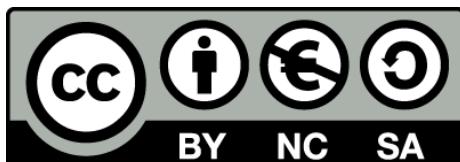




Electric polarization properties of single bacteria measured with electrostatic force microscopy

Theoretical and practical studies of Dielectric constant of single bacteria and smaller elements

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DOCTORAL THESIS

12 - References

- [1] S. V. Avery, *Nature Reviews Microbiology*, vol. 4, p. 577, 2006.
- [2] B. F. Brehm-Stecher and J. E. A, *Microbiology and molecular biology reviews*, vol. 68, p. 538, 2004.
- [3] Y. F. Dufrene, *Nature Reviews Microbiology*, vol. 2, p. 451, 2004.
- [4] D. Alesteens et al., *Nanoscale Research Letters*, vol. 2, pp. 265-371, 2007.
- [5] Y. F. Dufrene, *The Analyst*, vol. 133, pp. 297-301, 2008.
- [6] M. Castellarnau and e. al., *Biophysical Journal*, vol. 90, p. 3937, 2006.
- [7] W. C. Whitman, D. C. Coleman and W. J. Wiebe, *Proceedings of the National Academy of Sciences*, vol. 95, no. 12, pp. 6678-83, 1998.
- [8] C. Q. Choi, "Microbes Thrive in Deepest Spot on Earth," in *LiveScience*, 2013.
- [9] T. Katla et al., *Journal of Applied Microbiology*, vol. 93, no. 2, pp. 191-196, 2002.
- [10] A. L. Koch, *Crit. Rev. Microbiol.*, vol. 28, no. 1, pp. 61-77, 2002.
- [11] P. J. Hastings, S. M. Rosenberg and A. Slack, *Trends in Microbiology*, vol. 12, no. 9, pp. 401-4, 2004.
- [12] I. Chen and D. Dubnau, *Nature Reviews Microbiology*, vol. 2, no. 3, pp. 241-9, 2004.
- [13] R. Giraldi, B. E. Guth and L. R. Trabulsi, *Journal of Clinical Microbiology*, vol. 28, no. 6, pp. 1460-2, 1990.
- [14] -. INRA press service, "Identification of *Lactobacillus sakei* Genes Induced during Meat fermentation...", 2005.
- [15] D. Philippe et al., *Appl Environ Microbiol.*, vol. 76, no. 2, pp. 560-565, 2010.
- [16] C. Buchrieser et al., *FEMS Immunology and Medical Microbiology*, vol. 35, pp. 207-13, 2003.
- [17] M. Calderon-Miranda and G. Barvosa-Cánovas, *International Journal of Food Microbiology*, vol. 51, no. 1, pp. 31-38, 1999.
- [18] G. Binnig, H. Roher, C. Gerber and E. Weibel, *Physical Review Letters*, vol. 49, no. 1, pp. 57-61, 1982.
- [19] G. Binnig, C. F. Quate and C. Gerber, *Physical Review Letters*, vol. 56, no. 9, pp. 1318-1322, 1986.
- [20] R. Shao, S. V. Kalinin and D. A. Bonnell, *Applied Physics Letters*, pp. 1869-1871, 2003.
- [21] L. Fumagalli, G. Ferrari, M. Sampietro, I. Casuso, E. Martinez, J. Samitier and G. Gomila, *Nanotechnology*, vol. 17, no. 18, pp. 4581-4587, 2006.
- [22] I. Casuso, L. Fumagalli, G. Gomila and E. Padros, *Applied Physics Letters*, vol. 91, no. 6, p. 3, 2007.

- [23] G. Gomila, J. Toset and L. Fumagalli, *Journal of Applied Physics*, vol. 91, no. 24, pp. 024315-024318, 2008.
- [24] L. Fumagalli, G. Ferrari, M. Sampietro and G. Gomila, *Nano Letters*, vol. 9, no. 4, pp. 1604-1608, 2009.
- [25] A. Verdaguer, G. M. Sacha, H. Bluhm and M. Salmeron, *Surface Science*, vol. 344, no. 221-236, pp. 1478-1510, 1995.
- [26] J. Hu, X. D. Xiao, D. F. Ogletree and M. Salmeron, *Science*, vol. 268, no. 5208, pp. 267-269, 1995.
- [27] G. Gramse, I. Casuso, L. F. J Toset and G. Gomila, *Nanotechnology*, vol. 20, p. 395702, 2009.
- [28] D. Esteban-Ferrer, M. A. Edwards, L. Fumagalli, A. Juárez and G. Gomila, *ACS Nano*, vol. ASAP, 2014.
- [29] L. Fumagalli, D. Esteban-Ferrer, A. Cuervo, J. L. Carrascosa and G. Gomila, *Nature Materials*, vol. 11, pp. 808-816, 2012.
- [30] L. Fumagalli, G. Gramse, D. Esteban-Ferrer, M. A. Edwards and G. Gomila, *Applied Physics Letters*, vol. 96, no. 18, p. 183107, 2010.
- [31] O. Cherniavskaya, L. W. Chen, V. Weng, L. Yuditsky and L. E. Brus, *Journal of Physical Chemistry B*, vol. 107, no. 7, pp. 1525-1531, 2003.
- [32] G. Gomila, D. Esteban-Ferrer and L. Fumagalli, *Nanotechnology*, vol. 24, no. 50, p. 505713, 2013.
- [33] L. Fumagalli, G. Ferrari, M. Sampietro and G. Gomila, *Applied Physics Letters*, vol. 91, p. 243110.
- [34] A. Hudlet, M. Saint Jean, C. Guthmann and J. Berger, *J. Eur. Phys. J. B*, vol. 2, pp. 5-10, 1998.
- [35] J. M. Crowley, *Proceedings of ESA Annual Meeting on Electrostatics*, no. Paper D1, 2008.
- [36] W. R. Smythe, *Static and Dynamic Electricity*, New York: McGraw- Hill, 1968.
- [37] G. M. Sacha and J. J. Sáenz, *Applied Physics Letters*, vol. 85, p. 2610, 2004.
- [38] G. Gomila, G. Gramse and L. Fumagalli, *Nanotechnology*, vol. 25, p. 255702, 2014.
- [39] K. Asami, T. Hanai and N. Koizumi, *Biophysical Journal*, vol. 31, pp. 215-228.
- [40] R. Hölzel, *Biochim. Biophys. Acta*, vol. 1450, pp. 53-60, 1999.
- [41] A. Sanchis, A. P. Brown, M. Sancho, M. G, S. J. L, M. S and M. J. M, *Bioelectromagnetics*, vol. 28, pp. 393-401, 2007.
- [42] H. Fricke, H. P. Schwan, L. K and B. V, vol. 187, pp. 134-135, 1956.
- [43] M. Manoor, S. Zhang, A. J. Link and M. C. McAlpine, *Proc. Natl. Acad. Sci.*, vol. 107, pp. 19207-19212, 2010.
- [44] L. Yang and R. Bashir, *Biotechnol. Adv.*, vol. 26, pp. 135-150, 2008.
- [45] C. Bernabini, D. Holmes and H. Morgan, *Lab Chip*, vol. 11, pp. 407-412, 2011.
- [46] F. David, M. Hebeisen, G. Schade, E. Franco-Lara and M. DiBernardino, *Biotechnol. Bioeng.*, vol. 109, pp. 483-92, 2012.

- [47] Castellarnau M et al., *Biophys. J.*, vol. 91, pp. 3937-3945, 2006.
- [48] S. Park, M. Kokulu and A. Beskok, *Anal. Chem.*, vol. 81, pp. 2303-2310, 2009.
- [49] S. Giordano, *Materials*, vol. 2, pp. 1417-1479, 2009.
- [50] R. Pethig and D. B. Kell, *Phys. Med. Biol.*, vol. 32, pp. 933-970, 1987.
- [51] Simonson, *Rep. Prog. Phys.*, vol. 66, pp. 737-787, 2003.
- [52] A. Cuervo, P. D. Dans, C. J. L, M. Orozco, G. Gomila and L. Fumagalli, *Proc. Natl. Acad. Sci.*, 2014 (epub).
- [53] G. Benga, *Life*, vol. 61, pp. 112-133, 2009.
- [54] W. Bai, K. S. Zhao and K. Asami, *Biophys. Chem.*, vol. 122, pp. 136-142, 2006.
- [55] S. Giordano, *Materials*, vol. 2, pp. 1418-1479, 2009.
- [56] C. A. Balazs, T. Emerick and T. P. Russell, *Science*, vol. 314, pp. 1107-1110, 2006.
- [57] H.-Y. Chen, M. K. F. Lo, G. Yang, H. G. Monbouquette and Y. Yang, *Nature Nanotechnology*, vol. 3, pp. 543-547, 2008.
- [58] M. M. Van Schooneveld et al., *Nature Nanotechnology*, vol. 5, pp. 538-544, 2010.
- [59] P. Alivisatos, *Nature Biotechnology*, vol. 22, pp. 47-52, 2010.
- [60] X. Michalet et al., *Science*, vol. 307, pp. 538-544, 2008.
- [61] M. E. Davis, Z. Chen and D. M. Shin, *Nature Rev. Drug. Discov.*, vol. 7, pp. 771-782, 2008.
- [62] Y. C. Cao, R. Jin and C. A. Mirkin, *Science*, vol. 297, pp. 1536-1540, 2002.
- [63] A. Cvitkovic, N. Ocelic and R. Hillenbrand, *Nano Letters*, vol. 7, pp. 3177-3181, 2007.
- [64] J. Stadler, T. Schmid and R. Zenobi, *Nano Letters*, vol. 10, pp. 4514-4520, 2010.
- [65] J. Zhu et al., *Nature Photonics*, vol. 4, pp. 46-49, 2010.
- [66] S. Person, B. Deutsch, A. Mitra and L. Novotny, *Nano Letters*, vol. 11, pp. 257-261, 2011.
- [67] F. Huth, M. Schenell, J. Wittborn, N. Ocelic and H. R, *Nature Materials*, vol. 10, pp. 352-356, 2011.
- [68] S. J. A, Electromagnetic Theory, New York: McGraw-Hill, 1941.