

Control of colloid stability through zeta potential.

# **Control of Colloid Stability through Zeta Potential**

**( and its relationship to cardiovascular disease )**

**by Thomas M. Riddick**

Published in 1968

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## **SUGGESTED REFERENCE MATERIAL**

**There is little published material on the practical aspects of Zeta Potential, (as of 1968) and there are few books dealing solely with cell electrophoresis or Zeta Potential. The following publications, selected from the writer's library, are recommended. They range from introductory to sophisticated.**

### **1 — Introduction to Colloid Chemistry — including the Zeta Potential**

**1-1 Introduction to Colloid Chemistry—Mysels—Interscience (Wiley)—1959**

**1-2 A Short Textbook of Colloid Chemistry—Jirgensons & Straumanis—Wiley—1954**

### **2 — Introduction to Physical Chemistry**

**2-1 Experimental Physical Chemistry—Daniels et al—McGraw-Hill—1956**

**2-2 Physical Chemistry—Daniels & Alberty—Wiley—1966**

**2-3 Industrial Chemistry of Colloidal and Amorphous Materials—Lewis et al—Mac millan—1942**

### **3 — Introduction to Organic Chemistry**

**3-1 Introduction to Organic Chemistry—Lowy, Harrow & Apfelbaum—Wiley—1951**

**3-2 Organic Chemistry Simplified—Macy—Chemical Publishing—1955**

**3-3 The World of Carbon—Isaac Asimov—Collier Books—1962**

**3-4 The World of Nitrogen—Isaac Asimov—Collier Books—1962**

### **4 — Electrophoresis and the Zeta Potential**

**4-1 Electrophoresis—Ed. by Milan Bier—Academic Press—1959**

**4-2 Theory of the Stability of Lyophobic Colloids—Verwey & Overbeek—Elsevier Publishing, Amsterdam—1948**

**4-3 Colloid Science—Ed. by Kruyt—Elsevier—Vol. 1, 1952; Vol. 2, 1949**

**4-4 Advances in Colloid Science—Ed. by Mark & Verwey—Vol. III —Interscience—1950**

**4-5 Dielectric Behavior and Structure—Charles Phelp Smith—McGraw-Hill—1955**

**4-6 Electrophoresis of Proteins and the Chemistry of Cell Surfaces—Abramson, Moyer and Gorin—1942—Reprinted by University Microfilms, Arn Arbor, Mich. —1962**

**4-7 Selected Papers by A. P. Black and associates, dealing with cell electrophoresis and (unless otherwise noted) appearing in the Journal of AWWA, New York, N.Y.**

**a.) Electrophoretic Studies of Water Coagulation—50, 1467 (1958)**

**b.) Basic Mechanisms of Coagulation—52, 492 (1960)**

**c.) Electrophoretic Studies of Turbidity Removal by Coagulation with Aluminum Sulfate—53, 438 (1961)**

**d.) Electrophoretic Studies of Coagulation for Removal of Organic Color—53, 589 (1961)**

**e.) Electrophoretic Studies of Sludge Particles Produced in Lime-Soda Softening—53, 737 (1961)**

**f.) Determination of the Mobility of Colloidal Particles by Microelectrophoresis—54, 926 (1962)**

**g.) Mechanisms of Coagulation in Water Treatment—Journal San. Eng., Div. Am. Soc. Civil Eng.—Vol. 89, Part I, pp. 75-80 (Jan. 1963)**

**h.) The Nature of Organic Color in Water—Part I—55, 753 (1963); Part II—55, 897 (1963)**

**i.) Stoichiometry of the Coagulation of Color—Causing Organic Compounds with Ferric Sulfate—55, 1347 (1963)**

**j.) Electrophoretic Studies of Turbidity Removal with Ferric Sulfate—56, 99 (1964)**

**4-8 Electrokinetic Phenomena—Abramson—Reinhold—1934**

**4-9 The Electrical Double Layer Around a Spherical Colloid Particle—Loeb, Wiersema & Overbeek—MIT Press—1961**

**4-10 Double Layer and Electrode Kinetics—Paul Delahay—Interscience (Wiley)—1965**

**4-11 On the Theory of Electrophoresis—Ph.D. Thesis—Pieter H. Wiersema—Drukkerij Pasmans, v.d. Vemmestraat 76, Den Haag—1930**

## **5 — Colloid and Physical Chemistry**

**5-1 Colloid Science—Alexander & Johnson—Oxford Univ. Press—1950**

**5-2 Physical Chemistry—Rutgers—Interscience—1954**

**5-3 Colloid Science—McBain—D.C. Heath & Co.—1950**

**5-4 Physical Chemistry of Surface Films—Harkins—Reinhold—1952**

**5-5 Colloid Science—Symposium—Chemical Publishing—1947**

**5-6 Surface Chemistry—Bikerman—Academic Press—1958**

**5-7 Physical Chemistry of Surfaces—Adamson—Interscience—1960**

**5-8 Colloidal Dispersions—Carl Fisher—Wiley—1950**

**5-9 An Introduction to Colloid Chemistry—Van Olphen—Wiley—1963**

**5-10 Action of Phosphates on Finely Divided Solids—John W. Lyons—Monsanto Chemical Co., St. Louis, Mo.—1961**

**5-11 Cation Exchange in Soils—Walter P. Kelly—Reinhold—ACS—1948**

**5-12 Alkali Soils—W. P. Kelly—Reinhold—ACS—1951**

**5-13 Adsorption—C.L. Mantell—McGraw-Hill—1951**

**5-14 The Alkaline Earth and Heavy Metal Soaps—Stanley B. Elliott—Reinhold—ACS—1946**

**5-15 The Colloid Chemistry of Silica & Silicates—Ralph K. Iler—Cornell Univ. Press—1955**

**5-16 Surface Chemistry—Lloyd Osipow—Reinhold—ACS—1962**

**5-17 Flotation—A.M. Gaudin—McGraw-Hill—1957**

**5-18 Phthalocyanine Compounds—Moser & Thomas—Reinhold—ACS—1963**

**5-19 The Chemistry and Physics of Clays—Searle & Grimshaw—Interscience—1959**

**5-20 Fats & Oils-Kirschenbauer—Reinhold—1960**

**5-21 Emulsion and Water Soluble Paints and Coatings—Martens—Reinhold—1964**

**5-22 Colloidal Surfactants—Shinoda et al—Academic Press—1963**

**5-23 Physical Chemistry—Moore—Prentice-Hall—1962**

**5-24 Interfacial Phenomena—Davies & Rideal—Academic—1963**

**5-25 Surface Activity-Moilliet, Collie & W. Black—Van Nostrand—1961**

**5-26 Organic Colloids—Jirgensons—Elsevier—1958**

**5-27 Surface Phenomena in Chemistry and Biology—Danielli et al—Pergamon Press—1958**

**5-28 The Scientific Papers of J. Willard Gibbs—Vols. 1 & 2 —Repub. by Dover—1961**

**5-29 On Physical Adsorption—Ross & Olivier—Interscience—1964**

**5-30 Chemisorption—Hayward & Trapnell—Butterworths—1964**

**5-31 Emulsions—Paul Becher—Reinhold—1965**

**5-32 Chemistry & Physics of Interfaces—Symposium, June 15/16, 1964—ACS—1965**

## **6 — Polymer Chemistry**

**6-1 Natural and Synthetic High Polymers—Meyer—Interscience—1950**

**6-2 Principles of Polymer Chemistry—Flory—Cornell Univ. Press—1953**

**6-3 Textbook of Polymer Chemistry—Billmeyer—Interscience—1957**

**6-4 An Introduction to the Organic Chemistry of High Polymers—Marvel—Wiley—1959**

**6-5 Physical Chemistry of High Polymers—Huggins—Wiley—1958**

**6-6 Developments in Inorganic Polymer Chemistry—Lappert & Leigh—Elsevier—1962**

**6-7 The Chemistry of Plant Gums and Mucilages—Smith & Montgomery—Reinhold—ACS—1950**

**6-8 The Water Soluble Gums—Charles L. Mantell—1947—Reprinted by University Microfilms, Ann Arbor, Mich.**

**6-9 Water Soluble Resins—Davidson & Sittig—Reinhold—1962**

**6-10 List of Papers by V. K. LaMer and associates (Healy, Kane, Linford, Smeliie, and others), dealing with coagulation—particularly with long-chain polymers:**

**a.) Journal Colloid Science—11,704 — 11,710 — 11,720 (1956); 12,230 — 12,566 (1957); 13,589 (1958); 19,323 (1964)**

**b.) Journal Phys. Chem.—66,1835 (1962); 67,2417 (1963); 67,1977 (1963); 68,2273 (1964)**

**c.) Rev. Pure Appl. Chem.—13,112 (1963)**

**d.) Journal Am. Chem. Soc.—86,3450 (1964)**

**6-11 Properties and Structure of Polymers—Tobolsky—Wiley—1960**

**6-12 Autohesion and Adhesion of High Polymers (Polymer Reviews, Vol. 4) —S.S. Voyutskii—Interscience (Wiley)—1963**

## **7 — Surfactants**

**7-1 Surface Active Agents—Vol. I—Schwartz—Interscience—1949**

**7-2 Surface Active Agents and Detergents—Vol. II —Schwartz et al—Interscience—1958**

**7-3 Detergents and Emulsifiers (A listing of the principal surfactants produced in the U.S.A.)—Revised yearly—Published by John W. McCutcheon, Inc., Morristown, N.J.**

**7-4 Encyclopedia of Surface-Active Agents—Sisley & Wood—Vol. I, 1952—Vol. II, 1964—Chemical Publishing Co. Inc., 212 Fifth Ave., New York.**

**7-5 Nonionic Surfactants—Martin J. Schick—Marcel Dekker, pub., 95 Madison Ave., New York—1967**

**7-6 The Structure of Polymers—M.L. Miller—Reinhold—1966**

## **8 — Electro-Chemistry**

**8-1 Introduction to Electro-Chemistry—Glasstone—Van Nostrand—1942**

**8-2 Electro-Chemistry—Kortum & Bockris—Elsevier—Vols. 1 & 2, 1951**

## **9 — Organic Chemistry**

**9-1 Organic Chemistry—Morrison & Boyd—Allyn & Bacon, Inc., Boston—1959**

**9-2 Organic Chemistry—Vols. 1 & 2 —F.C. Whitmore—1937—Republished by Dover Publications, New York**

**9-3 Steric Effects in Organic Chemistry—Melvin S. Newman—Wiley—1956**

## **10 — Coagulation of Raw Sugar Juice**

**10-1 Papers by C. M. Bennett and associates on Coagulation and the Zeta Potential—Int'l Sugar Journal—1959, 1960**

## **11 — Blood Stability and Related Subjects**

**11-1 The Plasma Proteins—Vols. 1 & 2 —Putnam—Academic Press—1960**

**11-2 Blood Cells & Plasma Proteins—Tullis—Academic Press—1953**

**11-3 The Functions of the Blood—Macfarlane & Robb—Smith—Academic Press—1961**

**11-4 Blood Clotting and Allied Problems—Josiah Macy, Jr. Foundation—New York, N.Y.—(Five yearly conferences, 1948–1952)**

**11-5 International Symposium on Blood Platelets—Henry Ford Hospital—Little, Brown & Co., Boston—1961**

**11-6 Blood Coagulation—Collected Papers by Walter H. Seegers and associates—2 vols. (1953–1957 and 1957–1960)—Wayne Univ. College of Medicine—Detroit**

**11-7 Lipoids and Blood Platelets-Ferguson—Univ. of North Carolina Press—Chapel Hill—1960**

**11-8 The Plasma Proteins—Weil—J.B. Lippincott Co., Philadelphia—1959**

**11-9 Hemorrhagic DiseaseVQuick—Lea & Febiger, Philadelphia—1957**

**11-10 Standard Values in Blood—Albritton—W.B. Saunders Co.,**

**Philadelphia—1952**

**11-11 The Chemistry of Blood Coagulation—Morawitz—Charles C. Thomas, Springfield, Ill.—1958**

**11-12 Human Blood Coagulation—Biggs & Macfarlane—F.A. Davis Co., Philadelphia—1962**

**11-13 The Chemical Prevention of Cardiac Necroses—Hans Selye—Ronald Press, New York—1958**

**11-14 Thrombohemorrhagic Phenomena—Hans Selye—Chas. C. Thomas—1966**

**11-15 The Stress of Life—Hans Selye—McGraw-Hill—1956**

**11-16 Selected Papers by Melvin Knisely and associates on Intravascular Coagulation**

**a.) The Settling of Sludge During Life—Acta Anatomica, Supplement 41, 1 ad. Vol. 44—S. Karger—New York—1961**

**b.) Ante-Mortem Settling—Angiology, Vol. II, No. 6, Part 2—Dec. 1960**

**c.) Sludged Blood—Transactions of the Amer. Therapeutic Soc., Vols. XLVIII and XLIX, 1950**

**d.) Settling of Sludge in Human Patients—Angiojogy, Vol. 9, No. 6, Dec. 1958**

**e.) Enforced Postponement of Selective Phagocytosis—Southern Medical Journal, Journal of Southern Medical Assn., Vol. 56, No. 10, Oct. 1963, pp. 1,115-1,127, Birmingham, Ala.**

**f.) Experimental Separation of Quite Different Types of Circulatory Shock—Shock & Hypertension—Grune & Stratton—1965**

**g.) Intravascular Agglutination of the Flowing Blood Following the Injection of Radiopaque Contrast Media—Neurology, Vol. 12, No. 8, Aug. 1962, Minneapolis MN**

**h.) Knowlesi Malaria in Monkeys II—Angiology, Vol. 15, No. 9, Sept. 1964**

**i.) Intravascular Erythrocyte Aggregation (blood sludge)—Handbook of Physiology, Section 2: Circulation, Vol. III, 1965**

**j.) Life Magazine—May 31, 1948—Article entitled "Blood Sludge," pp.**

- 11-17 **The Anatomy and Physiology of Capillaries—August Krogh—1922—  
Repr. by Hafner Publishing Co., 31 E. 10th St., New York, N. Y.—1959**
- 11-18 **The Physiology of Blood Platelets—Marcus and Zucker—Grune &  
Stratton—1965**
- 11-19 **Coagulation and Transfusion in Clinical Medicine—Johnson &  
Greenwalt—Little, Brown & Co.—1965**
- 11-20 **Disseminated Intravascular Coagulation—Col. Robert M. Hardaway  
—Chas. C. Thomas—1966**
- 11-21 **Disseminated Intravascular Coagulation—Donald McKay—Hoeber  
Div. of Harper & Row—1965**
- 11-22 **Osmotic Regulation in Aquatic Animals—August Krogh—1939—  
Repr. by Dover—1965**
- 11-23 **Medical Electronics in Cardiovascular Disease—Chas. K. Friedberg  
—Grune & Stratton—1963**
- 11-24 **Diseases of the Heart—Chas. K. Friedberg—W.B. Saunders Co.—  
1956**
- 11-25 **Physiology of the Kidney and Body Fluids—Robt. F. Pitts—Year Book  
Med. Publishers, Chicago—1963**
- 11-26 **The Electrical Activity of the Nervous System—Mary Brazier—  
MacMillan—1958**
- 11-27 **Cardiovascular Dynamics—Rushmer—W.B. Saunders Co.—1961**
- 11-28 **Physiology and Biophysics of the Circulation—Alan C. Burton—Year  
Book Medical Publishers—1965**
- 11-29 **Diseases of the Heart and Blood Vessels—N.Y. Heart Assn.—Little,  
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- 11-30 **Blood Group Substances—Elvin A. Kabat—Academic Press—1956**
- 11-31 **Electrocardiography—Michael Bernreiter—J.B. Livpincott—1965**
- 11-32 **Biophysical Principles of Electrocardiography—Robert H. Bayley—  
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- 11-33 **The Heart Beat—Aldo A. Luisada—Hoeber—1953**



- 11-34 Biophysical Mechanisms in Vascular Homeostasis and Intravascular Thrombosis—Ed. by Philip N. Sawyer—Appleton-Century-Crofts—1965**
- 11-35 Atherosclerosis—Campbell Moses—Lea & Febiger—1963**
- 11-36 The Red Cell—T.A.J. Pranker—Blackwell Scientific Publications, Oxford, England—1961**
- 11-37 Renal Function—W.J. O'Connor—Williams & Wilkins Co.—1962**
- 11-38 An Introduction to the Study of Experimental Medicine—Claude Bernard—1865—Repr. by Dover, 1957**
- 11-39 Electrolytes and Cardiovascular Diseases, Vols. 1 & 2 —Eörs Bajusz—Williams and Wilkins—1966**
- 11-40 Nutritional Aspects of Cardiovascular Diseases—Eörs Bajusz—J.B. Lippincott—1965**
- 11-41 Conditioning Factors for Cardiac Necroses—Eörs Bajusz—A.G. Karger, Basel, Switzerland, & Intercontinental Medical Book Co., New York—1963**
- 11-42 Metal Binding in Medicine—edited by M. Seven—J.B. Lippincott—1960**
- 11-43 Chelation Therapy—Alfred Soffer—C.C. Thomas Publishers—1964**
- 11-44 Clinical Disorders of Hydration and Acid-Base Equilibrium—Louis G. Welt—Little Brown & Co.—1955**
- 11-45 The Cell—Fawcett—W.B. Saunders Co.—1966**
- 11-46 Biochemistry—Cantarow and Schepartz—W.B. Saunders Co.—1967**
- 11-47 Selected Papers by Edward H. Bloch, M.D. (or Bloch and associates):**
- a.) The in vivo Microscopic Intravascular and Vascular Reactions in Acute Poliomyelitis—Am. J. Med. Sciences, 226:24-37**
  - b.) In vivo Microscopic Observations of the Circulating Blood in Acute Myocardial Infarction—Am. J. Med. Sciences, 229:280-293**
  - c.) Microscopic Observations of the Circulating Blood in the Bulbar Conjunctiva in Man in Health and Disease—Ergebnisse d. Anatomie u. Entwicklungsge-schichte, 35:1-98 (A monograph)**
  - d.) A Comparison of the Surfaces of Human Erythrocytes from Health**

**and Disease by in vivo light microscopy and in vitro electron microscopy—Angiology, 7:479–494**

**e.) Diabetes and the Living Microvascular System—New York Acad. Sciences**

**f.) The Effect of Cellular Aggregation on Pressure-flow Relationship in the Microvascular System—Angiology, 12:473–476**

**g.) Rheology and the Dynamic Anatomy of the Microvascular System—Trans. Soc. Rheol., 7:9–18, 1963**

**h.) Microscopic Observations of the Acute Effects on the Extra- and Intrahepatic Circulation Produced by Anti-red Cell Sera—Anat. Record, 121:459, 1955**

**i.) Electron Microscopy of Human Erythrocytes from Health and Disease—Anat. Record, 112:442, 1952**

**j.) Electron Microscopy of Human Erythrocytes from Healthy and Sludged Blood—Science, 115:46, 1952**

**11–48 Amino Acids and Serum Proteins—ACS Advances in Chemistry Series—Ed. by Robert F. Gould—American Chemical Society—1964**

**11–49 Biochemistry—West, Todd, Mason and Van Bruggen—The Macmillan Co.—Fourth Edition, 1966**

**11–50 Blood and Other Body Fluids (Biological Handbook series)—Federation of American Societies for Experimental Biology, 9650 Wisconsin Ave., Washington 14, D.C.—1961**

**11–51 Standard Values in Nutrition and Metabolism (Biological Handbook series)—1954 (Same publisher as Ref. 11–50)**

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**11–53 Hypertension—Recent Advances—Ed. by Brest & Moyer—Lea & Febiger—1961**

**11–54 Pulsatile Blood Flow—E.O. Attinger, Editor—McGraw-Hill—1963**

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**12–2 Property of Ordinary Water Substance—Dorsey—Reinhold—1940**

- 12-3 Mechanisms of Inorganic Reactions—Basolo & Pearson—Wiley—1958**
- 12-4 The American Institute of Physics Handbook—McGraw-Hill—1957**
- 12-5 Tables of Dielectric Dispersion Data for Pure Liquids and Dilute Solutions— NBS Circular 589—U.S. Dept. of Commerce—Nat'l Bureau of Standards, Washington, D.C.—1958**
- 12-6 Dielectric Constants of Aqueous Solutions of Dextrose and Sucrose—Nat'l Bureau of Standards—Research Paper 2137 (1950)**
- 12-7 Precipitation from Homogeneous Solutions—Gordon et al—Wiley—1960**
- 12-8 The Body Fluids—Elkinton & Danowski—Williams & Wilkins Co.,—1955**
- 12-9 Oxidation Potentials—Wendel Latimer—Prentice Hall—1952**
- 12-10 Soluble Silicates—Vols. 1 & 2 —Jas. G. Vail—Reinhold—1952**
- 12-11 Wood Chemistry—Vols. 1 & 2 —Wise & Jahn—Reinhold—ACS—1944**
- 12-12 Industrial Microbiology—Prescott & Dunn—McGraw-Hill—1959**
- 12-13 The Atomic Nucleus—Korsunsky—Republished by Dover—1958**
- 12-14 The Structure of Electrolytic Solutions—Hamer—Wiley—1959**
- 12-15 Ions in Solution—Gurney—Reprinted by Dover—1962**
- 12-16 Polar Molecules—Debye—Reprinted by Dover—1929**
- 12-17 Kinetic Theory of Liquids—Frenkel—Reprinted by Dover—1955**
- 12-18 Ionic Processes in Solution—Gumey—Reprinted by Dover—1962**
- 12-19 The Nature of the Chemical Bond—Pauling—Cornell—Reprinted 1960**
- 12-20 Soil Microbiology—Waksman—Wiley—1952**
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- 12-22 Chemical Pathways of Metabolism—Vols. 1 & 2 —Greenberg—Academic Press—1954**
- 12-23 Phosphatides—Wittcoff—Reinhold—1951**

- 12-24 A Survey of Physical Theory—Max Planck—Reprinted by Dover—1960**
- 12-25 The Nature of Physical Theory—Bridgman—Reprinted by Dover—1936**
- 12-26 Scientific Autobiography—Max Planck—Philosophical Library, 15 East 40th St., New York, N.Y.—1949**
- 12-27 Fundamental Principles of Bacteriology—A.J. Salle—McGraw-Hill—1961**
- 12-28 Boron-Nitrogen Chemistry—Symposium—ACS—1964**
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- 12-39 The Role of Magnesium in Biologic Processes—Jerry K. Aikawa, M.D.—Charles C. Thomas, publisher—1963**
- 12-40 Heinz Handbook of Nutrition—Benjamin T. Burton—McGraw-Hill**

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12-41 Composition of Foods—Agricultural Handbook No. 8—U.S. Dept. of Agriculture—Revised Dec. 1963

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