- III. The First-Order Viscosity Contribution,  $\eta_1$ 
  - A. Spherically Symmetric Particles
  - B. Axisymmetric Particles
- IV. The Second-Order Viscosity Contribution,  $\eta_2$ 
  - A. The Hydrodynamic Contributions  $B^{(2)H}$  and  $\eta_2^H$
  - B. The Point Stresslet Model
  - C. The Brownian-Interactional Contributions  $B^{(2)B}$  and  $\eta_2^B$
- V. The Third-Order Viscosity Contribution,  $\eta_3$ 
  - A. The Viscosity Contribution,  $\eta_3^{(2)}$
  - B. The Viscosity Contribution,  $\eta_3^{(3)}$
  - C. The Coefficient  $\eta_3^H$  for the Point Stresslet Model
- VI. Numerical Procedures and Results
  - A. The Coefficient  $b_2^H$
  - B. The Coefficient  $b_2^B$ 
    - 1. Stick Boundary Conditions ( $s = 0$  and  $p = 0$ )
    - 2. Mixed-Boundary Conditions ( $0 \leq s \leq \frac{1}{3}$ ) [Fluid Droplet Model ( $0 \leq p \leq 1$ )]
    - 3. Numerical Calculation of  $b_2^B$
  - C. Sticky Spheres with Stick Boundary Conditions
- VII. Summary and Closing Remarks

\* Permanent address: Institute of Fundamental Technological Research, Polish Academy of Sciences, Świątokrzyska 21, PL-00-049 Warsaw, Poland.

*Advances in Chemical Physics, Volume 102*, Edited by I. Prigogine and Stuart A. Rice.  
ISBN 0-471-19144-2 © 1997 John Wiley & Sons, Inc.

**Acknowledgments**

- Appendix A.** Formulas for the Many-Body Mobility Tensors
- Appendix B.** The Case of Spherical Solute Particles
1. The Single-Particle Smoluchowski Equation
  2. The Two-Particle Smoluchowski Equation
  3. The Three-Particle Smoluchowski Equation
- Appendix C.** The Coefficients  $\mu^{ss,j}$  of Eq. (3.48)
1. Lemma
  2. Proof of Lemma
  3. Application of the Lemma
- Appendix D.** An Identity Connected with  $\eta_1^B$
- Appendix E.** Two Integrals of the Oseen Tensor
- Appendix F.** Existence of the Viscosity Contribution  $\eta_3^{(3)E}$
- Appendix G.** Series Expansions of Mobility Matrices
- References**





# A REVIEW OF FOAM DRAINAGE

D. WEAIRE AND S. HUTZLER

*Physics Department, Trinity College, Dublin, Ireland*

G. VERBIST AND E. PETERS\*

*Shell Research and Technology Centre, Amsterdam, 1030 BN Amsterdam,  
The Netherlands*

## CONTENTS

- I. Introduction
  - A. Notation
- II. Foam Structure
- III. Foam Equilibrium Under Gravity
- IV. Foam Drainage: History
  - A. Early Contribution
  - B. Kraynik's Solution
  - C. Profile Measurements
  - D. Further Elaboration of the Theory
- V. Elementary Experimental Observations of Forced Drainage
- VI. Various Experimental Methods
  - A. Segmented Measurements of Capacitance and Resistance
    - 1. Alternating Current Capacitance Measurement
    - 2. Conductance Measurement
  - B. Magnetic Resonance Imaging
  - C. Optical Glass Fiber Probe Method
- VII. The Foam Drainage Equation
- VIII. Solutions of the Foam Drainage Equation
  - A. Equilibrium
  - B. Steady Drainage
  - C. Solitary Wave: Wetting of a Dry Foam

\* Present address: Laboratory of Aero and Hydrodynamics, TU Delft, The Netherlands.



- D. Solitary Wave on an Already Wetted Foam
- E. Reduction to First Order, Pulses, and Free Drainage
  - 1. Pulses
  - 2. Free Drainage
- IX. The Theory of Solitary Waves
- X. Quantitative Comparison with Experiments
  - A. Formula for the Liquid Fraction
  - B. Forced Drainage
  - C. Free Drainage
  - D. Pulsed Drainage
  - E. Effective Viscosity
  - F. Widths of Wavefronts
  - G. Double Waves
- XI. Ongoing Experimental Investigation
- XII. Conclusion
  - A. Outstanding Issues
  - B. Potts Model Simulation
  - C. Future Work

Acknowledgements

References

