ISSN 2410-7751 (Print)
ISSN 2410-776X (Online)

Ж-л "Biotechnologia Acta"
V. 7, No 2, 2014

"Biotechnologia Acta" v. 7, no 2, 2014
doi: 10.15407/biotech7.02.034
P. 34-45, Bibliography 46, English.
Universal Decimal classification: 577.112: 543.544.17(045)

APPLICATION OF IMMUNOGLOBULIN-BINDING PROTEINS A, G, L IN THE AFFINITY CHROMATOGRAPHY

O. V. Sviatenko [1] , O. B. Gorbatiuk [2] , O. A. Vasylchenko [1]

[1]National Aviation University, Kyiv, Ukraine
[2]State Institute of Genetic and Regenerative Medicine of National Academy of Medical Sciences of Ukraine, Kyiv

Proteins A, G and L are native or recombinant proteins of microbial origin that bind to mammalian immunoglobulins. Preferably recombinant variants of proteins A, G, L are used in biotechnology for affinity sorbents production. Comparative characteristics of proteins A, G, L and affinity sorbents on the basis of them, advantages and disadvantages of these proteins application as ligands in the affinity chromatography are done. Analysis of proteins A, G, L properties is presented. Binding specificities and affinities of these proteins differ between species and antibody subclass. Protein A has high affinity to human IgG1, IgG2, IgG4, mouse IgG2a, IgG2b, IgG3, goat and sheep IgG2, dog, cat, guinea pig, rabbit IgG. Protein G binds strongly to human, mouse, cow, goat, sheep and rabbit IgG. Protein L has ability of strong binding to immunoglobulin kappa-chains of human, mouse, rat and pig. Expediency of application of affinity chromatography with usage of sorbents on the basis of immobilized proteins A, G, L are shown for isolation and purification of antibodies different classes. Previously mentioned method is used as an alternative to conventional methods of protein purification, such as ion-exchange, hydrophobic interactions, metal affinity chromatography, ethanol precipitation due to simplicity in usage, possibility of one-step purification process, obtaining of proteins high level purity, multiuse at maintenance of proper storage and usage conditions. Affinity sorbents on the basis of immobilized proteins A, G, L are used not only for antibodies purification, but also for extraction of different antibodies fractions from blood serum.

Key words: affinity chromatography, Staphylococcus protein A, peptostreptococcal protein L, protein G.

{spoiler title=Reference}

1. Bioaffinity chromatography. Turkovi J. (Ed.). *Netherlands: Elsevier Science Publishers*. 1993, P. 56–66.

2. *Boi C., Dimartino S., Sarti G. C.* Performance of a new protein a affinity membrane for the primary recovery of antibodies. *Biotechnol. Progr*. 2008, 24(3), 640–647.
http://dx.doi.org/10.1021/bp0704743

3. *Hickstein H., Korten G., Bast R., Barz D., Templin R., Schneidewind J. M., Kittner C., Nizze H., Schmidt R.* Protein A immunoadsorption (i. a.) in renal transplantation patients with vascular rejection. *Transfus. Sci*. 1998, 19(1), 53–57.

4. *Graille M., Stura E. A., Corper A. L., Sutton B. J., Taussig M. J., Charbonnier J.-B., Silverman G. J.* Crystal structure of a Staphylococcus aureus protein. A domain complexed with the Fab fragment of a human IgM antibody: Structural basis for recognition of B-cell receptors and superantigen activity. *Proc. Natl. Acad. Sci (USA)*, 2000, 97(10), 5399–5404.
http://dx.doi.org/10.1073/pnas.97.10.5399

5. *Qian J., Khoury G. E., Issa H., Al-Qaoud K., Shihab P., Lowe C. R.* A synthetic Protein G adsorbent based on the multi-component Ugi reaction for the purification of mammalian immunoglobulins. *J. Chromatogr. B*. 2012, V. 898, P. 15–23.
http://dx.doi.org/10.1016/j.jchromb.2012.03.043

6. Pierce Biotechnology. Instructions: Pierce™ Ig Binding Proteins (Protein A, G, A/G and L). Rockford: *Thermo Fisher Sci. Inc*. 2013, P. 1–6.
http://dx.doi.org/10.1016/j.jchromb.2006.09.030

7. *Pat. 6,548,639 B1 USA PCT/SE98/02036.* IgG binding protein from Staphylococcus and nucleotide sequence encoding this protein. *Frykberg L.*; *Uppsala*. N 09/554,080, decl. 12.05.00, publ.15.04.03.

8. *Nord K., Hober S., Linhult M.* Protein A chromatography for antibody purification. *J. Chromatogr. B*. 2007, 848(1), 40–47.

9. *Svyatenko O. V., Vasylchenko O. A., Vasilchenko K. K.* Application of Staphylococcus protein A in the affinity chromatography and immunoadsorption. *Problems of Environmental biotechnology.* Available at http:jml.nau.edu.ua.index,php/ecobiotech/issue/current/showToc (accessed, February, 2013).

10. *Gottschalk U.* Process scale purification of antibodies. Gottschalk U. (Ed.). Hoboken: *Wiley & Sons*. 2009, P. 79–90.

11. *Sjobring U., Bjorck L., Kastern W.* Streptococcal Protein G Gene structure and protein binding properties. *J. Biol. Chem*. 1991, 366(1), 399–405.

12. *Nitsche-Schmitz D. P., Johansson H. M., Sastalla I., Reissmann S., Frick I.-M., Chhatwal G. S.* Group G Streptococcal IgG Binding Molecules FOG and Protein G Have Different Impacts on Opsonization by C1q. *J. Biol. Chem.* 2007, 282(24), 17530–17536. http://dx.doi.org/10.1074/jbc.M702612200

13. *Saha K., Bender F., Gizeli E.* Comparative study of IgG binding to proteins g and a: nonequilibrium kinetic and binding constant determination with the acoustic waveguide device. *Anal. Chem.* 2003, 75(4), 835–842. http://dx.doi.org/10.1021/ac0204911

14. *Karanicolas J., Brooks III C. L.* The origins of asymmetry in the folding transition states of protein L and protein G. *Prot. Sci*. 2002, 11(10), 2351–2361. http://dx.doi.org/10.1110/ps.0205402

15. *Sadler D. P., Petrik E., Taniguchi Y., Pullen J. R., Kawakami M., Radford S. E., Brockwell D. J.* Identification of a Mechanical Rheostat in the Hydrophobic Core of Protein L. *J. Mol. Biol.* 2009, 393(1), 237–248. http://dx.doi.org/10.1016/j.jmb.2009.08.015

16. *Kim D. E., Fisher C., Baker D.* A Breakdown of Symmetry in the Folding Transition State of Protein L. *J. Mol. Biol.* 2000, 298(5), 971–984. http://dx.doi.org/10.1006/jmbi.2000.3701

17. *Pierce* Antibody purification Available at: www.piercenet.com.

18. *Roquea C. A., Taipaa M. A., Lowe C. R.* An artificial protein L for the purification of immunoglobulins and Fab fragments by affinity chromatography A. *J. Chromatogr. A*. 2005, 1064(2), 157–167. http://dx.doi.org/10.1016/j.chroma.2004.11.102

19. Pierce Biotechnology. Instructions: Pierce® Protein L Agarose. *Rockford: Thermo Fisher Sci. Inc*. 2008, P. 1–4.

20. *Snyder H. W., Cochran S. K., Balint J. P., Bertram J. H., Mittelman A., Guthrie T. H., Jones F. R.* Experience With Protein A-Immunoadsorption in Treatment-Resistant Adult Immune Thrombocytopenic Purpura. *Blood*. 1992, 79(9), 2237–2245.

21. *McMillan R.* Chronic idiopathic thrombocytopenic purpura. *Engl. J. Med*. 1981, 304,

1135–1147.
http://dx.doi.org/10.1056/NEJM198105073041904

22. *Clair St. W. E., Pisetsky D. S., Haynes B. F.* Rheumatoid Arthritis. Clair St. W. E.(Ed.). Lipp incott:
Williams & Wilkins
. 2004, P. 394–398.

23. *Doesch A. O., Mueller S., Konstandin M., Celik S., Frankenstein L., Zugck C., Dengler T. J., Fleming T., Bierhaus A., Katus H. A.* Effects of protein A immunoadsorption on methylglyoxal levels in patients with chronic dilated cardiomyopathy and diabetes mellitus.
Appl. Cardiopulm. Pathophysiol
. 2011, V. 15, P. 3–13.

24. *Doesch A. O., Mueller S., Konstandin M., Celik S., Kristen A., Frankenstein L., Goeser S., Kaya Z., Zugck C., Dengler T. J., Katus H. A.* Effects of Protein A Immunoadsorption in Patients with Chronic Dilated Cardiomyopathy.
J. Clin. Apheresis
. 2010, 25(6), 315–322.
http://dx.doi.org/10.1002/jca.20263

25. *Schwenger V., Morath C.* Immunoadsorption in nephrology and kidney transplantation. *Nep hrol Dial Transplant*
. 2010, 25(8), 2407–2413.
http://dx.doi.org/10.1093/ndt/gfq264

26. *Österväla E.* Protein G Sepharose 4 Fast Flow. *Uppsala: GE Healthcare Bio-Sci. AB,* 2007 , P. 2–6.

27. *Schubert S., Freitag R.* Comparison of ceramic hydroxy- and fluoroapatite versus Protein A/G-based resins in the isolation of a recombinant human antibody from cell culture supernatant. *J. Chromatogr. A.* 2007, 1142(1), 106–113.
http://dx.doi.org/10.1016/j.chroma.2006.08.075

28. *Gaza-Bulseco G., Hickman K., Sinicropi-Yao S., Hurkmans K., Chumsae C., Liu H.* Effect of the conserved oligosaccharides of recombinant monoclonal antibodies on the separation by protein A and protein G chromatography.
J. Chromatogr.
2009, 1216(12), 2382–2387.
http://dx.doi.org/10.1016/j.chroma.2009.01.014

29. *Shields R. L., Lai J., Keck R., O'Connell L. Y., Hong K., Meng Y. G., Weikert S. H., Presta L. G.* Lack of fucose on human IgG1 N-linked oligosaccharide improves binding to human Fcgamma Rin and antibody dependent cellular toxicity. *J. Biol. Chem*.
2002, 277(30), 26733–26740.
http://dx.doi.org/10.1074/jbc.M202069200

30. *Davies J., Jiang L., Pan L. Z., LaBarre M. J., Anderson D., Reff M.* Expression of GnTIII in a recombinant anti-CD20 CHO production cell line: Expression of antibodies with altered glycoforms leads to an increase in ADCC through higher affinity for FC gamma RIII.
Biotechnol. Bioeng.
2001, 74(4), 288–294.
http://dx.doi.org/10.1002/bit.1119

31. *Gaza-Bulseco G., Faldu S., Hurkmans K., Chumsae C., Liu H.* Effect of methionine oxidation of a recombinant monoclonal antibody on the binding affinity to protein A and protein G. *J. Chromatogr. B*. 2008,
870(1), 55–62.
http://dx.doi.org/10.1016/j.jchromb.2008.05.045

32. *Schenka J. A., Fettkec J., Lenza C., Albersd K., Mallwitzd F., Gajovic-Eichelmanne N., Ehrentreich-Furstere E., Kuschf E., Sellrie F.* Secretory leukocyte protease inhibitor (SLPI) might contaminate murine monoclonal antibodies after purification on protein G.
J. Biotechnol
. 2012, 158(1-2), 34–35.
http://dx.doi.org/10.1016/j.jbiotec.2011.12.025

33. *Sennikov S. V., Golikova E. A., Kireev F. D., Lopatnikova J. A.* Purification of human

immunoglobulin G autoantibodies to tumor necrosis factor using affinity chromatography and magnetic separation. *The Journal of Immunol. Meth.* 2013. Available at: http://dx.doi.org/10.1016/ j.jim.2013.01.012.

34. *Patel S.Y., Ding L., Brown M. R., Lantz L., Gay T., Cohen S., Martyak L. A., Ku-bak B., Holland S. M.* Anti-IFN-gamma autoantibodies in disseminated nontuberculous mycobacterial infections. *J. Immunol*. 2005, 175(7), 4769–4776. http://dx.doi.org/10.4049/jimmunol.175.7.4769

35. *Puel A., Picard C., Lorrot M., Pons C., Chrabieh M., Lorenzo L., Mamani-Matsuda M., Jouanguy E., Gendrel D., Casanova J. L.* Recurrent staphylococcal cellulitis and subcutaneous abscesses in a child with autoantibodies against IL-6. *J. Immunol*. 2008, 180(1), 647–654. http://dx.doi.org/10.4049/jimmunol.180.1.647

36. *Uchida K., Nakata K., Trapnell B. C., Terakawa T., Hamano E., Mikami A., Matsushita I., Seymour J. F., Oh-Eda M., Ishige I., Eishi Y., Kitamura T., Yamada Y., Hanaoka K., Keicho N.* High affinity autoantibodies specifically eliminate granulocyte–macrophage colony-stimulating factor activity in the lungs of patients with idiopathic pulmonary alveolar proteinosis. *Blood*. 2004, 103(3), 1089–1098. http://dx.doi.org/10.1182/blood-2003-05-1565

37. Pierce Protein AG Magnetic Beads Available at: http://www.piercenet.com/product/proteinag-magnetic-beads.

38. *Roque A. C. A., Taipaa M. A., Lowe C. R.* An artificial protein L for the purification of immunoglobulins and Fab fragments by affinity chromatograpy. *J. Chromatogr. A*. 2005, 1064(2), 157–167. http://dx.doi.org/10.1016/j.chroma.2004.11.102

39. *Graille M., Stura E. A., Housden N. G., Beckingham J. A., Bottomley S. P., Beale D.,*

Taussig M. J., Sutton B. J., Gore M. G.,Charbonnier J.-B. Complex between Peptostreptococcus magnus protein L and a human antibody reveals structural convergence in the interaction modes of Fab binding proteins.
Structure
. 2001, 9(8), 679–687.
http://dx.doi.org/10.1016/S0969-2126(01)00630-X

40. *Muzard J., Adi-Bessalem S., Juste M., Laraba-Djebari F., Aubrey N., Billiald P.* Grafting of protein L-binding activity onto recombinant antibody fragments.
Anal. Biochem
. 2009, 388(2), 331–338.

41. *Nilson B. H. K., Solomon A., Bjurck L., Ekerstrum B.* Protein L from Pepto-strep-tococcus magnus binds to the K light chain variable domain.
J. Biol. Chem
. 1992, 267(4), 2234–2239.

42. *Housden N. G., Harrison S., Housden H. R., Thomas K.-A., Beckingham J. A., Roberts S. E., Bottomley S. P., Graille M., Stura E., Gore M. G.* Observation and characterization of the interaction between a single immunoglobulin binding domain of protein L and two equivalents of human k-light chains. *J. Biol. Chem*
. 2004, 279(10), 9370–9378.
http://dx.doi.org/10.1074/jbc.M312938200

43. *Cossins A. J., Harrison S., Popplewell A. G., Gore M. G.* Recombinant production of a VL single domain antibody in *Escherichia coli*
and analysis of its interaction with peptostreptococcal protein L.
Prot. Expr. Purif.
2007, 51(2), 253–259.
http://dx.doi.org/10.1016/j.pep.2006.07.013

44. *Murphy, J. P. Duggleby C. J., M. A. Atkinson, Trowern A. R., Atkinson T., Goward C. R.* The functional unit of Peptostreptococcal protein L.
Mol. Microbiol

. 1994, 12(6), 911–920.
http://dx.doi.org/10.1111/j.1365-2958.1994.tb01079.x

45. *Bottomley S. P., Beckingham J. A., Murphy J. P., Atkinson M., Sutton B. J., Gore M. G.* Cloning, expression and purification of PpL-1, a kappa-chain binding protein, based upon protein L from Peptostreptococcus magnus.
Bioseparation
. 1995, 5(6), 359–367.

46. *Harrison S. L., Housden N. G., Bottomley S. P., Cossins A. J., Gore M. G.* Generation and expression of a minimal hybrid Ig-receptor formed between single domains from proteins L and G. *Prot. Expr. Purif.* 2008, 58(1), 12–22.
http://dx.doi.org/10.1016/j.pep.2007.11.007

{/spoiler}