

4. CRYSTALLIZATION

References

4.1

- Astier, J. P., Veessler, S. & Boistelle, R. (1998). *Protein crystals orientation in a magnetic field*. *Acta Cryst.* **D54**, 703–706.
- Ataka, M., Katoh, E. & Wakayama, N. L. (1997). *Magnetic orientation as a tool to study the initial stage of crystallization of lysozyme*. *J. Cryst. Growth*, **173**, 592–596.
- Baldwin, E. T., Crumly, K. V. & Carter, C. W. (1986). *Practical, rapid screening of protein crystallization conditions by dynamic light scattering*. *Biophys. J.* **49**, 47–48.
- Bancel, P. A., Cajipe, V. B., Rodier, F. & Witz, J. (1998). *Laser seeding for biomolecular crystallization*. *J. Cryst. Growth*, **191**, 537–544.
- Berne, P. F., Doublé, S. & Carter, C. W. Jr (1999). *Molecular biology for structural biology*. In *Crystallization of nucleic acids and proteins*, edited by A. Ducruix & R. Giegé, 2nd ed. Oxford University Press.
- Boggon, T. J., Chayen, N. E., Snell, E. H., Dong, J., Lautenschlager, P., Potthast, L., Siddons, D. P., Stojanoff, V., Gordon, E., Thompson, A. W., Zagalsky, P. F., Bi, R.-C. & Helliwell, J. R. (1998). *Protein crystal movements and fluid flows during microgravity growth*. *Philos. Trans. R. Soc. London Ser. A*, **356**, 1045–1061.
- Bonneté, F., Malfois, M., Finet, S., Tardieu, A., Lafont, S. & Veessler, S. (1997). *Different tools to study interaction potentials in γ -crystallin solutions: relevance to crystal growth*. *Acta Cryst.* **D53**, 438–447.
- Bosch, R., Lautenschlager, P., Potthast, L. & Stapelmann, J. (1992). *Experiment equipment for protein crystallization in μ g facilities*. *J. Cryst. Growth*, **122**, 310–316.
- Bott, R. R., Navia, M. A. & Smith, J. L. (1982). *Improving the quality of protein crystals through purification by isoelectric focusing*. *J. Biol. Chem.* **257**, 9883–9886.
- Carter, D. C., Lim, K., Ho, J. X., Wright, B. S., Twigg, P. D., Miller, T. Y., Chapman, J., Keeling, K., Ruble, J., Vekilov, P. G., Thomas, B. R., Rosenberger, F. & Chernov, A. A. (1999). *Lower dimer impurity incorporation may result in higher perfection of HEWL crystal grown in μ g – a case study*. *J. Cryst. Growth*, **196**, 623–637.
- Chayen, N. E. (1996). *A novel technique for containerless protein crystallization*. *Protein Eng.* **9**, 927–929.
- Chayen, N. E. (1997). *A novel technique to control the rate of vapour diffusion, giving larger protein crystals*. *J. Appl. Cryst.* **30**, 198–202.
- Chayen, N. E., Boggon, T. J., Cassetta, A., Deacon, A., Gleichmann, T., Habash, J., Harrop, S. J., Helliwell, J. R., Nieh, Y. P., Peterson, M. R., Raftery, J., Snell, E. H., Hädener, A., Niemann, A. C., Siddons, D. P., Stojanoff, V., Thompson, A. W., Ursby, T. & Wulff, M. (1996). *Trends and challenges in experimental macromolecular crystallography*. *Q. Rev. Biophys.* **29**, 227–278.
- Chayen, N. E., Lloyd, L. F., Collyer, C. A. & Blow, D. M. (1989). *Trigonal crystals of glucose isomerase require thymol for their growth and stability*. *J. Cryst. Growth*, **97**, 367–374.
- Chayen, N. E., Shaw Stewart, P. D., Maeder, D. L. & Blow, D. M. (1990). *An automated system for micro-batch protein crystallisation and screening*. *J. Appl. Cryst.* **23**, 297–302.
- Chernov, A. A. (1997a). *Crystals built of biological macromolecules*. *Phys. Rep.* **288**, 61–75.
- Chernov, A. A. (1997b). *Protein versus conventional crystals: creation of defects*. *J. Cryst. Growth*, **174**, 354–361.
- Chernov, A. A. (1999). *Estimates of internal stress and related mosaicity in solution grown crystals: proteins*. *J. Cryst. Growth*, **196**, 524–534.
- Christopher, G. K., Phipps, A. G. & Gray, R. J. (1998). *Temperature-dependent solubility of selected proteins*. *J. Cryst. Growth*, **191**, 820–826.
- Cole, T., Kathman, A., Koszelak, S. & McPherson, A. (1995). *Determination of the local refractive index for protein and virus crystals in solution by Mach-Zehnder interferometry*. *Anal. Biochem.* **231**, 92–98.
- Crossio, M.-P. & Jullien, M. (1992). *Fluorescence study of precrystallization of ribonuclease A: effect of salts*. *J. Cryst. Growth*, **122**, 66–70.
- Cudney, B., Patel, S. & McPherson, A. (1994). *Crystallization of macromolecules in silica gels*. *Acta Cryst.* **D50**, 479–483.
- D'Arcy, A., Elmore, C., Stihle, M. & Johnston, J. E. (1996). *A novel approach to crystallizing proteins under oil*. *J. Cryst. Growth*, **168**, 175–180.
- Declercq, J.-P., Evrard, C., Carter, D. C., Wright, B. S., Etienne, G. & Parello, J. (1999). *A crystal of a typical EF-hand protein grown under microgravity diffracts X-rays beyond 0.9 Å resolution*. *J. Cryst. Growth*, **196**, 595–601.
- DeLucas, L. J., Long, M. M., Moore, K. M., Rosenblum, W. M., Bray, T. L., Smith, C., Carson, M., Narayana, S. V. L., Harrington, M. D., Carter, D., Clark, A. D. Jr, Nanni, R. G., Ding, J., Jacobo-Molina, A., Kamer, G., Hughes, S. H., Arnold, E., Einspahr, H. M., Clancy, L. L., Rao, G. S. J., Cook, P. F., Harris, B. G., Munson, S. H., Finzel, B. C., McPherson, A., Weber, P. C., Lewandowski, F. A., Nagabhushan, T. L., Trotta, P. P., Reichert, P., Navia, M. A., Wilson, K. P., Thomson, J. A., Richards, R. N., Bowersox, K. D., Meade, C. J., Baker, E. S., Bishop, S. P., Dunbar, B. J., Trinh, E., Prah, J., Sacco, A. Jr & Bugg, C. E. (1994). *Recent results and new developments for protein crystal growth in microgravity*. *J. Cryst. Growth*, **135**, 183–195.
- DeMattei, R. C. & Feigelson, R. S. (1992). *Controlling nucleation in protein solutions*. *J. Cryst. Growth*, **122**, 21–30.
- DeMattei, R. C. & Feigelson, R. S. (1993). *Thermal methods for crystallizing biological macromolecules*. *J. Cryst. Growth*, **128**, 1225–1231.
- Dobrianov, I., Finkelstein, K. D., Lemay, S. G. & Thorne, R. E. (1998). *X-ray topographic studies of protein crystal perfection and growth*. *Acta Cryst.* **D54**, 922–937.
- Dock, A.-C., Lorber, B., Moras, D., Pixa, G., Thierry, J.-C. & Giegé, R. (1984). *Crystallization of transfer ribonucleic acids*. *Biochimie*, **66**, 179–201.
- Dock-Bregeon, A.-C., Chevrier, B., Podjarny, A., Moras, D., deBear, J. S., Gough, G. R., Gilham, P. T. & Johnson, J. E. (1988). *High resolution structure of the RNA duplex [U(U–A)₆A]₂*. *Nature (London)*, **209**, 375–378.
- Dock-Bregeon, A.-C., Moras, D. & Giegé, R. (1999). *Nucleic acids and their complexes*. In *Crystallization of nucleic acids and proteins*, 2nd ed. A. Ducruix & R. Giegé, edited by Oxford University Press.
- Ducruix, A. & Giegé, R. (1999). Editors. *Crystallization of proteins and nucleic acids: a practical approach*, 2nd ed. Oxford: IRL Press.
- Ducruix, A., Guilloateau, J.-P., Riès-Kautt, M. & Tardieu, A. (1996). *Protein interactions as seen by solution X-ray scattering prior to crystallogenesis*. *J. Cryst. Growth*, **168**, 28–39.
- Durbin, S. D. & Carlson, W. E. (1992). *Lysozyme crystal growth studied by atomic force microscopy*. *J. Cryst. Growth*, **122**, 71–79.
- Durbin, S. D. & Feher, G. (1990). *Studies of crystal growth mechanisms by electron microscopy*. *J. Mol. Biol.* **212**, 763–774.
- Durbin, S. D. & Feher, G. (1996). *Protein crystallization*. *Annu. Rev. Phys. Chem.* **47**, 171–204.
- Ebel, C., Faou, P. & Zaccà, G. (1999). *Protein–solvent and weak protein–protein interactions in halophilic malate dehydrogenase*. *J. Cryst. Growth*, **196**, 395–402.
- Ferré-D'Amaré, A. & Burley, S. K. (1997). *Dynamic light scattering in evaluating crystallizability of macromolecules*. *Methods Enzymol.* **276**, 157–166.
- Finet, S., Bonneté, F., Frouin, J., Provost, K. & Tardieu, A. (1998). *Lysozyme crystal growth, as observed by small angle X-ray scattering, proceeds without crystallization intermediates*. *Eur. Biophys. J.* **76**, 554–561.
- Fitzgerald, P. M. D. & Madson, N. B. J. (1986). *Improvement of limit of diffraction and useful X-ray lifetime of crystals of glycogen debranching enzyme*. *J. Cryst. Growth*, **76**, 600–606.

REFERENCES

4.1 (cont.)

- Fourme, R., Ducruix, A., Ries-Kautt, M. & Capelle, B. (1995). *The perfection of protein crystals probed by direct recording of Bragg reflection profiles with a quasi-planar X-ray wave*. *J. Synchrotron Rad.* **2**, 136–142.
- García-Ruiz, J. M. & Moreno, A. (1994). *Investigations on protein crystal growth by the gel acupuncture method*. *Acta Cryst.* **D50**, 484–490.
- García-Ruiz, J. M., Moreno, A., Otalora, F., Rondon, D., Viedma, C. & Zauscher, F. (1998). *Teaching protein crystallization by the gel acupuncture method*. *J. Chem. Educ.* **75**, 442–446.
- García-Ruiz, J. M., Novella, M. L. & Otalora, F. (1999). *Supersaturation patterns in counter-diffusion crystallization methods followed by Mach-Zehnder interferometry*. *J. Cryst. Growth*, **196**, 703–710.
- García-Ruiz, J. M. & Otalora, F. (1997). *Crystal growth studies in microgravity with the APCF. II. Image analysis studies*. *J. Cryst. Growth*, **182**, 155–167.
- Georgalis, Y., Zouni, A., Eberstein, W. & Saenger, W. (1993). *Formation dynamics of protein precrystallization fractal clusters*. *J. Cryst. Growth*, **126**, 245–260.
- George, A., Chiang, Y., Guo, B., Abrabshahi, A., Cai, Z. & Wilson, W. W. (1997). *Second virial coefficient as predictor in protein crystal growth*. *Methods Enzymol.* **276**, 100–110.
- Giegé, R., Dock, A.-C., Kern, D., Lorber, B., Thierry, J.-C. & Moras, D. (1986). *The role of purification in the crystallization of proteins and nucleic acids*. *J. Cryst. Growth*, **76**, 554–561.
- Giegé, R., Drenth, J., Ducruix, A., McPherson, A. & Saenger, W. (1995). *Crystallogenesis of biological macromolecules. Biological, microgravity, and other physico-chemical aspects*. *Prog. Cryst. Growth Charact.* **30**, 237–281.
- Giegé, R., Moras, D. & Thierry, J.-C. (1977). *Yeast transfer RNA^{Asp}: a new high resolution X-ray diffracting crystal form of a transfer RNA*. *J. Mol. Biol.* **115**, 91–96.
- Gilliland, G., Tung, M., Blakeslee, D. M. & Ladner, J. E. (1994). *Biological macromolecule crystallization database, version 3.0: new features, data and the NASA archive for protein crystal growth data*. *Acta Cryst.* **D50**, 408–413.
- Green, A. A. & Hughes, W. L. (1995). *Protein fractionation on the basis of solubility in aqueous solutions of salts and organic solvents*. *Methods Enzymol.* **1**, 67–90.
- Gripou, C., Legrand, L., Rosenman, I., Vidal, O., Robert, M.-C. & Boué, F. (1997). *Lysozyme-lysozyme interactions in under- and super-saturated solutions: a simple relation between the second virial coefficient in H₂O and D₂O*. *J. Cryst. Growth*, **178**, 575–584.
- Haas, C. & Drenth, J. (1998). *The protein-water phase diagram and the growth of protein crystals from aqueous solution*. *J. Phys. Chem.* **102**, 4226–4232.
- Hampel, A., Labananskas, M., Connors, P. G., Kirkegard, L., Raj Bhandary, U. L., Sigler, P. B. & Bock, R. M. (1968). *Single crystals of transfer RNA from formyl-methionine and phenylalanyl transfer RNA's*. *Science*, **162**, 1384–1386.
- Harlos, K. (1992). *Micro-bridges for sitting-drop crystallizations*. *J. Appl. Cryst.* **25**, 536–538.
- Henisch, H. K. (1988). *Crystals in gels and Liesegang rings*. Cambridge, MA: Cambridge University Press.
- Hilgenfeld, R., Liesum, A., Storm, R. & Plaas-Link, A. (1992). *Crystallization of two bacterial enzymes on an unmanned space mission*. *J. Cryst. Growth*, **122**, 330–336.
- Hirschler, J., Charon, M.-H. & Fontecilla-Camps, J. C. (1995). *The effects of filtration on protein nucleation in different growth media*. *Protein Sci.* **4**, 2573–2577.
- Izumi, K., Sawamura, S. & Ataka, M. (1996). *X-ray topography of lysozyme crystals*. *J. Cryst. Growth*, **168**, 106–111.
- Jakoby, W. B. (1971). *Crystallization as a purification technique*. *Methods Enzymol.* **22**, 248–252.
- Jerusalmi, D. & Steitz, T. A. (1997). *Use of organic cosmotropic solutes to crystallize flexible proteins: application to T7 RNA polymerase and its complex with the inhibitor T7 lysozyme*. *J. Mol. Biol.* **274**, 748–756.
- Judge, R. A., Forsythe, E. L. & Pusey, M. L. (1998). *The effect of protein impurities on lysozyme crystal growth*. *Biotech. Bioeng.* **59**, 776–785.
- Jurnak, F. (1986). *Effect of chemical impurities in polyethylene glycol on macromolecular crystallization*. *J. Cryst. Growth*, **76**, 577–582.
- Kam, Z., Shore, H. B. & Feher, G. (1978). *On the crystallization of proteins*. *J. Mol. Biol.* **123**, 539–555.
- Karpukhina, S. Ya., Barynin, V. V. & Lobanova, G. M. (1975). *Crystallization of catalase in the ultracentrifuge*. *Sov. Phys. Crystallogr.* **20**, 417–418.
- Kimble, W. L., Paxton, T. E., Rousseau, R. W. & Sambanis, A. (1998). *The effect of mineral substrates on the crystallization of lysozyme*. *J. Cryst. Growth*, **187**, 268–276.
- Komatsu, H., Miyashita, S. & Suzuki, Y. (1993). *Interferometric observation of the interfacial concentration gradient layers around a lysozyme crystal*. *Jpn. J. Appl. Phys.* **32**(2), 1855–1857.
- Konnert, J. H., D'Antonio, P. & Ward, K. B. (1994). *Observation of growth steps, spiral dislocations and molecular packing on the surface of lysozyme crystals with the atomic force microscope*. *Acta Cryst.* **D50**, 603–613.
- Kozzelak, S., Day, J., Leja, C., Cudney, R. & McPherson, A. (1995). *Protein and virus crystal growth on International Microgravity Laboratory-2*. *Biophys. J.* **69**, 13–19.
- Kozzelak, S. & McPherson, A. (1988). *Time lapse microphotography of protein crystal growth using a color VRC*. *J. Cryst. Growth*, **90**, 340–343.
- Kozzelak, S., Martin, D., Ng, J. & McPherson, A. (1991). *Protein crystal growth rates determined by time lapse microphotography*. *J. Cryst. Growth*, **110**, 177–181.
- Kurihara, K., Miyashita, S., Sasaki, G., Nakada, T., Suzuki, Y. & Komatsu, H. (1996). *Interferometric study on the crystal growth of tetragonal lysozyme crystal*. *J. Cryst. Growth*, **166**, 904–908.
- Kuznetsov, Y. G., Malkin, A. J., Greenwood, A. & McPherson, A. (1995). *Interferometric studies of growth kinetics and surface morphology in macromolecular crystal growth: canavalin, thaumatin, and turnip yellow mosaic virus*. *J. Struct. Biol.* **114**, 184–196.
- Lenhoff, A. M., Pjura, P. E., Dilmore, J. G. & Godlewski, T. S. Jr (1997). *Ultracentrifugal crystallization of proteins: transport-kinetic modelling, and experimental behavior of catalase*. *J. Cryst. Growth*, **180**, 113–126.
- Lorber, B. & Giegé, R. (1992). *A versatile reactor for temperature controlled crystallization of biological macromolecules*. *J. Cryst. Growth*, **122**, 168–175.
- Lorber, B. & Giegé, R. (1996). *Containerless protein crystallization in floating drops: application to crystal growth monitoring under reduced nucleation conditions*. *J. Cryst. Growth*, **168**, 204–215.
- Lorber, B. & Giegé, R. (1999). *Biochemical aspects of macromolecular solutions and crystals*. In *Crystallization of nucleic acids and proteins*, edited by A. Ducruix & R. Giegé, 2nd ed. Oxford University Press.
- Lorber, B., Jenner, G. & Giegé, R. (1996). *Effect of high hydrostatic pressure on nucleation and growth of protein crystals*. *J. Cryst. Growth*, **158**, 103–117.
- Luft, J. R., Albright, D. T., Baird, J. K. & DeTitta, G. T. (1996). *The rate of water equilibration in vapor-diffusion crystallizations: dependence on the distance from the droplet to the reservoir*. *Acta Cryst.* **D52**, 1098–1106.
- Luft, J. & Cody, V. (1989). *A simple capillary vapor diffusion apparatus for surveying macromolecular crystallization conditions*. *J. Appl. Cryst.* **22**, 396.
- Luft, J. R., Cody, V. & DeTitta, G. T. (1992). *Experiences with HANGMAN: a macromolecular hanging drop vapor diffusion technique*. *J. Cryst. Growth*, **122**, 181–185.
- Luft, J. R., Rak, D. M. & DeTitta, G. T. (1999a). *Microbatch macromolecular crystallization in micropipettes*. *J. Cryst. Growth*, **196**, 450–455.
- Luft, J. R., Rak, D. M. & DeTitta, G. T. (1999b). *Microbatch macromolecular crystallization on a thermal gradient*. *J. Cryst. Growth*, **196**, 447–449.

4. CRYSTALLIZATION

4.1 (cont.)

- McPherson, A. (1976). *Crystallization of proteins from polyethylene glycol*. *J. Biol. Chem.* **251**, 6300–6303.
- McPherson, A. (1982). *The preparation and analysis of protein crystals*. New York: John Wiley and Sons.
- McPherson, A. (1990). *Current approaches to macromolecular crystallization*. *Eur. J. Biochem.* **189**, 1–23.
- McPherson, A. (1996). *Macromolecular crystal growth in microgravity*. *Crystallogr. Rev.* **6**, 157–305.
- McPherson, A. (1998). *Crystallization of biological macromolecules*. Cold Spring Harbor and New York: Cold Spring Harbor Laboratory Press.
- McPherson, A., Malkin, A. J. & Kuznetsov, Y. G. (1995). *The science of macromolecular crystallization*. *Structure*, **3**, 759–768.
- McPherson, A., Malkin, A. J., Kuznetsov, Y. G. & Koszelak, S. (1996). *Incorporation of impurities into macromolecular crystals*. *J. Cryst. Growth*, **168**, 74–92.
- McPherson, A. & Shlichta, P. (1988). *Heterogeneous and epitaxial nucleation of protein crystals on mineral surfaces*. *Science*, **239**, 385–387.
- Malkin, A. J., Cheung, J. & McPherson, A. (1993). *Crystallization of satellite tobacco mosaic virus. I. Nucleation phenomena*. *J. Cryst. Growth*, **126**, 544–554.
- Malkin, A. J., Kuznetsov, Yu. G., Land, T. A., DeYoreo, J. J. & McPherson, A. (1995). *Mechanisms of growth for protein and virus crystals*. *Nature Struct. Biol.* **2**, 956–959.
- Malkin, A. J., Kuznetsov, Yu. G. & McPherson, A. (1996). *Defect structure of macromolecular crystals*. *J. Struct. Biol.* **117**, 124–137.
- Malkin, A. J. & McPherson, A. (1993). *Light scattering investigations of protein and virus crystal growth: ferritin, apoferritin and satellite tobacco mosaic virus*. *J. Cryst. Growth*, **128**, 1232–1235.
- Malkin, A. J. & McPherson, A. (1994). *Light-scattering investigations of nucleation processes and kinetics of crystallization in macromolecular systems*. *Acta Cryst. D50*, 385–395.
- Matthews, B. W. (1985). *Determination of protein molecular weight, hydration, and packing from crystal density*. *Methods Enzymol.* **114**, 176–187.
- Mikol, V., Hirsch, E. & Giegé, R. (1990). *Diagnostic of precipitant for biomacromolecule crystallization by quasi-elastic light scattering*. *J. Mol. Biol.* **213**, 187–195.
- Mikol, V., Rodeau, J.-L. & Giegé, R. (1989). *Changes of pH during biomacromolecule crystallization by vapor diffusion using ammonium sulfate as the precipitant*. *J. Appl. Cryst.* **22**, 155–161.
- Mikol, V., Rodeau, J.-L. & Giegé, R. (1990). *Experimental determination of water equilibrium rates in the hanging drop method of protein crystallization*. *Anal. Biochem.* **186**, 332–339.
- Miller, T. V., He, X. M. & Carter, D. C. (1992). *A comparison between protein crystals grown with vapor diffusion methods in microgravity and protein crystals using a gel liquid–liquid diffusion ground based method*. *J. Cryst. Growth*, **122**, 306–309.
- Minezaki, Y., Nimura, N., Ataka, M. & Katsura, T. (1996). *Small angle neutron scattering from lysozyme solutions in unsaturated and supersaturated states (SANS from lysozyme solutions)*. *Biophys. Chem.* **58**, 355–363.
- Nakada, T., Sazaki, G., Miyashita, S., Durbin, S. D. & Komatsu, H. (1999). *Impurity effects on lysozyme crystallization as directly observed by atomic force microscopy*. *J. Cryst. Growth*, **196**, 503–510.
- Neal, B. L., Asthagiri, D., Velev, O. D., Lenhoff, A. M. & Kaler, E. W. (1999). *Why is the osmotic second virial coefficient related to protein crystallization?* *J. Cryst. Growth*, **196**, 377–387.
- Ng, J., Kuznetsov, Y. G., Malkin, A. J., Keith, G., Giegé, R. & McPherson, A. (1997). *Visualization of RNA crystals growth by atomic force microscopy*. *Nucleic Acids Res.* **25**, 2582–2588.
- Ng, J., Lorber, B., Witz, J., Théobald-Dietrich, A., Kern, D. & Giegé, R. (1996). *The crystallization of biological macromolecules from precipitates. Evidence for Ostwald ripening*. *J. Cryst. Growth*, **168**, 50–62.
- Ng, J. D., Lorber, B., Giegé, R., Koszelak, S., Day, J., Greenwood, A. & McPherson, A. (1997). *Comparative analysis of thaumatin crystals grown on earth and in microgravity*. *Acta Cryst. D53*, 724–733.
- Otalora, F. & García-Ruiz, J. M. (1997). *Crystal growth studies in microgravity with APCF. I. Computer simulation of transport dynamics*. *J. Cryst. Growth*, **182**, 141–154.
- Otalora, F., García-Ruiz, J. M., Gavira, J. A. & Capelle, B. (1999). *Topography and high resolution diffraction studies in tetragonal lysozyme*. *J. Cryst. Growth*, **196**, 546–558.
- Papanikolaou, Y. & Kokkinidis, M. (1997). *Solubility, crystallization and chromatographic properties of macromolecules strongly depend on substances that reduce the ionic strength of the solution*. *Protein Eng.* **10**, 847–850.
- Peters, R., Georgalis, Y. & Saenger, W. (1998). *Accessing lysozyme nucleation with a novel dynamic light scattering detector*. *Acta Cryst. D54*, 873–877.
- Plester, V., Stapelmann, J., Potthast, L. & Bosch, R. (1999). *The protein crystallization facility, a new European instrument to investigate biological macromolecular crystal growth on board the International Space Station*. *J. Cryst. Growth*, **196**, 638–648.
- Price, S. R. & Nagai, K. (1995). *Protein engineering as a tool for crystallography*. *Curr. Opin. Biotechnol.* **6**, 425–430.
- Pronk, S. E., Hofstra, H., Groendijk, H., Kingma, J., Swarte, M. B. A., Dorner, F., Drenth, J., Hol, W. G. J. & Witholt, B. (1985). *Heat-labile enterotoxin of Escherichia coli. Characterization of different crystal forms*. *J. Biol. Chem.* **260**, 13580–13584.
- Provost, K. & Robert, M.-C. (1995). *Crystal growth of lysozymes in media contaminated by parent molecules: influence of gelled media*. *J. Cryst. Growth*, **156**, 112–120.
- Pusey, M., Witherow, W. K. & Nauman, R. (1988). *Preliminary investigations into solutal flow about growing tetragonal lysozyme crystals*. *J. Cryst. Growth*, **90**, 105–111.
- Pusey, M. L. (1993). *A computer-controlled microscopy system for following protein crystal growth rates*. *Rev. Sci. Instrum.* **64**, 3121–3125.
- Ray, W. J. Jr & Puvathingal, J. M. (1985). *A simple procedure for removing contaminating aldehydes and peroxides from aqueous solutions of polyethylene glycols and of nonionic detergents that are based on the polyoxyethylene linkage*. *Anal. Biochem.* **146**, 307–312.
- Rhim, W.-K. & Chung, S. K. (1990). *Isolation of crystallizing droplets by electrostatic levitation*. *Methods Companion Methods Enzymol.* **1**, 118–127.
- Richard, B., Bonneté, F., Dym, O. & Zaccai, G. (1995). *Archaea, a laboratory manual*, pp. 149–154. Cold Spring Harbor Laboratory Press.
- Riès-Kautt, M. & Ducruix, A. (1991). *Crystallization of basic proteins by ion pairing*. *J. Cryst. Growth*, **110**, 20–25.
- Riès-Kautt, M. & Ducruix, A. (1999). *Phase diagrams*. In *Crystallization of nucleic acids and proteins*, edited by A. Ducruix & R. Giegé, 2nd ed. Oxford University Press.
- Robert, M. C., Bernard, Y. & Lefaucheux, F. (1994). *Study of nucleation-related phenomena in lysozyme solutions. Application to gel growth*. *Acta Cryst. D50*, 496–503.
- Robert, M.-C. & Lefaucheux, F. (1988). *Crystal growth in gels: principles and applications*. *J. Cryst. Growth*, **90**, 358–367.
- Robert, M.-C., Vidal, O., García-Ruiz, J. M. & Otalora, F. (1999). *Crystallization in gels and related methods*. In *Crystallization of nucleic acids and proteins*, edited by A. Ducruix & R. Giegé, 2nd ed. Oxford University Press.
- Rosenberger, F. (1996). *Protein crystallization*. *J. Cryst. Growth*, **166**, 40–54.
- Rosenberger, F., Vekilov, P. G., Muschol, M. & Thomas, B. R. (1996). *Nucleation and crystallization of globular proteins – what do we know and what is missing*. *J. Cryst. Growth*, **168**, 1–27.
- Rossi, G. L. (1992). *Biological activity in the crystalline state*. *Curr. Opin. Struct. Biol.* **2**, 816–820.
- Salemme, F. R. (1972). *A free interface diffusion technique for crystallization of proteins for X-ray crystallography*. *Arch. Biochem. Biophys.* **151**, 533–540.
- Sauter, C., Lorber, B., Kern, D., Cavarelli, J., Moras, D. & Giegé, R. (1999). *Crystallogenes studies on yeast aspartyl-tRNA synthetase*.

REFERENCES

4.1 (cont.)

- tase: use of phase diagram to improve crystal quality. *Acta Cryst.* **D55**, 149–156.
- Sauter, C., Ng, J. D., Lorber, B., Keith, G., Brion, P., Hosseini, M. W., Lehn, J.-M. & Giegé, R. (1999). Additives for the crystallization of proteins and nucleic acids. *J. Cryst. Growth*, **196**, 365–376.
- Sazaki, G., Yoshida, E., Komatsu, H., Nakada, T., Miyashita, S. & Watanabe, K. (1997). Effects of a magnetic field on the nucleation and growth of protein crystals. *J. Cryst. Growth*, **173**, 231–234.
- Shlichta, P. J. (1986). Feasibility of mapping solution properties during the growth of protein crystals. *J. Cryst. Growth*, **76**, 656–662.
- Shu, Z.-Y., Gong, H.-Y. & Bi, R.-C. (1998). In situ measurements and dynamic control of the evaporation rate in vapor diffusion crystallization of proteins. *J. Cryst. Growth*, **192**, 282–289.
- Skouri, M., Lorber, B., Giegé, R., Munch, J.-P. & Candau, S. J. (1995). Effect of macromolecular impurities on lysozyme solubility and crystallizability. Dynamic light scattering, phase diagram, and crystal growth studies. *J. Cryst. Growth*, **152**, 209–220.
- Snell, E., Helliwell, J. R., Boggon, T. J., Lautenschlager, P. & Potthast, L. (1996). First ground trials of a Mach-Zehnder interferometer for implementation into a microgravity protein crystallization facility – the APCF. *Acta Cryst.* **D52**, 529–533.
- Snell, E. H., Weisgerber, S., Helliwell, J. R., Weckert, E., Hölzer, K. & Schroer, K. (1995). Improvements in lysozyme protein crystal perfection through microgravity growth. *Acta Cryst.* **D51**, 1099–1102.
- Sousa, R., Lafer, E. M. & Wang, B.-C. (1991). Preparation of crystals of T7 RNA polymerase suitable for high resolution X-ray structure analysis. *J. Cryst. Growth*, **110**, 237–246.
- Stojanoff, V., Siddons, D. P., Monaco, L. A., Vekilov, P. & Rosenberger, F. (1997). X-ray topography of tetragonal lysozyme grown by the temperature-controlled technique. *Acta Cryst.* **D53**, 588–595.
- Stojanoff, V., Snell, E. F., Siddons, D. P. & Helliwell, J. R. (1996). An old technique with a new application: X-ray topography of protein crystals. *Synchrotron Radiat. News*, **9**, 25–26.
- Strickland, C. L., Puchalski, R., Savvides, S. N. & Karplus, P. A. (1995). Overexpression of *Crithidia fasciculata* trypanothione reductase and crystallization using a novel geometry. *Acta Cryst.* **D51**, 337–341.
- Stura, E. A. & Wilson, I. A. (1990). Analytical and production seeding techniques. *Methods Companion Methods Enzymol.* **1**, 38–49.
- Suzuki, Y., Miyashita, S., Komatsu, H., Sato, K. & Yagi, T. (1994). Crystal growth of hen egg white lysozyme under high pressure. *Jpn. J. Appl. Phys.* **33**, 1568–1570.
- Syguusch, J., Coulombe, R., Cassanto, J. M., Sportiello, M. G. & Todd, P. (1996). Protein crystallization in low gravity by step gradient diffusion method. *J. Cryst. Growth*, **162**, 167–172.
- Taleb, M., Didierjean, C., Jelsch, C., Mangeot, J.-P., Capelle, B. & Aubry, A. (1999). Crystallization of biological macromolecules under an external electric field. *J. Cryst. Growth*, **200**, 575–582.
- Thaller, D., Eichele, G., Weaver, L. H., Wilson, E., Karlsson, R. & Jansonius, J. N. (1985). Seed enlargement and repeated seeding. *Methods Enzymol.* **114**, 132–135.
- Thibault, F., Langowski, L. & Leberman, R. (1992). Pre-nucleation crystallization studies on aminoacyl-tRNA synthetases by dynamic light scattering. *J. Mol. Biol.* **225**, 185–191.
- Thiessen, K. J. (1994). The use of two novel methods to grow protein crystals by microdialysis and vapor diffusion in an agarose gel. *Acta Cryst.* **D50**, 491–495.
- Thomas, B. R., Vekilov, P. G. & Rosenberger, F. (1998). Effects of microheterogeneity in hen egg-white lysozyme crystallization. *Acta Cryst.* **D54**, 226–236.
- Thomas, D. H., Rob, A. & Rice, D. W. (1989). A novel dialysis procedure for the crystallization of proteins. *Protein Eng.* **2**, 489–491.
- Timasheff, S. N. & Arakawa, T. (1988). Mechanism of protein precipitation and stabilization by co-solvents. *J. Cryst. Growth*, **90**, 39–46.
- Vaney, M. C., Maignan, S., Riès-Kautt, M. & Ducruix, A. (1996). High-resolution structure (1.33 Å) of a HEW lysozyme tetragonal crystal grown in the APCF apparatus. Data and structural comparison with a crystal grown under microgravity from SpaceHab-01 mission. *Acta Cryst.* **D52**, 505–517.
- Vekilov, P. G., Ataka, M. & Katsura, T. (1992). Laser Michelson interferometry investigation of protein crystal growth. *J. Cryst. Growth*, **130**, 317–320.
- Vekilov, P. G. & Rosenberger, F. (1996). Dependence of lysozyme growth kinetics on step sources and impurities. *J. Cryst. Growth*, **158**, 540–551.
- Vekilov, P. G. & Rosenberger, F. (1998). Protein crystal growth under forced solution flow: experimental setup and general response of lysozyme. *J. Cryst. Growth*, **186**, 251–261.
- Vidal, O., Robert, M.-C. & Boué, F. (1998a). Gel growth of lysozyme crystals studied by small angle neutron scattering: case of agarose gel, a nucleation promotor. *J. Cryst. Growth*, **192**, 257–270.
- Vidal, O., Robert, M.-C. & Boué, F. (1998b). Gel growth of lysozyme crystals studied by small angle neutron scattering: case of silica gel, a nucleation inhibitor. *J. Cryst. Growth*, **192**, 271–281.
- Vuillard, L., Rabilloud, T., Leberman, R., Berthet-Colominas, C. & Cusack, S. (1994). A new additive for protein crystallization. *FEBS Lett.* **353**, 294–296.
- Weber, B. H. & Goodkin, P. E. (1970). A modified microdiffusion procedure for the growth of single protein crystals by concentration-gradient equilibrium dialysis. *Arch. Biochem. Biophys.* **141**, 489–498.
- Yonath, A., Müssig, J. & Wittmann, H. G. (1982). Parameters for crystal growth of ribosomal subunits. *J. Cell. Biochem.* **19**, 145–155.
- Zeppenauer, M. (1971). Formation of large crystals. *Methods Enzymol.* **22**, 253–266.

4.2

- Allen, J. P., Feher, G., Yeates, T. O., Komiya, H. & Rees, D. C. (1987). Structure of the reaction center from *Rhodobacter sphaeroides* R-26: the protein subunits. *Proc. Natl Acad. Sci. USA*, **84**, 6162–6166.
- Bordier, C. (1981). Phase separation of integral membrane proteins in Triton X-114 solution. *J. Biol. Chem.* **256**, 1604–1607.
- Buchanan, S. K., Fritsch, G., Ermler, U. & Michel, H. (1993). New crystal form of the photosynthetic reaction centre from *Rhodobacter sphaeroides* of improved diffraction quality. *J. Mol. Biol.* **230**, 1311–1314.
- Buchanan, S. K., Smith, B. S., Venkatrami, L., Xia, D., Esser, L., Palnitkar, M., Chakraborty, R., van der Helm, D. & Deisenhofer, J. (1999). Crystal structure of the outer membrane active transporter *FepA* from *Escherichia coli*. *Nature Struct. Biol.* **6**, 56–63.
- Chang, C. H., El-Kabbani, D., Tiede, D., Norris, J. & Schiffer, M. (1991). Structure of the membrane-bound protein photosynthetic reaction center from *Rhodobacter sphaeroides*. *Biochemistry*, **30**, 5352–5360.
- Chang, G., Spencer, R. H., Lee, A. T., Barclay, M. T. & Rees, D. C. (1998). Structure of the *MscL* homolog from *Mycobacterium tuberculosis*: a gated mechanosensitive ion channel. *Science*, **282**, 2220–2226.
- Cowan, S. W., Garavito, R. M., Jansonius, J. N., Jenkins, J. A., Karlsson, R., König, N., Pai, E. F., Pauptit, R. A., Rizkallah, P. J., Rosenbusch, J. P., Rummel, G. & Schirmer, T. (1995). The structure of *OmpF* porin in a tetragonal crystal form. *Structure*, **3**, 1041–1050.
- Cowan, S. W., Schirmer, T., Rummel, G., Steiert, M., Gosh, R., Pauptit, R. A., Jansonius, J. N. & Rosenbusch, J. P. (1992). Crystal structures explain functional properties of two *E. coli* porins. *Nature (London)*, **358**, 727–733.
- Deisenhofer, J., Epp, O., Miki, K., Huber, R. & Michel, H. (1985). Structure of the protein subunits in the photosynthetic reaction