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# **HOMOASOCIACIÓN DE PORFIRINAS SOLUBLES EN AGUA**

Memoria que presenta Carlos Escudero Rodríguez para optar al título de Doctor en  
Química

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## Bibliografia

- [1] Rothmund P., *J. Am. Chem. Soc.*, 1936, **58**, 625.
- [2] Fisher H., Gleim W., *Liebigs Ann. Chem.*, 1936, **521**, 157.
- [3] Eisner U., Linstead R.P., *J. Chem. Soc.*, 1955, 3742.
- [4] Krol S., *J. Org. Chem.*, 1959, **24**, 2065.
- [5] Longo F.R., Thorne E.J., Adler A.D., Dym S., *J. Heterocyclic Chem.*, 1975, **12**, 1305.
- [6] Neya S., Yodo H., Funasaki N., *J. Heterocyclic Chem.*, 1993, **30**, 549.
- [7] Taniguchi S., Hasegawa H., Nishimura M., Takahashi M., Synlett, 1999, 73.
- [8] Neya S., Funasaki N., *Tetrahedron Lett.*, **43**, 2002, 1057.
- [9] Neya S., Quan J., Hoshino T., Hata M., Funasaki N., *Tetrahedron Lett.*, **45**, 2004, 8629.
- [10] Neya S., Quan J., Hata M., Hoshino T., Funasaki N., *Tetrahedron Lett.*, **47**, 2006, 8731.
- [11] Rothmund P., *J. Am. Chem. Soc.*, 1935, **57**, 2010.
- [12] Rothmund P., *J. Am. Chem. Soc.*, 1939, **61**, 2912.
- [13] Rothmund P., Menotti A.R., *J. Am. Chem. Soc.*, 1941, **63**, 267.
- [14] Aronoff S., Calvin M., *J. Org. Chem.*, 1943, **8**, 205.
- [15] Calvin M., Ball R.H., Aronoff S., *J. Am. Chem. Soc.*, 1943, **65**, 2259.
- [16] Ball R.H., Dorough G.D., Calvin M., *J. Am. Chem. Soc.*, 1946, **68**, 2278.
- [17] Adler A.D., Longo F.R., Shergalis W., *J. Am. Chem. Soc.*, 1964, **86**, 3145.
- [18] Adler A.D., Longo F.R., Finarelli J.D., Goldmacher J., Assour J., Korsakoff L., *J. Org. Chem.*, 1967, **32**, 476.
- [19] Barnett G.H., Hudson M.F., Smith K.M., *Tetrahedron Lett.*, 1973, 2887.
- [20] Rousseau K., Dolphin D., *Tetrahedron Lett.*, 1974, 4251.
- [21] Adler A.D., Sklar L., Longo F.R., Finarelli J.D., Finarelli M.G., *J. Heterocyclic Chem.*, 1968, **5**, 669.
- [22] Kim J.B., Adler A.D., Longo F.R., *J. Am. Chem. Soc.*, 1972, **94**, 3986.
- [23] Dolphin D., *J. Heterocyclic Chem.*, 1970, **7**, 275.
- [24] Evans B., Smith K.M., Fuhrhop J.H., *Tetrahedron Lett.*, 1977, 443.
- [25] Lindsey J.S., Schreiman I.C., Hsu H.C., Kearney P.C., Marguerettaz A. M., *J. Org. Chem.*, 1987, **57**, 827.
- [26] Lindsey J.S., Wagner R.W., *J. Org. Chem.*, 1989, **54**, 828.
- [27] Lindsey J.S., MacCrum K.A., Tyhonas J.S., Chuang Y., *J. Org. Chem.*, 1994, **59**, 579.
- [28] Li F., Tyhonas J.S., MacCrum K.A., Lindsey J.S., *Tetrahedron*, 1997, **53**, 12339.
- [29] Geier G.R. III, Ciringh Y., Li F., Haynes D.M., Lindsey J.S., *Org. Lett.*, 2000, **2**, 1745.
- [30] Geier G.R. III, Lindsey J.S., *J. Chem. Soc., Perkin Trans. 2*, 2001, 677.
- [31] Geier G.R. III, Lindsey J.S., *J. Chem. Soc., Perkin Trans. 2*, 2001, 687.
- [32] Geier G.R. III, Littler B.J., Lindsey J.S., *J. Chem. Soc., Perkin Trans. 2*, 2001, 701.

- [33] Geier G.R. III, Littler B.J., Lindsey J.S., *J. Chem. Soc., Perkin Trans. 2*, 2001, 712.
- [34] Lindsey J.S., "The Porphyrin Handbook", eds. Kadish K.M., Smith K.M. and Guillard R., Academic Press, San Diego, CA, **2000**, vol. 1, chapter 2, p. 63.
- [35] Furuta H., Asano T., Ogawa T., *J. Am. Chem. Soc.*, 1994, **116**, 767.
- [36] Chmielewski P.J., Latos-Grazynski L., Rachlewicz K., Glowiac T., *Angew. Chem. Int. Ed. Engl.*, 1994, **33**, 779.
- [37] Senge M.O., Bischoff I., Nelson N.Y., Smith K., *J. Porphyrins Phthalocyanines*, 1999, **3**, 99.
- [38] Littler B.J., Ciringh Y., Lindsey J.S., *J. Org. Chem.*, 1999, **64**, 2864.
- [39] Treibs A., Haberle N., *Liebigs Ann. Chem.*, 1968, **718**, 183.
- [40] Manka J.S., Lawrence D.S., *Tetrahedron Lett.*, 1989, **30**, 6989.
- [41] Kim J.B., Longo F.R., "Porphyrin Chemistry Advances", Ed. F.R. Longo, Ann Arbor Science Publishers, Inc., Michigan, **1979**, p. 305.
- [42] Fuhrhop J.H., "Porphyrins and Metalloporphyrins", Ed. K.M. Smith, Elsevier Scientific Publishing Co., North Holland Biomedical Press, New York, **1976**, chapter 15, p. 625.
- [43] Fuhrhop J.H., "The Porphyrins", Ed. D. Dolphin, Academic Press, New York, **1978**, vol. 2, chapter 5, p. 131.
- [44] Treibs A., *Justus Liebigs Ann. Chem.*, 1933, **506**, 196.
- [45] Fischer H., Treibs A., *Justus Liebigs Ann. Chem.*, 1927, **457**, 209.
- [46] Srivastava T., Tsutsui M., *J. Org. Chem.*, 1973, **38**, 2103.
- [47] El Hachemi Z., *Tesis Doctoral*, **2002**, Dpt. Química Orgànica. Universitat de Barcelona.
- [48] Jaramillo T., *Tesis de Licenciatura*, **1997**. Dpt. Química Orgànica. Universitat de Barcelona.
- [49] García-Ortega H., Ribó J.M., *J. Porphyrins Phthalocyanines*, 2000, **4**, 564.
- [50] Kús P., Stefaniak M., *Monatshefte für Chemie*, 2004, **135**, 509.
- [51] Uemura T., Iguchi T., Satake S., Uraki H., Iida Y., *European Patent Application 834537A1*, **1998**.
- [52] García-Ortega H., *Tesis Doctoral*, **2003**, Dpt. Química Orgànica. Universitat de Barcelona.
- [53] March J., "Advanced Organic Chemistry; Reactions, mechanisms and structure", 2<sup>nd</sup> ed., Ed. McGraw-Hill, **1977**, p. 479.
- [54] Kort C.W.F., Cerfontain H., *Recl. Trav.Chim. Pays-Bas*, 1968, **87**, 24.
- [55] Kort C.W.F., Cerfontain H., *Recl. Trav.Chim. Pays-Bas*, 1969, **88**, 860.
- [56] Kort C.W.F., Cerfontain H., *Recl. Trav.Chim. Pays-Bas*, 1969, **88**, 1298.
- [57] Koeberg-Telder A., Cerfontain H., *J. Chem. Soc., Perkin Trans. 2*, 1973, 633.
- [58] Koeberg-Telder A., Cerfontain H., *Recl. Trav.Chim. Pays-Bas*, 1971, **90**, 193.
- [59] Koeberg-Telder A., Cerfontain H., *Recl. Trav.Chim. Pays-Bas*, 1972, **91**, 22.

- [60] Cerfontain H., *Recl. Trav.Chim. Pays-Bas*, 1985, **104**, 153.
- [61] Perrin C.L., *J. Am. Chem. Soc.*, 1977, **99**, 5516.
- [62] Freire de Queiroz J., Carneiro J.W.M., Sabino A.A., Sparrapan R., Elberlin M.N., Esteves P.M., *J. Org. Chem.*, 2006, **71**, 6192.
- [63] Frisch M.J., Trucks G.W., Schlegel H.B., Scuseria G.E., Robb M.A., Cheeseman J.R., Montgomery J.A., Vreven Jr.T., Kudin K.N., Burant J.C., Millam J.M., Iyengar S.S., Tomasi J., Barone V., Mennucci B., Cossi M., Scalmani G., Rega N., Petersson G.A., Nakatsuji H., Hada M., Ehara M., Toyota K., Fukuda R., Hasegawa J., Ishida M., Nakajima T., Honda Y., Kitao O., Nakai H., Klene M., Li X., Knox J.E., Hratchian H.P., Cross J.B., Adamo C., Jaramillo J., Gomperts R., Stratmann R.E., Yazyev O., Austin A.J., Cammi R., Pomelli C., Ochterski J.W., Ayala P.Y., Morokuma K., Voth G.A., Salvador P., Dannenberg J.J., Zakrzewski V.G., Dapprich S., Daniels A.D., Strain M.C., Farkas O., Malick D.K., Rabuck A.D., Raghavachari K., Foresman J.B., Ortiz J.V., Cui Q., Baboul A.G., Clifford S., Cioslowski J., Stefanov B.B., Liu G., Liashenko A., Piskorz P., Komaromi I., Martin R.L., Fox D.J., Keith T., Al-Laham M.A., Peng C.Y., Nanayakkara A., Challacombe M., Gill P.M.W., Johnson B., Chen W., Wong M.W., González C., Pople J.A., *Gaussian 3.0*, Gaussian Inc., Pittsburgh, P.A., **2003**.
- [64] Barnett G.H., Smith K.M., *J. Chem. Soc., Chem. Comm.*, 1974, 772.
- [65] Johnson E.C., Dolphin D., *Tetrahedron Letters*, 1976, **26**, 2197.
- [66] Arnold D.P., Bott R.C., Eldridge H., Elms F.M., Smith G., Zojaji M., *Aust. J. Chem.*, 1997, **50**, 495.
- [67] Smith K.M., Barnett G.H., Evans B., Martynenko Z., *J. Am. Chem. Soc.*, 1979, **101**, 5953.
- [68] Jaquinod L., “*The Porphyrin Handbook*”, eds. Kadish K.M., Smith K.M. and Guillard R., Academic Press, San Diego, CA, **2000**, vol. 1, chapter 5, p. 207.
- [69] Ridd J.H., Sandall J.P.B., *J. Chem. Soc., Chem. Comm.*, 1981, 402.
- [70] Johnston J.F., Ridd J.H., Sandall J.P.B., *J. Chem. Soc., Chem. Comm.*, 1989, 245.
- [71] Blankenship R. E., Brune D. C., Wittmerhaus B. P., “*Light-Energy Transduction in Photosynthesis: Higher Plant and Bacterial Models*”, S. E. Stevens Jr. and D. A. Bryant Eds., American Society of Plant Physiologists, Rockville, MD, **1988**, p. 32.
- [72] Kagan N. E., Mauzerall D., Merrifield R. B., *J. Am. Chem. Soc.*, 1977, **99**, 5484.
- [73] Perkins W.R., Minchey S.R., Boni L.T., Swenson C.E., Popescu M.C., Pasternack R.F., Janoff A.S., *Biochim. Biophys. Acta*, 1992, **1107**, 271.
- [74] Dougherty T. J., *Advances in Photochemistry*, 1992, **17**, 275.
- [75] Bonnett R., “*Chemical Aspects of Photodynamic Therapy*”, Gordon and Breach Science Publishers, The Netherlands, **2000**, p. 149.

- [76] White W. I., *"The Porphyrins"*, Dolphin D. Ed, Acad. Press. Inc. New York, **1979**, vol. 5, chapter 7, p. 303.
- [77] Pasternack R. F., Huber P. R., Boyd P., Engasser G., Francesconi L., Gibbs E., Fasella P., Cerio-venturo G., Hinds L. de C., *J. Am. Chem. Soc.*, 1972, **94**, 4511.
- [78] Fleischer E.B., Palmer J.M., Srivastava T.S., Chartterjee A., *J. Am. Chem. Soc.*, 1971, **93**, 3162.
- [79] Rabinowitch E., Epstein L.F., *J. Am. Chem. Soc.*, 1941, **63**, 69.
- [80] Hunter C.A., Sanders J.K.M., *J. Am. Chem. Soc.*, 1990, **112**, 5525.
- [81] Hunter, C.A. *Chem. Soc. Reviews*, 1994, 101.
- [82] Sutter T.P.G., Rahimi R., Hambright P., Bommer J.C., Kumar M., Neta P., *J. Chem. Soc. Faraday. Trans.*, 1993, **89**, 495.
- [83] Tabata M., Tanaka M., *J. Chem. Soc., Chem. Commun.*, 1985, 42.
- [84] Crusats J., *Tesi Doctoral*, **1996**, Dpt. Química Orgànica. Universitat de Barcelona.
- [85] Hamor M.J., Hamor T.A., Hoard J.L., *J. Am. Chem. Soc.*, 1964, **86**, 1938.
- [86] Stone A., Fleischer E.B., *J. Am. Chem. Soc.*, 1968, **90**, 2735.
- [87] Walter R.I., *J. Am. Chem. Soc.*, 1953, **75**, 3860.
- [88] Ghosh A., *"The Porphyrin Handbook"*, eds. Kadish K.M., Smith K.M. and Guillard R., Academic Press, San Diego, CA, **2000**, vol. 7, chapter 47, p. 16.
- [89] R. M. Claramunt, J. Elguero, A. R. Katritzky, *Adv. Heterocycl. Chem.*, 2000, **77**, 16.
- [90] Allen F.H., Kennard O., Taylor R., *Acc. Chem. Res.*, 1983, **16**, 146.
- [91] Scheidt W.R., *"The Porphyrin Handbook"*, eds. Kadish K.M., Smith K.M. and Guillard R., Academic Press, San Diego, CA, **2000**, vol. 3, chapter 16, p. 96.
- [92] Bond A.D., Feeder N., Redman J.E., Teat S.J., Sanders J.K.M., *Crystal Growth & Design*, 2002, **2**, 27.
- [93] Silvers S.J., Tulinsky A., *J. Am. Chem. Soc.*, 1967, **89**, 3331.
- [94] Byrn M.P., Curtis C.J., Khan S.I., Sawin P.A., Tsurumi R., Strouse C.E., *J. Am. Chem. Soc.*, 1990, **112**, 1865.
- [95] Byrn M.P., Curtis J., Hsiou Y., Khan S.I., Sawin P.A., Tendick K., Terzis A., Strouse C.E., *J. Am. Chem. Soc.*, 1993, **115**, 9480.
- [96] Coordinate file TPHPOR10 de Cambridge Data Base, Hamor M.J., Hamor T.A., Hoard J.L., *J. Am. Chem. Soc.*, 1964, **86**, 1938 (ref. 85).
- [97] Coordinate file TPPPFEFC de Cambridge Data Base, Stone A., Fleischer E.B., *J. Am. Chem. Soc.*, 1968, **90**, 2735 (ref. 86).
- [98] Harvey P.D., *"The Porphyrin Handbook"*, eds. Kadish K.M., Smith K.M. and Guillard R., Academic Press, San Diego, CA, **2000**, vol. 18, chapter 113, p. 70.
- [99] Alexander A.E., *J. Chem. Soc.* **1937**, 1813.
- [100] Bergeron J.A., Gaines Jr. G.L., Bellamy W.D., *J. Colloid Interface Sci.*, **1967**, 25, 97.

- [101] Kasha M., Rawls H.R., El-Bayoumi M.A., *Pure Appl. Chem.*, 1965, **11**, 371.
- [102] Hunter C.A., Sanders J.K.M., Stone A.J., *Chem. Phys.*, 1989, **133**, 395.
- [103] Barber D.C., Freitag-Beeston R.A., Whitten D.G., *J. Phys. Chem.*, 1991, **95**, 4074.
- [104] Kroon J.M., Koehorst R.B.M., Van Dijk M., Sanders G.M., Sudhölter E.J.R., *J. Mater. Chem.*, 1997, **7**, 615.
- [105] Eichhorn E., Wöhrle D., Pressner D., *Liq. Cryst.*, 1997, **22**, 643.
- [106] Bonnett R., “*Chemical Aspects of Photodynamic Therapy*”, Gordon and Breach Science Publishers, The Netherlands, **2000**, p. 252.
- [107] Fiddler H., Terpstra J., Wiersma D.A., *J. Chem. Phys.*, 1991, **94**, 6895.
- [108] Bohn P.W., *Annu. Rev. Phys. Chem.*, 1993, **44**, 37.
- [109] Ribó J.M., Crusats J., Farrera J.A., Valero M.L., *J. Chem. Soc., Chem. Commun.*, 1994, 681.
- [110] Rubires R., Farrera J.A., Ribó J.M., *Chem. Eur. J.*, 2001, **7** (2), 436.
- [111] Kadish K.M., Maiya G.B., Araullo C., Guillard R., *Inorg. Chem.*, 1989, **28**, 2725.
- [112] Senge M.O., Smith K.M., *J. Chem. Soc., Chem. Commun.*, 1994, 923.
- [113] Chi X., Guerin A.J., Haycock R.A., Hunter C.A., Sarson L.D., *J. Chem. Soc., Chem. Commun.*, 1995, 2563.
- [114] Endnisch C., Fuhrhop J.-H., Buschmann J., Luger P., Siggel U., *J. Am. Chem. Soc.*, 1996, **118**, 6671.
- [115] Salehi A., Shirazi A., Bruice T.C., *Inorg. Chim. Acta*, 1992, **194**, 119.
- [116] Ramírez-Gutiérrez O., *Tesis Doctoral*, **2004**, Dpt. Química Orgànica. Universitat de Barcelona.
- [117] Hambright P., “*The Porphyrin Handbook*”, eds. Kadish K.M., Smith K.M. and Guillard R., Academic Press, San Diego, CA, **2000**, vol. 3, chapter 18, p. 148.
- [118] Pasternack R.F., Schaefer K.F., Hambright P., *Inorg. Chem.*, 1994, **33**, 2062.
- [119] Micali N., Mallamace F., Castriciano M., Romeo A., Scolaro L.M., *Anal. Chem.*, 2001, **73**, 4958.
- [120] Ohno O., Kaizu Y., Kobayashi H., *J. Chem. Phys.*, 1993, **99**, 4128.
- [121] Akins D.L., Zhu H.R., Guo C., *J. Phys. Chem.*, 1994, **98**, 3612.
- [122] Rubires R., *Tesi Doctoral*, **2000**. Dpt. Química Orgànica. Universitat de Barcelona.
- [123] Crusats J., Claret J., Díez-Pérez I., El-Hachemi Z., García-Ortega H., Rubires R., Sagués F., Ribó J.M., *Chem. Commun.*, 2003, 1588.
- [124] Rubires R., Crusats J., El-Hachemi Z., Jaramillo T., López M., Valls E., Farrera J.A., Ribó J. M., *New J. Chem.*, 1999, **23**, 189.
- [125] Rahman M., Harmon J., *J. Porphyrins Phthalocyanines*, 2007, **11**, 125.
- [126] García-Ortega H., Crusats J., Feliz M., Ribó J. M., *J. Org. Chem.*, 2002, 67,4170.
- [127] Hibbert F., Hunte K.P.P., *J. Chem. Soc. Perkin II*, 1977, 1624.

- [128] Cunderlikova B., Kaalhus O., Cunderlik R., Mateasik A., Moan J., Kongshaug M., *Photochem. Photobiol.*, 2004, **79**, 242.
- [129] Pasternack R.F., Sutin N., Turner D.H., *J. Am. Chem. Soc.*, 1976, **98**, 1908.
- [130] Bullock J.I., Simpson P.W.G., *J. Chem. Soc. Faraday. Trans.1*, 1981, **77**, 1991.
- [131] Büchler J.W., “*Porphyrins and Metalloporphyrins*”, Ed. K.M. Smith, Elsevier Scientific Publishing Co., North Holland Biomedical Press, New York, **1976**, chapter 5, p. 157.
- [132] Zanoni R., Boschi T., Licoccia S., Paolesse R., Tagliatesta P., *Inorganica Chimica Acta*, 1988, **145**, 175.
- [133] Moulder J.F., Stickle W.F., Sobol P.E., Bomben K.D., “*Handbook of X-ray Photoelectron Spectroscopy*”, ed. Jill Chastain, Perkin Elmer Corporation, Minnesota, **1992**, p. 25.
- [134] Iler R.K., “*The Chemistry of Silica*”, John Wiley, New York, **1979**, p. 640.
- [135] Ernstsson M., Larsson A., *Coll. Surf. A*, 2000, **168**, 215.
- [136] Castriciano M.A., Romeo A., Scolaro L.M., *J. Porphyrins Phthalocyanines*, 2002, **6**, 431.
- [137] Dimitriev O.P. *Synth. Met.*, 2001, **122**, 315.
- [138] Dimitriev O.P. *Synth. Met.*, 2002, **125**, 359.
- [139] Monti D., Venanzi M., Russo M., Bussetti G., Goletti C., Montalti M., Zaccheroni N., Prodi L., Rella R., Manera M.G., Mancini G., Di Natale C., Paolesse R., *New J. Chem.*, 2004, **28**, 1123.
- [140] Bellamy L.J., “*The Infrared Red Spectra of Complex Molecules*”, 2<sup>nd</sup> edition, ed. Chapman and Hall, London, **1980**, vol. 2, p. 225.
- [141] Ferriso C.C., Horning D.F., *J. Am. Chem.Soc.*, 1953, **75**, 4113.
- [142] Ribó J.M., Rubires R., El-Hachemi Z., Farrera J.A., Campos J., Pakhomov G.L., Vendrell M., *Mat.Sci. Eng. C*, 2000, **11**, 107-115.
- [143] Rubires R., Muller C., Campos L., El-Hachemi Z., Pakhomov G.L., Ribó J.M., *J. Porphyrins Phthalocyanines*, 2002, **6**, 107.
- [144] Castriciano M.A., Romeo A., Villari V., Angelini N., Micali N., Scolaro L.M., *J. Phys. Chem. B*, 2005, **109**, 12086.
- [145] Andrade S.M., Costa S.M.B., *Biophys. J.*, 2002, **82**, 1607.
- [146] Andrade S.M., Costa S.M.B., *Chem. Eur. J.*, 2006, **12**, 1046.
- [147] Maiti N.C., Ravikanth M., Mazumdar S., Periasamy N., *J. Phys. Chem.*, 1995, **99**, 17192.
- [148] Akins D.L., Özçelik S., Zhu H.R., Guo C., *J. Phys. Chem.*, 1996, **100**, 14390.
- [149] Micali N., Romeo A., Lauceri R., Purrello R., Mallamace F., Scolaro L.M., *J. Phys. Chem. B.*, 2000, **104**, 9416.
- [150] Ribó J.M., Bofill J.M., Crusats J., Rubires R., *Chem. Eur. J.*, 2001, **7**, 2733.
- [151] Wiesendanger R., Anselmetti D., “*Scanning Tunneling Microscopy I*”, Eds. Güntherodt H.J., Wiesendanger R., Berlin, **1992**, p. 138.
- [152] Feddes B., Kravchenco I.I., Seiberling L.E., *Scanning*, 1998, **20**, 376.

- [153] Ribó J.M., Crusats J., Sagues F., Claret J.M., Rubires R., *Science*, 2001, **292**, 2063.
- [154] Wada S., Fujiwara K., Monjushiro H., Watarai H., *J. Phys.: Condens. Matter.*, 2007, **19**, 375105 (12 pp).
- [155] Tsuda A., Akhtarul Alam Md., Harada T., Yamaguchi T., Ishii N., Aida T., *Angew. Chem. Int. Ed.*, 2007, **46**, 8198.
- [156] Wolffs M., George S.J., Tomović Z., Meskers S.C.J., Schenning A.P.H.J., Meijer E.W., *Angew. Chem. Int. Ed. En.*, 2007, **46**, 8203.
- [157] Kikuchi N., Gent A., Yeomans J.M., *Eur. Phys. J. E*, 2002, **9**, 63.
- [158] Tanaka H., *J. Phys. Condens. Matter*, 2005, **17**, S2795.
- [159] Snir Y., Kamien R.D., *Science*, 2005, **307**, 1067.
- [160] D.W. Howard, E. N. Lightfoot, J. O. Hirschfelder, *AIChE J.*, 1976, **22**, 794.
- [161] Makino M., Doi M., *Phys. Fluids*, 2005, **17**, 103605.
- [162] Ruch E., *Angew. Chem.*, 1977, **89**, 67.
- [163] Ruch E., *Angew. Chem. Int. Ed. Eng.*, 1977, **16**, 65.
- [164] Balaban T.S., *Acc. Chem. Res.*, 2005, **38**, 612.
- [165] Papaseit C., Pochon N., Tabony J., *Proc. Natl. Acad. Sci. USA*, 2000, **97**, 8364.
- [166] Ono K., Yoshizawa M., Kato T., Watanabe K., Fujita M., *Angew. Chem. Int. Ed.*, 2007, **46**, 1803.
- [167] Sugimoto T., Sada K., Tateishi Y., Suzuki T., Sei Y., Yamaguchi K., Shinkai S., *Tetrahedron Letters*, 2005, **46**, 5347.
- [168] Fiammengo R., Timmerman P., Huskens J., Versluis K., Heck A.J.R., Reinhoudt D.N., *Tetrahedron*, 2002, **58**, 757.
- [169] Gulino F.G., Lauceri R., Frish L., Evan-Salem T., Cohen Y., De Zorzi R., Geremia S., Di Costanzo L., Randaccio L., Sciotto D., Purrello R., *Chem. Eur. J.*, 2006, **12**, 2722.
- [170] Moschetto G., Lauceri R.; Gulino F.G., Sciotto D., Purrello R., *J. Am. Chem. Soc.*, 2002, **124**, 14536.
- [171] Di Costanzo L., Geremia S., Randaccio L., Purrello R., Lauceri R., Sciotto D., Gulino F.G., Pavone V., *Angew. Chem. Int. Ed.*, 2001, **40**, 4245.
- [172] De Napoli M., Nardis S., Paolesse R., Vicente M.G.H., Lauceri R., Purrello R., *J. Am. Chem. Soc.*, 2004, **126**, 5934.
- [173] Castriciano M.A., Romeo A., Villari V., Micali N., Scolaro L.M., *J. Phys. Chem. B*, 2003, **107**, 8765.
- [174] Pasternack R.F., Collings P.J., *Science*, 1995, **269**, 935.
- [175] Dresselhaus M.S., Dresselhaus G., *Adv. Phys.*, 2002, **51**, 1.
- [176] Phillips C.L., Nagle Jr. H.T., “*Sistemas de control digital. Análisis y diseño*”, 2ª edición, ed. Gustavo Gili, London, **1993**, p. 98.



- [177] Zhong Z.W., Lu Y.G., *Int. J. Adv. Manuf. Technol.*, 2004, **23**, 462.
- [178] Angelescu D.E., Harrison C.K., Trawick M.L., Chaikin P.M., Register R.A., Adamson D.H., *Appl. Phys. A*, 2004, **78**, 387.
- [179] Király Z., Findenegg G.H., *Langmuir*, 2005, **21**, 5047.
- [180] Kawasaki H., Shinoda M., Miyahara M., Maeda H., *Colloid Polym. Sci.*, 2005, **283**, 359.
- [181] Atkin R., Craig V.S.J., Wanless E.J., Biggs S., *Adv. Coll. Interface Sci.*, 2003, **103**, 219.
- [182] Sokolov I., Yang H., Ozin G.A., Henderson G.S., *Adv. Mater.*, 1997, **9**, 917.
- [183] Manne S., Gaub H.E., *Science*, 1995, **270**, 1480.
- [184] Mao G., Chen D., Handa H., Dong W., Kurth D.G., Möhwald H., *Langmuir*, 2005, **21**, 578.
- [185] Van Gorkom M., Van der Molen M.H., Korver O., *Biochimica et Biophysica Acta*, 1975, **392**, 1, 147.
- [186] Pérez-García Ll., Amabilino D., *Chem. Soc. Rev.*, 2002, **31**, 342.
- [187] Cadenhead D.A., Balthasar D.M., *J. Colloid Interface Sci.*, 1985, **107**, 567.
- [188] Meine K., Vollhardt D., Weidemann G., *Langmuir*, 1998, **14**, 1815.
- [189] Gehlert U., Vollhardt D., Brezesinski G., Möhwald H., *Langmuir*, 1996, **12**, 4892.
- [190] Rabe J.P., Buchholz S., *Science*, 1991, **253**, 424.
- [191] Cyr D.M., Venkataraman B., Flynn G.W., Black A., Whitesides G.M., *J. Phys. Chem.*, 1996, **100**, 13747.
- [192] Hibino M., Sumi A., Hatta I., *Jpn. J. Appl. Phys.*, 1995, **34**, 3354.
- [193] Tao F., Cai Y., Bernasek S.L., *Langmuir*, 2005, **21**, 1269.
- [194] Goto M., Kozawa K., Uchida T., *Bull. Chem. Soc. Jpn.*, 1988, **61**, 1434.
- [195] Larsson K., *Acta Chem. Scand.*, 1966, **20**, 2255.
- [196] Kodali D.R., Redgrave T.G., Small D.M., Atkinson D., *Biochemistry*, 1985, **24**, 519.
- [197] Nandi N., Vollhardt D., Brezesinski G., *J. Phys. Chem. B*, 2004, **108**, 327.
- [198] Turk H., Ford W. T., *J. Org. Chem.*, 1991, **56**, 1253.
- [199] Panicucci R., Bruice T. C., *J. Am. Chem. Soc.*, 1990, **112**, 6063.
- [200] Ribó J. M., Farrera J. A., Valero M. L., Virgili A., *Tetrahedron*, 1995, **51**, 3705.
- [201] Valero M. L., *Tesis de Licenciatura*, **1994**, Dpt. Química Orgànica. Universitat de Barcelona.
- [202] Valls E., *Tesi de Llicenciatura*, **1995**, Dpt. Química Orgànica. Universitat de Barcelona.
- [203] López M., *Tesi de Llicenciatura*, **1997**, Dpt. Química Orgànica. Universitat de Barcelona.
- [204] Binnig G., Rohrer H., *Helv. Phys. Acta*, 1982, **55**, 726.
- [205] Binnig G., Rohrer H., Gerber Ch., Weibel E., *Phys. Rev. Lett.*, 1982, **49**, 57.
- [206] Binnig G., Rohrer H., Gerber Ch., Weibel E., *Phys. Rev. Lett.*, 1983, **50**, 120.
- [207] Binnig G., Quate C.F., Gerber Ch., *Phys. Rev. Lett.*, 1986, **56**, 930.

- [208] Vesenka J., Guthold M., Tang C.L., Keller D., Delaine E., Bustamante C., *Ultramicroscopy*, 1992, **42-44**, 1243.
- [209] Gómez E., Vallés E., Gorostiza P., Servat J., Sanz F., *J. Electrochem. Soc.*, 1995, **12**, 4091.

