J. Adhesion Sci. Technol. Vol. 6, No. 4, pp. 401–412 (1992)

Robert J. Good, innovator in colloid and surface chemistry

INTRODUCTION

Professor Robert J. Good, to whom this Festschrift is dedicated, is one of those phenomena one encounters very rarely: a genuine scientist's scientist. For the last 40 years Good has unremittingly studied the interfacial aspects of wetting, adhesion, contact angles, and solubility. In 1957 and 1960 he published, with L. A. Girifalco, the now world-famous papers, introducing the 'geometric mean' hypothesis and the Φ parameter [7, 8, 13], which provided the first modern breakthrough in the quest to understand the puzzling nature of interfacial interactions between organic compounds and water. Widespread recognition soon came and prestigious awards followed. However, all this did not lead him to rest on his laurels, nor did it instill in him a rigid conviction of the infallibility of his theory. The theory is, indeed, perfectly sound, and predictive with respect to one major class of interactions. But it gradually became apparent that whilst it covered all the observed phenomena impeccably, it did not 'describe' them in a manner which could significantly enhance our understanding of the fundamental physical and/or chemical nature of the interactions in highly polar substances. Thus, with his deep-rooted curiosity and his thorough understanding of the problem and of its complete physical–chemical background, Good not only remained receptive to all suggestions for improvement and to new theories from other workers, but he also continued to encourage and to lead discussions on the subject within his own circle, and kept a research program going in the field of apolar and polar interactions among condensed-phase materials. When novel breakthroughs arose from these activities within his own circle, he was, and still is, delighted with these developments and never hesitated to abandon less-promising pathways in favor of more productive approaches and of theories which appeared more cogent from a physical–chemical viewpoint.

Thus, the sheer number, the high quality, the unusual diversity, and, frequently, the marked originality of the papers contributed to the Symposium in Honor of Professor Robert J. Good by his colleagues and former and present collaborators should not surprise anyone who knows him and his work.

BIOGRAPHICAL SKETCH

Professor Good was the second son of four sons of a family living in Nebraska. Professor Good's mother was from Exmouth, Devonshire, England; his father met her in England while on a Rhodes scholarship to the University of Oxford, where he took his law degree. His father subsequently practiced law in Lincoln, NB, and later in Omaha; in 1931 he was elected Attorney-General of the State of Nebraska and served in that position for 2 years.

Robert Good attended elementary school and high school in Lincoln, NB, and then went to Amherst College, Amherst, MA, where he obtained his B.A. in chemistry in 1942. He went on to the University of California at Berkeley, where he obtained an M.S. in chemistry in 1943. In 1950 he obtained a Ph.D. in chemistry at the University of Michigan.

At Amherst, he started in a pre-medical major, but switched to chemistry after 1 year. This was after taking freshman chemistry from a fine surface chemist and physical chemist, Ralph A. Beebe. He did a senior project under another important surface chemist, David C. Graham, on the electric double layer at the dropping mercury electrode. At Berkeley, he started to work on a thermodynamic problem under Kenneth S. Pitzer. He then turned to nuclear chemistry to prepare for work on the Manhattan Project, but was advised, 'Forget it': Draft boards hadn't been told about that project, and were calling up everybody who went on it.

During 1943–1944 Good worked as a chemist at Dow Chemical Co., Pittsburg, CA, and from 1944 to 1946 at American Cyanamid & Chemical Co., Azusa, CA. During 1953–1957 he was Associate Professor in the Department of Applied Science, University of Cincinnati, Cincinnati, OH. During 1957–1964 he was Senior Scientist at the Convair Space Science Laboratory, General Dynamics Co., San Diego, CA. Since 1964 Good has been Professor, Department of Chemical Engineering, State University of New York at Buffalo.

At Dow Chemical Co., Pittsburg, CA, he worked as a chemist on the development of chlorination reactions. At American Cyanamid, Azusa, CA, he worked in a poison gas plant that made cyanogen chloride, doing control analysis. After V-J day, while waiting for admission to graduate school, he worked on additives for oil well drilling mud. He read up on the colloidal chemistry of clays, on rheology, and on DLVO theory. (The Verwey and Overbeek book *Theory of the Stability of Lyophobic Colloids* became available in 1948.) At Michigan, he learned considerable colloid chemistry from F. E. Bartell and from his students such as Robert S. Hansen, Ying Fu, and others. He chose Lawrence O. Brockway for research advisor, to work on a surface chemistry problem: the flotation of sulfide ores, with alkyl xanthates to make them hydrophobic. Electron diffraction by solid surfaces was the principal research tool. His first independent paper was based on work done while at Michigan but not included in his thesis [2].

After he received his Ph.D., he worked in the Research Laboratory of the Monsanto Chemical Co., Anniston, AL. There, he worked on liquid dielectrics for capacitors and transformers: the chlorinated biphenyls. (See ref. 9 on this subject.) Monsanto wanted to publish some papers on 'pure' chemistry and so asked him to propose something. The result was ref. 3, which includes some solubility theory after the manner of Hildebrand and Guggenheim. In 1953 he went to Cincinnati as an assistant professor, to take charge of several existing, sponsored projects for the Navy, the Air Force, the Army, and private industry. Results: refs 4–13 and 16, 19, and 20. Reference 4 (which was mainly the Ph.D. thesis of Louis A. Girifalco), though a report to the Air Force, may be ranked as a publication because it contains the material that became the Good–Girifalco theory, [7, 8, 13], and it is sometimes cited in the literature. Eight other papers, between 1960 and 1986, were direct outgrowths of those first three. The acid–base theory, which started in collaboration with Chaudhury and van Oss in 1986, has so far led to over 25 papers.

Other studies at Cincinnati included the 'direct' problem of adhesion, e.g. mechanical tests on coatings and adhesives, and also the adhesion of ice to aircraft wings (see the title of ref. 4). He also studied surface diffusion in an adsorbed film, the swelling of rubber by solvents, and the diffusion of oxygen through synthetic polymers, as well as the dielectric losses in polar, insulating liquids, and the theory of surface entropy. At the University of Cincinnati, he taught surface chemistry and statistical thermodynamics. At the Convair Space Science Lab, General Dynamics at San Diego, he continued the development of the Good–Girifalco theory and did some measurements related to it, e.g. interfacial tensions and contact angles (see refs 14, 15, 17, and 18). He also worked, from time to time, on projects related to the *Atlas* rocket production and to various aircraft made by Convair.

At Buffalo, he was taught surface chemistry, materials science, corrosion engineering, thermodynamics, and statistical thermodynamics. His research has been on surface and colloid chemistry, and he also wrote some papers on the direct problem of adhesion (15 papers; see, in particular, refs 33, 39, 44, and 126), on corrosion, on materials science (e.g. cement [73, 74]), and on thermodynamics. He holds a patent [51] on the use of polymers for the stationary phase in open-tube gas chromatography; the work was done for Phillips Petroleum Co. Recently, he has worked on the surface chemistry of coal, with a view to alleviating the acid rain problem. Four papers are in print [121, 129–131], and there is a patent applied for [128] based on this work; several more papers are in preparation. One paper on corrosion [83] explains the passivity of iron, aluminum, nickel, chromium, etc. (which is of great importance in corrosion resistance and in electrochemistry) as being caused by the semiconductor behavior of oxides such as Fe_2O_3. Another paper on corrosion is ref. 22, about grain-boundary attack on metals.

His theoretical thermodynamics and statistical thermodynamics papers, other than the Good–Girifalco–van Oss–Chaudhury papers are refs 2, 6, 21, 25, 28–30, 38, 52, 53, 60, 69, 71, 79, 80, 97, and 106. Many of these arose from teaching, alternately, courses in surface chemistry and in thermodynamics.

In 1984, Dr. M. K. Chaudhury obtained his Ph.D. with Professor Good, with a thesis on 'Short-range and long-range forces in colloidal and macroscopic systems'. Here Chaudhury applied the Lifshitz approach to interfacial interactions and to surface properties of condensed-phase materials. Chaudhury and Good [109, 127] showed that in macroscopic systems, dispersion, induction, and orientation interaction forces can all be grouped together, and are described by similar equations and decay at the same rate, as a function of distance. The theory of these electromagnetic interactions had been developed first by van der Waals and later, London, and after the war (for macroscopic phenomena) by Lifshitz. So, it was proposed to allude to these collective electrodynamic interactions as Lifshitz–van der Waals or LW forces. These results suddenly made it easy to emerge from the quandary which had stymied everyone up to this point, namely how to distinguish 'polar' interactions such as Keesom (dipole-dipole) forces from other 'polar' interactions of the class of, for example, hydrogen bonds. This opened the way to a rational treatment of the interplay between Lifshitz–van der Waals and Lewis acid–base (AB), or electron acceptor/electron donor, interactions in interfacial phenomena [95, 99, 100, 102–105, 107–112, 114, 116–125, 128, 130]. Many of these papers are of biological interest, as are, in addition, refs 24, 40–42, and 49.

Professor Good also worked on microemulsions, bringing to bear (in collaboration with Drs. Ho and van Oss) the techniques of light scattering and ultracentrifugation. He discovered an anomalous sedimentation effect, in which the particles drifted downward at a rate that was about an order of magnitude larger than that expected from the particle size. With Dr. M. V. Ostrovsky, he studied the dynamics of particle fissioning and recombination in multiphase systems [87–89, 96]. He contributed to the study of porosity, particularly the role played by adsorbed films on the internal pore surface, ahead of the advancing liquid front [34, 45, 57, 58]. This led to a generalization of the Lucas–Washburn equation for the rate of penetration of a liquid into a bed of powder or a porous solid. He also investigated the effect of internal roughness of pores and how it affects the determination of pore size [77, 86].

Professor Good also long had an interest in the philosophy of science, and in 1980 [75] he published a model of the methodology used by most (if not all) physical scientists. It involves two feedback loops: one is a cycle of theorizing (without additional experimentation) and the other a cycle of experimentation to test the results from the theorizing loop. The scientist switches back and forth between the two kinds of loop. The closure of the process comes when the experimental results, and the predictions, are in agreement, and when both are compatible with all the rest of scientific knowledge.

On a personal level, Bob Good is the most agreeable companion imaginable. He is exceedingly entertaining, polite but incisive in his opinions, most convivial, and unfailingly helpful to friends and colleagues. His charming Scottish wife, Maud, even though not personally conversant with our abstruse discipline, has become as much a landmark in the world of colloid and surface chemistry as Bob himself. Bob Good is further known for his excellent taste in unblended malt Scotch whisky, and for his predilection for English poetry, in the venerable mode of the limerick.

CAREL J. VAN OSS
State University of New York at Buffalo

AWARDS

The two major awards earned by Professor Good were:

Kendall (1976): The American Chemical Society Award in Colloid or Surface Chemistry, sponsored by the Kendall Co.:

'For his pioneering investigations of atomic and molecular interactions across interfaces, and the application of the resulting, new concepts to scientific, technological, and biological problems.'

The Jacob R. Schoellkopf Award (1979): The Western New York Section of the American Chemical Society:

'For his pioneering research in surface thermodynamics, the theoretical chemistry of adhesion phenomena, the factors controlling the penetration of liquids into porous solids, and physical aspects influencing the aggregation of living cells.'

SELECTED SCIENTIFIC AND PROFESSIONAL SOCIETIES AND ACTIVITIES

American Chemical Society.
The Chemical Society, Faraday Division.
National Association of Corrosion Engineers.
Chairman, San Diego Section, American Chemical Society, 1961–1962.
Chairman, Gordon Conference on Chemistry at Interfaces, 1975.
National Councilor, American Chemical Society, 1974–1982, representing Western New York Section.
National Alternate Councilor, American Chemical Society, 1968–1971, representing Colloid and Surface Chemistry Division.
The Adhesion Society.
Member, National Colloid Symposium Committee, American Chemical Society, 1966, and Chairman for 41st Symposium, 1966.
Chairman, Educational Committee, Western New York Section, National Association of Corrosion Engineers, 1975–1979.
Chairman, Buffalo Section, Sigma Xi, 1975–1976.
Colloid and Surface Science Symposium: General Chairman for 51st Annual Meeting, 1977.

PUBLICATIONS

1. R. J. Good, An electron diffraction investigation of surface reactions in flotation, Ph.D. Thesis, University of Michigan (1950) (Advisor: L. O. Brockway).
2. R. J. Good, A thermodynamic derivation of Wenzel's modification of Young's equation, together with a theory of hysteresis, *J. Am. Chem. Soc.* **74**, 5041 (1953).
3. R. J. Good, E. E. Hardy, A. M. Ellenburg and H. B. Richards, Jr., The solubility of *p*-terphenyl in *o*- and *m*-terphenyls and in biphenyl, *J. Am. Chem. Soc.* **75**, 436–442 (1953).
4. P. E. Berghausen, R. J. Good, G. Kraus, B. Podolsky and W. Soller, Fundamental studies of the adhesion of ice to solids, WADC Report No. 55-44, Wright Air Development Center, Wright Patterson Air Force Base, Ohio (1955).
5. R. J. Good and J. Ross, The adsorption and surface diffusion of butane on Spheron 6 (2700°) carbon black, *J. Phys. Chem.* **60**, 1167 (1956).
6. R. J. Good, Surface entropy and surface orientation of polar liquids, *J. Phys. Chem.* **61**, 810–812 (1957).
7. R. J. Good and L. A. Girifalco, A Theory for the estimation of surface and interfacial energies, I. Derivation and application of interfacial tension, *J. Phys. Chem.* **61**, 904–909 (1957).
8. R. J. Good, L. A. Girifalco and G. Kraus, A Theory for the estimation of surface and interfacial energies, II. Application to surface thermodynamics of teflon and graphite, *J. Phys. Chem.* **62**, 1418–1422 (1958).
9. R. J. Good, J. W. Winslow, Jr. and P. E. Berghausen, Dielectric dispersion in viscous polar liquids, *J. Chem. Phys.* **27**, 309–331 (1958).
10. R. J. Good, C. A. Guderjahn, D. A. Paynter and P. E. Berghausen, Heat of bulb breaking in heat of immersion calorimetry, *J. Chem. Phys.* **28**, 520–521 (1958).
11. R. J. Good, C. A. Guderjahn, D. A. Paynter and P. E. Berghausen, The slow evolution of heat in heat of immersion calorimetry, *J. Phys. Chem.* **63**, 2066–2068 (1959).
12. R. J. Good and L. Spenadel, Synthetic rubber for self-sealing fuel tanks, *Ind. Eng. Chem.* **51**, 935–936 (1959).
13. R. J. Good and L. A. Girifalco, A Theory for the estimation of surface and interfacial energies, III. Estimation of surface energies from contact angle data, *J. Phys. Chem.* **64**, 561–565 (1960).
14. R. J. Good and G. Ferry, The Wetting of Solids by Liquid Hydrogen, *Adv. Cryog. Eng.* **8**, 306–310 (1963).
15. R. J. Good and J. T. Neu, Fluid behavior in zero gravity, *AIAA J.* **1**, 814–819 (1963).
16. R. J. Good, Theory for the estimation of surface and interfacial energies, IV. Surface energies of some fluorocarbon surfaces from contact angle measurements. In: *Contact Angle, Wettability and Adhesion,* Advances in Chemistry Series, No. 43, pp. 74–87. American Chemical Society, Washington, DC (1964).

17. R. J. Good and W. G. Givens, The contact angle at the mercury–gallium–glass interface. In: *Contact Angle, Wettability and Adhesion*, Advances in Chemistry Series, No. 43, pp. 211–221. American Chemical Society, Washington, DC (1964).
18. R. J. Good and W. G. Givens, Transport of aqueous solutions at a mercury–glass interface, induced by electric polarization, *J. Phys. Chem.* **68**, 418–419 (1964).
19. R. J. Good, On the estimation of surface energies from contact angles, *Nature* **212**, 276–277 (1966).
20. R. J. Good, On the physical significance of the parameters that govern wetting. In: *Wetting*, Soc. Chem. Ind. (London), Monograph No. 25, pp. 328–350 (1966).
21. R. J. Good and M. C. Phillips, Theory of the dipole energy of a monolayer. In: *Wetting*, Soc. Chem. Ind. (London), Monograph No. 25, pp. 444–448 (1966).
22. R. J. Good, Surface energy and the corrosion and embrittlement of metals by liquid metals. In: *The Environment-Sensitive Mechanical Behavior of Materials*, A. R. C. Westwood and N. Stoloff (Eds), pp. 541–561. Gordon and Breach, New York (1967).
23. R. J. Good, Intermolecular and interatomic forces. In: *Treatise on Adhesion and Adhesives*, R. L. Patrick (Ed.), pp. 9–68. Marcel Dekker, New York (1967).
24. R. J. Good and N. L. Gershfeld, Line tension and the penetration of a cell membrane by an oil droplet, *J. Theor. Biol.* **17**, 246 (1967).
25. R. J. Good, A thermodynamic analysis of the formation of bilayer films, *J. Colloid Interface Sci.* **31**, 540–544 (1969).
26. R. J. Good, Intermolecular force across an interface, *Trans. Soc. Automotive Eng.* (Jan. 1970).
27. R. J. Good and E. Elbing, Generalization of the theory for the estimation of interfacial energies: theory of systems with high mutual solubilities and with various degrees of polarity, *Ind. Eng. Chem.* **62**, 54–78 (1970); also translated into Japanese for the journal *Hyomen (Surface)* **10**, 624 (1973).
28. R. J. Good and C. J. Hope, A new combining rule for intermolecular distances, *J. Chem. Phys.* **53**, 540–543 (1970).
29. R. J. Good and C. J. Hope, Test of combining rules for intermolecular distances: potential function constants from second virial coefficients, *J. Chem. Phys.* **55**, 111–116 (1971).
30. R. J. Good and C. J. Hope, Application of the 'geometric mean' combining rule for intermolecular distances to the theory of interfacial energies, *J. Colloid Interface Sci.* **35**, 171 (1971).
31. R. J. Good, J. A. Kvikstad and W. O. Bailey, Hysteresis of contact angles: the effect of elongation and roughness, as studied by scanning electron microscopy. In: *Scanning Electron Microscopy of Polymers and Coatings*, L. H. Princen (Ed.), pp. 153–164. Applied Polymer Symposium. John Wiley, New York (1971).
32. R. J. Good, J. A. Kvikstad and W. O. Bailey, Anisotropic forces in a stretch-oriented polymer, *J. Colloid Interface Sci.* **35**, 314 (1971).
33. R. J. Good, Thermal effects in the peeling separation of an adhering system. In: *Aspects of Adhesion*, vol. 6, pp. 24–42. University of London Press, London (1971).
34. R. J. Good, Transport of a fluid in a porous medium: a generalization of the Washburn equation, *Chem. Ind.* 600 (1971).
35. J. D. Eick, R. J. Good, J. R. Fromer, A. W. Neumann and L. N. Johnson, Influence of roughness on wetting and adhesion, *J. Adhesion* **3**, 23 (1971).
36. M. C. Phillips, R. J. Good, D. A. Cadenhead and H. F. King, Dipole interactions in monomolecular layers, *J. Colloid Interface Sci.* **37**, 437 (1971).
37. R. J. Good, R. R. Stromberg and R. L. Patrick (Eds), *Techniques of Surface and Colloid Chemistry and Physics*, vol. 1. Marcel Dekker, New York (1972).
38. A. W. Neumann and R. J. Good, Thermodynamics of contact angles, I. Heterogeneous solid surfaces, *J. Colloid Interface Sci.* **38**, 341 (1972).
39. R. J. Good, Theory of 'cohesive' vs. 'adhesive' separation in an adhering system, *J. Adhesion* **4**, 133–154 (1972).
40. R. J. Good, Theory of the adhesion of cells and the spontaneous sorting-out of mixed cell aggregates, *J. Theor. Biol.* **37**, 413–434 (1972).
41. C. J. van Oss, R. J. Good and A. W. Neumann, The connection of interfacial free energies and surface potentials with phagocytosis and cellular adhesiveness, *J. Electroanal. Chem. Interfacial Electrochem.* **37**, 387 (1972).

42. C. J. van Oss, C. F. Gillman and R. J. Good, The influence of shape of phagocytes on their adhesiveness, *Immunol. Commun.* **1**, 627 (1972).
43. J. D. Eick, L. N. Johnson, J. R. Fromer, R. J. Good and A. W. Neumann, Surface topography: its influence on wetting and adhesion in a dental system, *J. Dental Res.* **51**, 780 (1972).
44. R. J. Good, Bikerman's dogma, or the real probability of interfacial separation in an adhering system, *Proc. Tech. Symp. Non-Woven Product Technology: Materials, Processes and Evaluation*, 219–224 (1973).
45. R. J. Good, The rate of penetration of a fluid into a porous body initially devoid of adsorbed material, *J. Colloid Interface Sci.* **42**, 473 (1973).
46. R. J. Good, The role of wetting and spreading in adhesion. In: *Aspects of Adhesion*, D. J. Alner and K. W. Allen (Eds), pp. 182–301. Transcripta Books, London (1973).
47. A. W. Neumann, R. J. Good, P. Ehrlich, P. K. Basu and G. J. Johnston, The temperature dependence of the surface tension of solutions of atactic polystyrene, *J. Macromol. Sci., Phys.* **B7**, 525 (1973).
48. R. J. Good, Surface physics of adhesion, state of the art, 1972. In: *Recent Advances in Adhesion*, L. H. Lee (Ed.), pp. 107–119. Gordon and Breach, London (1973).
49. C. J. van Oss, R. M. Fike, R. J. Good and J. M. Reinig, Cell microelectrophoresis simplified by the reduction and uniformization of the electro-osmotic backflow, *Anal. Biochem.* **60**, 242 (1974).
50. A. W. Neumann, R. J. Good, C. J. Hope and M. Sejpal, A corresponding states approach to estimate surface free energies of low energy solids from contact angles, *J. Colloid Interface Sci.* **49**, 291 (1974).
51. R. J. Good, Chromatographic apparatus with polymeric partitioning phase (assigned to Phillips Petroleum Company), U.S. Patent No. 3,808,125 (1974).
52. R. J. Good, Equilibrium film pressure on a flat, low-energy solid. In: *Adsorption at Interfaces*, K. L. Mittal (Ed.), ACS Symposium Series No. 8, pp. 28–47. American Chemical Society, Washington, DC (1975).
53. R. J. Good, Spreading pressure and contact angle, *J. Colloid Interface Sci.* **52**, 308 (1975).
54. R. J. Good, J. D. Eick and A. W. Neumann, Thermodynamics of contact angles. II. Rough solid surfaces, *J. Colloid Interface Sci.* **53**, 235 (1975).
55. R. J. Good, How to solve the problem of adhesion: a prescription. In: *Adhesion Science and Technology*, L. H. Lee (Ed.), Part A, p. 37. Plenum Press, New York (1975).
56. R. J. Good, The role of interfacial processes in adhesion. In: *Adhesion Science and Technology*, L. H. Lee (Ed.), Part A, p. 107. Plenum Press, New York (1976).
57. R. J. Good and N. J. Lin, Rate of penetration of a fluid into a porous body. II. Verification of the generalization of the Washburn equation, for organic liquids in glass capillaries, *J. Colloid Interface Sci.* **54**, 52 (1976).
58. R. J. Good and N. J. Lin, Rate of penetration of a fluid into a porous body. III. Glass fibres and TiO_2 powder. In: *Colloid and Interface Science, Vol. III, Adsorption, Catalysis, Solid Surfaces, Wetting, Surface Tension and Water*, M. Kerker (Ed.), pp. 277–299. Academic Press, New York (1976).
59. R. J. Good, On the definition of adhesion, *J. Adhesion* **8**, 1 (1976).
60. R. J. Good, Thermodynamics of adsorption and Gibbsian distance parameters in two- and three- component systems (Proc. IUPAC International Conference on Colloid and Surface Science, Budapest, Sept. 1975), *Pure Appl. Chem.* **48**, 427 (1976).
61. C. J. van Oss, R. J. Good, A. W. Neumann and J. D. Wieser, Comparison between attachment and detachment approaches to the quantitative study of cell adhesion to low energy solids, *J. Colloid Interface Sci.* **59**, 505 (1977).
62. R. J. Good, Surface free energy of solids and liquids: thermodynamics, molecular forces and structure, *J. Colloid Interface Sci.* **59**, 398 (1977).
63. R. J. Good, Modeling cell rearrangement, *BioScience* **27**, 816 (1977).
64. R. J. Good and J. K. Paschek, The wetting of outgassed glass and silica by mercury, and the dependence of contact angles on water vapor pressure. In: *Proceedings of the Conference on Wetting, Loughborough University, England, September 1976*, J. F. Padday (Ed.), pp. 147-160. Academic Press, New York (1978).
65. R. J. Good, The locus of failure and its implications for adhesion measurement. In: *Adhesion Measurement of Thin Films, Thick Films and Bulk Coatings*, K. L. Mittal (Ed.), STP 640,

pp. 18–29. American Society for Testing and Materials, Philadelphia (1978).
66. R. J. Good and E. D. Kotsidas, The contact angle of water on polystyrene: a study of the cause of hysteresis, *J. Colloid Interface Sci.* **66**, 360 (1978).
67. R. J. Good and E. D. Kotsidas, Contact angles on swollen polymers: the surface energy of crosslinked polystyrene, *J. Adhesion* **10**, 17 (1979).
68. R. J. Good and R. R. Stromberg (Eds), *Colloid and Surface Science*, vol. 11. Plenum Press, New York (1979).
69. R. J. Good, Contact angles and the surface free energies of solids. In: *Colloid and Surface Science*, R. J. Good and R. R. Stromberg (Eds), vol. 11, pp. 1–29. Plenum Press, New York (1979).
70. A. W. Neumann and R. J. Good, Methods of measuring contact angles. In: *Colloid and Surface Science*, R. J. Good and R. R. Stromberg (Eds), vol. 11, pp. 31–91. Plenum Press, New York (1979).
71. R. J. Good and F. P. Buff, Excess interfacial entropy and total energy in binary, liquid–liquid systems. In: *The Modern Theory of Capillarity*, A. I. Rusanov and F. C. Goodrich (Eds), pp. 44–62. Khimia, Leningrad (1980) (in Russian) and Akademie-Verlag, Berlin (1981) (in English).
72. R. J. Good and M. N. Koo, The effect of drop size of contact angle, *J. Colloid Interface Sci.* **71**, 283 (1979).
73. S. Hanafi, S. A. Abo-El-Enein, R. Sh. Mikhail, R. J. Good and J. Irani, Hydration characteristics of post-hydration compressed expansive clinker pastes, *Cemento* **76**, Oct.–Dec., 189 (1979).
74. R. Sh. Mikhail, S. Hanafi, S. A. Abo-El-Enein, R. J. Good and J. Irani, Morphology and surface area changes in the thermal dissociation of Iceland spar, *J. Colloid Interface Sci.* **75**, 74 (1980).
75. R. J. Good, Surface chemistry and the difference between search and research, *CHEMTECH.* **10**, 100–109 (1980).
76. C. J. van Oss, A. W. Neumann, R. J. Good and D. R. Absalom, The influence of extremely small attractive as well as repulsive van der Waals–London forces on cell interactions. In: *Bioelectrochemistry: Ions, Surfaces, Membranes*, M. Blank (Ed.), Advances in Chemistry 188, p. 107. American Chemical Society, Washington, DC (1980).
77. R. J. Good and R. Sh. Mikhail, The contact angle in mercury-intrusion porosimetry, *Powder Technol.* **29**, 53 (1981).
78. R. J. Good, The semantic physics of adhesion. In: *Treatise on Adhesion and Adhesives*, R. L. Patrick (Ed.), vol. 5, pp. 293–312. Marcel Dekker, New York (1981).
79. R. J. Good, Thermodynamics of adsorption and Gibbsian distance parameters, II. The pressure coefficient of interfacial tensions in ternary two- and three-phase systems, *J. Colloid Interface Sci.* **85**, 128 (1982).
80. R. J. Good, Thermodynamics of adsorption and Gibbsian distance parameters, III. Interfacial distances and the surface excess volume, *J. Colloid Interface Sci.* **85**, 141 (1982).
81. R. J. Good and C. J. Sun, A quasi-periodic time dependence of interfacial tension in an oil–water–surfactant system, *J. Colloid Interface Sci.* **91**, 341 (1983).
82. M. K. Chaudhury and R. J. Good, Retarded van der Waals force theory of stable thick films in a system of three condensed phases, *J. Colloid Interface Sci.* **94**, 292 (1983).
83. R. J. Good, On the oxidation rate laws of metals that form nonstoichiometric oxides. In: *Passivity of Metals and Semiconductors*, M. Froment (Ed.), pp. 43–50. Elsevier, Amsterdam (1983).
84. C. J. van Oss and R. J. Good, The equilibrium distance between two bodies immersed in a liquid, *Colloids Surf.* **8**, 373 (1984).
85. E. Matijevic and R. J. Good (Eds), *Surface and Colloid Science*, vol. 13. Plenum Press, New York (1984).
86. R. J. Good, The value of the mercury contact angle for use in mercury intrusion porosimetry. In: *Surface and Colloid Science*, E. Matijevic and R. J. Good (Eds), p. 283. Plenum Press, New York (1984).
87. M. V. Ostrovsky and R. J. Good, Mechanism of microemulsion formation in systems with low interfacial tension, *J. Colloid Interface Sci.* **102**, 206 (1984).
88. R. J. Good and M. V. Ostrovsky, Mass transfer and dynamic liquid–liquid interfacial tension. I. Experiment, *J. Colloid Interface Sci.* **106**, 122 (1985).
89. M. V. Ostrovsky and R. J. Good, Mass transfer and dynamic liquid–liquid interfacial tension. II. Theory of the relation between change of interfacial tension and change of phase volume with time, *J. Colloid Interface Sci.* **106**, 131 (1985).

90. M. V. Ostrovsky and R. J. Good, Mass transfer and dynamic liquid–liquid interfacial tension. III. Theory of the non-equilibrium pressure coefficient of interfacial tension, *J. Colloid Interface Sci.* **106**, 140 (1985).
91. R. J. Good and F. Shoraka, The interaction of interfacial forces and viscoelastic effects in polymer adhesion and wear. In: *Polymer Wear and Its Control,* L. H. Lee (Ed.), ACS Symposium Series 287, p. 39. American Chemical Society, Washington, DC (1985).
92. R. J. Good, G. E. Broers, X. Yang and J. T. Ho, The anomaly of sedimentation at normal gravity in microemulsions, *J. Colloid Interface Sci.* **107**, 290 (1985).
93. R. J. Good and M. K. Chaudhury, A quantitative theory of the negative adsorption of non-electrolytes caused by repulsive van der Waals forces, *Langmuir* **1**, 673, (1985).
94. R. J. Good, G. E. Broers, C. J. van Oss and X. Yang, Anomalous ultracentrifugation observations with microemulsions, *J. Colloid Interface Sci.* **107**, 290 (1985).
95. C. J. van Oss, L. L. Moore, R. J. Good and M. K. Chaudhury, Surface thermodynamic properties, chromatographic and salting out behavior of IgA and other serum proteins, *J. Protein Chem.* **4**, 425–463 (1985).
96. M. V. Ostrovsky and R. J. Good, Methodology of experimental investigation of the kinetic and aggregative unstability of macroemulsions, *J. Dispersion Sci. Technol.* **7**, 95 (1986).
97. R. J. Good, Thermodynamics of adsorption and Gibbsian distance parameters. IV. Reply to Motomura regarding surface excess volume and Gibbs dividing surfaces, *J. Colloid Interface Sci.* **110**, 298 (1986).
98. R. J. Good, C. J. van Oss, J. T. Ho, X. Yang, G. E. Broers and M. Cheng, Sedimentation in middle phase microemulsions: an investigation using light scattering and ultracentrifugation, *Colloids Surf.* **20**, 187–209 (1986).
99. C. J. van Oss, R. J. Good and M. K. Chaudhury, The role of van der Waals forces and hydrogen bonds in 'hydrophobic interactions' between biopolymers and low energy surfaces, *J. Colloid Interface Sci.* **111**, 378 (1986).
100. C. J. van Oss, R. J. Good and M. K. Chaudhury, The nature of antigen–antibody interaction: primary and secondary bonds; optimal conditions for association and dissociation, *J. Chromatogr.* **376**, 111 (1986).
101. R. J. Good and F. Shoraka, The temperature rise in viscoelastic separation of an adhering system: a non-adiabatic study. In: *Materials Sciences for the Future (31st SAMPE Symposium, 1986),* J. L. Bauer and R. Dunaetz (Eds). Society for the Advancement of Materials and Process Engineering, Azusa, CA (1986).
102. C. J. van Oss, R. J. Good and M. K. Chaudhury, Protein solubility, *J. Protein Chem.* **5**, 385 (1986).
103. C. J. van Oss, M. K. Chaudhury and R. J. Good, The mechanism of partition in aqueous media, *Sep. Sci. Technol.* **22**, 1515–1526 (1987).
104. C. J. van Oss, M. J. Roberts, R. J. Good and M. K. Chaudhury, Determination of the apolar component of the surface tension of water by contact angle measurement on gels, *Colloids Surf.* **23**, 369–373 (1987).
105. C. J. van Oss, R. J. Good and M. K. Chaudhury, Mechanism of DNA (Southern) and protein (Western) blotting on cellulose nitrate and other membranes, *J. Chromatogr.* **391**, 53–65 (1987).
106. R. J. Good, A contribution to the teaching of thermodynamics: a paradox based on the Gibbs–Duhem equation, *Chem. Eng. Ed.* 94–97 (1987).
107. C. J. van Oss, R. J. Good and M. K. Chaudhury, Determination of hydrophobic interaction energy: application to separation processes, *Sep. Sci. Technol.* **22**, 1 (1987).
108. C. J. van Oss, M. K. Chaudhury and R. J. Good, Monopolar surfaces, *Adv. Colloid Interface Sci.* **28**, 35–64 (1987).
109. C. J. van Oss, M. K. Chaudhury and R. J. Good, Interfacial Lifshitz–van der Waals and polar interactions in macroscopic systems, *Chem. Rev.* **88**, 927–941 (1988).
110. C. J. van Oss and R. J. Good, On the mechanism of 'hydrophobic' interactions, *J. Dispersion Sci. Technol.* **9**, 355–362 (1988).
111. C. J. van Oss, M. K. Chaudhury and R. J. Good, Polar interactions, hydration pressure and membrane fusion. In: *Molecular Mechanisms of Membrane Fusion,* S. Ohki, D. Doyle, T. D. Flanagan and S. W. Hui (Eds), p. 113. Plenum Press, New York (1988).
112. C. J. van Oss and R. J. Good, Orientation of the water molecules of hydration of human serum

albumin, *J. Protein Chem.* **7**, 179 (1988).
113. R. J. Good and R. K. Gupta, Rheological, interfacial and thermal control of polymer adhesion. I. Isothermal theory, *J. Adhesion* **26**, 13–26 (1988).
114. C. J. van Oss, R. J. Good and M. K. Chaudhury, Additive and non-additive surface tension components and the interpretation of contact angle data, *Langmuir* **4**, 884–891 (1988).
115. M. V. Ostrovsky and R. J. Good, Mass transfer and dynamic liquid–liquid interfacial tension. 4. Relaxation processes in nonequilibrium multicomponent heterogeneous systems, *J. Colloid Interface Sci.* **124**, 238–247 (1988).
116. C. J. van Oss, L. Ju, M. K. Chaudhury and R. J. Good, Estimation of the polar parameters of the surface tension of liquids by contact angle measurements on gels, *J. Colloid Interface Sci.* **128**, 313 (1988).
117. C. J. van Oss and R. J. Good, Surface tension and the solubility of polymers and biopolymers: the role of polar and apolar interfacial free energies, *J. Macromol. Sci., Chem.* **A26**, 1183–1203 (1989).
118. C. J. van Oss, M. K. Chaudhury and R. J. Good, The mechanism of phase separation of polymers in organic media—apolar and polar systems, *Sep. Technol.* **22**, 15 (1989).
119. R. J. Good and N. Srivatsa, Hydrogen bonding and the wetting of coal, *Proc. Ann. Tech. Conf. on Filtration*, 27–29 March, American Filtration Society, Pittsburgh, PA (1989).
120. C. J. van Oss, R. J. Good and H. J. Busscher, Estimation of the polar surface parameters of glycerol and formamide, for use in contact angle measurements on polar solids, *J. Dispersion Sci. Technol.* **11**, 75–81 (1990).
121. R. J. Good, N. R. Srivatsa, M. Islam, H. T. L. Huang and C. J. van Oss, Theory of the acid–base hydrogen bonding interactions, contact angles and the hysteresis of wetting: application to coal and graphite surfaces, *J. Adhesion Sci. Technol.* **4**, 607–617 (1990).
122. C. J. van Oss, R. F. Giese and R. J. Good, Re-evaluation of the surface tension components and parameters of polyacetylene from contact angles of liquids, *Langmuir* **6**, 1711–1713 (1990).
123. C. J. van Oss, K. Arnold, R. J. Good, K. Gawrisch and S. Ohki, Interfacial tension and the osmotic pressure of solutions of polar polymers, *J. Macromol. Sci., Chem.* **A27**, 563–580 (1990).
124. C. J. van Oss and R. J. Good, Relation between the apolar and polar components of the interaction energy between the chains of nonionic surfactants and their CMC in water, *J. Dispersion Sci. Technol.* **12**, 95–105 (1991).
125. C. J. van Oss and R. J. Good, Surface enthalpy and entropy and the physico-chemical nature of hydrophobic and hydrophilic interactions, *J. Dispersion Sci. Technol.* **12**, 273 (1991).
126. R. J. Good and R. K. Gupta, The coupling of interfacial, rheological and thermal control mechanisms in adhesion. In: *Adhesive Bonding*, L. H. Lee (Ed.), ch. 3, pp. 47–73. Plenum Press, New York (1991).
127. R. J. Good and M. K. Chaudhury, Theory of adhesive forces across interfaces. I. The Lifshitz–van der Waals component of interaction and adhesion. In: *Fundamentals of Adhesion*, L. H. Lee (Ed.), ch. 3, pp. 137–151. Plenum Press, New York (1991).
128. R. J. Good and M. K. Badgujar, Coal recovery process, U.S. Patent application, Docket No. B 6501 (1990).
129. R. J. Good, M. K. Chaudhury and C. J. van Oss, Theory of adhesive forces across interfaces. II. Interfacial hydrogen bonds as acid/base phenomena and as factors enhancing adhesion. In: *Fundamentals of Adhesion*, L. H. Lee (Ed.), pp. 153–172. Plenum Press, New York (1991).
130. R. J. Good and M. Islam, Liquid bridges and the oil agglomeration method of coal benefici-ation: an elementary theory of stability, *Langmuir* (in press).
131. T.-Y. Chen, J. A. Tsamopoulos and R. J. Good, Capillary bridges between parallel and non-parallel surfaces, and their stability, *J. Colloid Interface Sci.* (in press).

SELECTED, NOTABLE PAPERS PRESENTED AT MAJOR PROFESSIONAL MEETINGS, ETC.

Theory for the estimation of surface energies from heat of immersion data, Gordon Research Conference on Chemistry at Interfaces (1957).

The molecular nature of interfacial tension, Gordon Research Conference on the Science of Adhesion (1963).

Surface energies and the embrittlement of metals by liquid metals, Gordon Research Conference on Chemistry at Interfaces (1964).

Intermolecular forces, interfacial energy and adhesion, Gordon Conference on the Science of Adhesion (1964).

Heat of peeling, and the theory of adhesive failure, Gordon Research Conference on the Science of Adhesion (1969).

Invited Lecturer, 7th Annual Conference on Adhesion, London (1969): A new thermal effect in the peeling separation of an adhesive system.

Invited Lecturer, International Conference on the Physics of Adhesion, Karlsruhe, Germany (1969): A new thermal effect in the peeling separation of an adhesive system.

Interface forces and the general theory of adhesion, University of Utah, Conference on Adhesion (1970).

Theory of wetting and spreading in adhesion, 9th Annual Conference on Adhesion, London (1971).

Theory of the adhesion of living cells and the spontaneous sorting-out of cells from aggregates, Gordon Research Conference on Chemistry at Interfaces (1971).

Kendall Award Lecture, American Chemical Society Centennial Meeting, New York, 6 April (1976): Surface free energy of solids: thermodynamics, molecular forces and structure.

The adhesion of coatings and films to solids, Gordon Research Conference on Coatings and Films (1978).

Surface chemistry and the difference between search and research, Lecture on receiving the Schoellkopf Award of the Western New York Section of the American Chemical Society (1979).

Theory of the oxidation rate laws of metals that form non-stoichiometric oxides, 5th International Symposium on Passivity, Bombannes, France (1983).

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