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详细信息展示

Mechanisms of protein stabilization at very low pH

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Keywords: protein stabilization at low pH; aquaporin; potassium channel; Acidithiobacillus ferrooxidans

Abstract: Physicochemical properties of periplasmic loops exposed to low pH were determined for two membrane proteins from the bioleaching-proteobacterium Acidithiobacillus ferrooxidans. The selected proteins were an aquaporin and a potassium (K^+) channel and the properties evaluated were surface area, hydrophobicity and amino acid composition. Properties were mapped onto three dimensional protein models and subjected to Accessible Surface Area (ASA) analysis and Molecular Dynamics (MD) simulations. Results were compared to equivalent loops from homologous proteins derived from microorganisms that live in neutral pH environments. It was found that periplasmic loops of both the aquaporin and the K^+ channel protein of At. ferrooxidans have less surface area and exhibit greater hydrophobicity compared to their neutrophilic homologs. A reduction of the percentage of amino acids that are negatively charged (aspartic and glutamic acid) and an increase in the percentage of positively charged amino acids (histidine, arginine and lysine) was also observed in the periplasmic loops of the aquaporin and potassium (K^+) channel of At. ferrooxidans. Finally, an increase in the proline content of the loops of At. ferrooxidans was detected. Hypotheses for how these features could help stabilize the structure and function of proteins in extremely acidic condition are presented. It is noted that these proposed mechanisms are similar to those shown to be operational for the stabilization of thermophilic proteins. The data and hypotheses presented could help provide a theoretical foundation for designing proteins with improved molecular functions for bioleaching and acid mine drainage remediation. It is also valuable information for understanding the molecular underpinnings and evolution of protein function at low pH.

1 Introduction

Whereas the molecular basis of thermostability of proteins has been extensively studied [1, 2], little is known about the mechanisms that underpin the stability and function of proteins that function at low pH. Of particular interest is how membrane embedded transporters maintain ion transport selectivity in the face of a delta pH that can be 107 times higher than at neutral pH especially those that use protons as energy sources

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for the import or export of other ions. For example, it was recently shown that the gating of a formate channel (FocA) in *Salmonella typhimurium* operates in a pH-dependent manner [3]. Gating was shown to be mediated via the reorientation of N termini of the peptide chains and it was speculated that protonation of a histidine might be the basis for pH sensing. In addition, preliminary information is emerging for proteins that function at pH 3-4 from *Alycyclobacillus acidocaldarius* [4, 5], *Bacillus sp. Ferdowsicus* [6] and *Scytalidium acidophilum* [7], in which it was observed that positively charged and polar residues tend to be more frequent on the surface of these proteins and, conversely, a reduction of negatively charged amino acids was detected. However, it is not yet known if these mechanisms are also exploited by proteins that function at very low pHs including as low as pH 0.

Regarding mechanisms for protein stabilization that operate at extremely low pH, defined here as $< \text{pH } 3$, increased hydrophobicity is emerging as an important candidate. For example, increased hydrophobic interactions have been suggested to stabilize protein polymerization in AcoP that is required for cytochrome c oxidase (CcO) function [8]. Also, it has been proposed that proline residues can promote the stability of HIPIP in *Acidithiobacillus ferrooxidans* [9]. Higher levels than average of proline have also been reported for cytochrome c4 [10] and rusticyanin in *At. ferrooxidans* [11].

In an earlier effort to address the issue of how proteins function in extremely acidic environments (pH 1), we generated models for two transmembrane proteins from the acidophile *At. ferrooxidans* that are predicted to be channels for water (model AqpF) and potassium (model KcnA), respectively [12]. AqpF was shown to have features in common with aquaporins from neutrophilic organisms including the average water occupancy of the channel and the characteristic bi-polar water orientation within the selectivity filter that reduces the intrusion of protons. However, it also exhibited particular features that might help explain its adaption to low pH, such as short periplasmic loops and the presence of an asparagine (Asn39) residue as part of the selectivity filter. The latter could enhance proton-blocking capability and so be critical for function at low pH. Regarding the low pH adaption of the K^+ channel, it was shown it does not expose ionizable amino acids to the external surface, presumably because the protonation of these residues at pH 1 would be deleterious. The selective K^+ channel also exhibited more basic residues than neutrophilic orthologs that would help protect against protonation. In this paper, we extend these models to include predictions for the surface area, hydrophobicity and presence or absence of charged amino acids and prolines in the periplasmic loops of aquaporin and the K^+ channel protein of *At. ferrooxidans*. These properties are compared with those of homologous regions from neutrophilic microorganisms in order to suggest mechanisms for stabilization of proteins at very low pH.

2 Materials and methods

- ➔ Leaching behavior of calcium from a low grade copper sulfide ore
- ➔ The effect of KNO_3 on substrate utilisation by *Sulfobacillus sp.* in mixed ferrous ion and tetrathionate growth medium
- ➔ Results and discussion of the pH experiments
- ➔ pH
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- ➔ Purification and enzymatic properties of arsenic resistance protein ArsH from heterogeneous expression in *E. coli* BL21
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Comparative homology modeling of a predicted *At. ferrooxidans* ATCC 23270^{TS} potassium (K^+) channel (Kaf) and aquaporin (AqpF) proteins was performed using Modeler v4.0 [13] and ICM Molsoft [14] using the PDB 2f2b (1.68 Å) from *Methanobacterium thermoautotrophicum* and the PDB 1k4c (2 Å) from *Streptomyces coelicolor* as templates, respectively. Multiple sequence alignments of proteins were carried out using ClustalW [15]. Structures and models were analyzed using Procheck [16]. The best AqpF tetramer model was selected to be used in MD simulation. The molecular dynamics simulation was carried out using the NAMD [17] program with CHARMM27 parameter set [18]. The homotetrameric functional K^+ channel was built using the tool STAMP structural alignment in VMD software [19].

Both *At. ferrooxidans* models were submitted to ADIT validation server from PDB Database [20]. The coordinates were evaluated in terms of format coordinates, close contacts, bond distances and angles, torsion angles, chirality and missing atoms. Crystal structure coordinates for the aquaporin and K^+ channel were extracted for *Escherichia coli* (agpZ) and *Streptomyces lividans* (3eff) respectively from the Protein Data Bank [20]. All proteins models were submitted to suite of tools at BLUESTAR STING to evaluate the ASA (Accessible Surface Area), Hydrophobicity and ESP (Electrostatic Surface Potential) values of periplasmic predicted loops [21].

Hydrophobicity indices were deduced according to amino acid hydrophobicity values [22, 23] and weighed by accessibility to solvent.

3 Results and discussion

The predicted cell membrane locations and orientations of an aquaporin and a potassium (K^+) channel from *At. ferrooxidans* and the loops that are exposed to the low pH of the periplasm and that are the subject of this study are indicated in Figure 1.

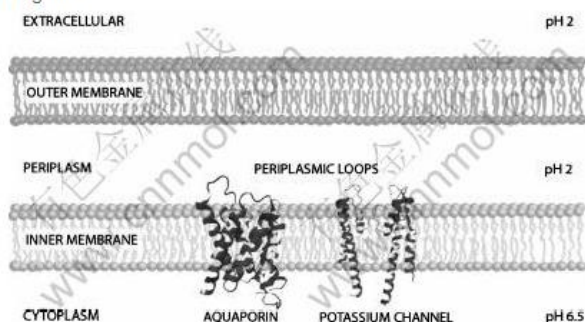


Figure 1 Scheme of the cell compartments of the Gram negative bacterium *At. ferrooxidans*, showing the predicted locations of an aquaporin and K^+ channel protein embedded in the cell membrane, indicating the loops exposed to the low pH of the periplasm that are the subject of this study

Aquaporins are homotetrameric proteins involved in the uptake of water into the cell [24]. Each monomer has six loops, four of which are exposed to the cytoplasm (pH 6.5) and three towards the periplasm (pH 2) [25]. The K^+ channel is typically composed of homotetramers with some exceptions found in eukaryotes [26]. Bacterial K^+ channels show a core composed of two transmembrane segments TM1 and TM2 and a short pore that forms the selectivity filter. Between TM1 and TM2, there is one loop exposed to the periplasm [27].

3.1 Surface area and hydrophobicity

Table 1 shows the calculated surface areas of the exposed loops for aquaporin and the K^+ channel of *At. ferrooxidans* compared to the homologous regions in proteins from *E. coli* and *S. lividans*. The latter two microorganisms were chosen for comparison because (i) their periplasmic loops are exposed to neutral pH and (ii) their aquaporin and K^+ channel protein have crystal structures [28, 29] allowing detailed comparisons to be made at the atomic level. The calculated total areas of the exposed loops are less in both aquaporin and the K^+ channel of *At. ferrooxidans* compared to the equivalent proteins in *E. coli* and *S. lividans*, with ratios of 1856/2389 (=0.78) and 620/922 (=0.67) for the aquaporin and K^+ channel protein, respectively. In addition, the number of amino acids is less in both cases for *At. ferrooxidans* with ratios of 21/37 (=0.57) and 9/14 (=0.64), respectively. Thus, we conclude that the periplasmic loops of the *At. ferrooxidans* proteins are shorter and have smaller surface areas exposed to solvent than their neutrophilic counterparts. A trend to have shorter exposed loops is also found in proteins from thermophilic microorganisms and this property has been proposed to contribute towards entropic stabilization of the loops by increasing amino acid contact density [1].

Table 1 Surface properties of loops exposed to the periplasm of (A) an aquaporin and (B) a K^+ channel of the acidophile *At. ferrooxidans* compared to the equivalent loops of two neutrophilic microorganisms, *E. coli* and *S. lividans*, respectively

Model ID	Organism (pH environment of exposed loops)	Surface area (\AA^2)	Number amino acids	Hydrophobic index
(A) Aquaporin				
aqpF	<i>At. ferrooxidans</i> (pH 2)	1856	21	1.48
aqpZ	<i>E. coli</i> (pH 7)	2389	37	0.9
(B) K^+ channel				
Kaf	<i>At. ferrooxidans</i> (pH 2)	620	9	1.25
3eff	<i>S. lividans</i> (pH 7)	922	14	0.78

The hydrophobic index for the periplasmic loops of the four proteins was calculated as described in section

2. The periplasmic loops of the aquaporin and K^+ channel protein of *At. ferrooxidans* have substantially more hydrophobicity compared to the equivalent loops in the two neutrophilic microorganisms (Table 1). Increased hydrophobicity would tend to repel protons thus protecting the entrance to the channel and pore of the aquaporin and K^+ channel. It has been previously reported that, in contrast to other organisms, the K^+ channel protein of *At. ferrooxidans* contains an aspartic residue in the selectivity filter which, at pH 1, would probably be protonated promoting the solvation of the potassium ion [12]. This, in turn, would facilitate the discrimination between potassium and protons in the selectivity filter. We hypothesize that the observed increase in hydrophobicity of the periplasmic loops would help stabilize the structure around the selectivity filter and thus aid in proton repulsion.

3.2 Charged amino acids and proline content in periplasmic loops

The percentage of positively charged amino acids (arginine, histidine and lysine), negatively charged amino acids (glutamic and aspartic acid) and proline were calculated for the exposed loops of the aquaporins and the K^+ channel of *At. ferrooxidans*, *E. coli* and *S. lividans* (Figure 2). Both the aquaporin (Figure 2A) and the K^+ channel (Figure 2B) periplasmic loops of *At. ferrooxidans* contain a higher percentage of positively charged amino acids and a lower percentage of negatively charged amino acids compared to the homologous regions of the periplasmic loops of the two neutrophilic microorganisms. A similar finding has been reported for the exposed loops of a subtilisin-like protease from the thermophile *Thermoanaerobacter yonseiensis* [30].

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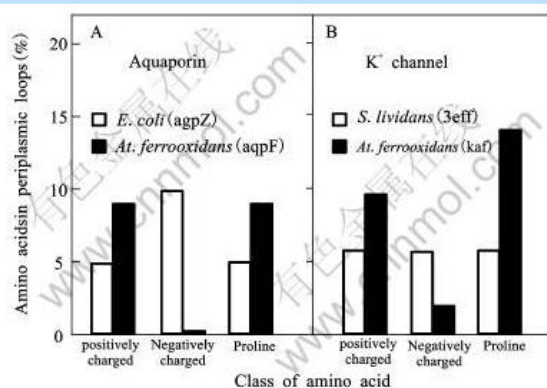


Figure 2 The frequency (%) of positively charged (arginine, histidine and lysine) and negatively charged (glutamic and aspartic acid) amino acids in the periplasmic loops of (A) aquaporin and (B) the K^+ channel of *At. ferrooxidans* compared to the homologous regions of these proteins from the neutrophilic microorganisms *E. coli* and *S. lividans*, respectively

In acidic conditions (pH 2), aspartate and glutamate could be in a protonation-deprotonation equilibrium (pK 3.6 and 4.3 respectively) leading to destabilization of folds. This suggests that the reduced content of these amino acids in the loops of *At. ferrooxidans* is an adaptation to minimize this potential problem. The observed increase in positively charged amino acids could be an additional strategy to stabilize proteins at low pH. Lysine and asparagine at pH 2 are expected to be protonated and would aid in the electrostatic repulsion of protons. An alternate hypothesis is that the positively charged amino acids could form hydrogen bonds or salt bridges with negatively charged amino acids to maintain the conformation of the loops. However, our models show that there are no readily accessible negatively charged residues in the neighborhood of the positively charged amino acids, reducing the likelihood that this mechanism is important in stabilizing the periplasmic loops of the aquaporin and K^+ channel.

Regarding the proline content, higher frequencies were found in the periplasmic loops of the two proteins from *At. ferrooxidans* compared to homologous regions from the neutrophilic microorganisms (Figure 2). A similar increase in proline content has been observed in proteins from thermophiles and it was suggested that proline can increase thermostability as a result of its ability to increase amino acid interactions [31-34]. It is hypothesized that a similar mechanism exists in acidophiles whereby proline, by virtue of its ability to potentiate more amino acid contacts, can assist in stabilization of protein structure at low pH.

3.3 Critical placement of two prolines

In addition to the general mechanism whereby prolines can potentially increase stabilization, we propose that two of the prolines in the K^+ channel of *At. ferrooxidans* carry out a local role in the stabilization of the lobby or entrance zone of this protein. The lobby has a critically located aspartic acid that is part of the characteristic GYGD motif found in many K^+ channel proteins. This aspartic acid in the K^+ channel of other organisms aids in the deprotonation of the solvated K^+ ion. However, at pH 2 this residue would be expected to be protonated. We propose that the additional two prolines found in the *At. ferrooxidans* K^+ channel help

maintain a very hydrophobic environment repelling hydrophilic molecules like water that could protonate the aspartate residue and block the potassium desolvation.

4 Conclusions

Molecular modeling of two membrane embedded proteins, a predicted aquaporin and K^+ channel, from *At. ferrooxidans* reveals general and specific properties that we propose help stabilize the periplasmic loops of these proteins at very low pH ($< pH 3$). The general properties include (i) reduced loop size and loop surface area, (ii) increased hydrophobicity, (iii) increased positively charged amino acids and decreased negatively charged amino acids and (iv) increased proline content. The specific properties include the occurrence of critically located amino acids. Many of these properties have also been suggested to stabilize proteins against heat denaturation in thermophilic microorganisms. Knowledge of the properties that help stabilize proteins at low pH is not only useful for understanding protein function and evolution but is also a prerequisite for redesigning proteins for biotechnological applications.

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References

- [1] England, J. L., Shakhnovich, B. E. and Shakhnovich, E. I. (2003). Natural selection of more designable folds: A mechanism for thermophilic adaptation, *Proceedings of the National Academy of Sciences of the United States of America*, 100(15), 8727-8731.
- [2] Maugini, E., Tronelli, D., Bossa, F. and Pascarella, S. (2009). Structural adaptation of the subunit interface of oligomeric thermophilic and hyperthermophilic enzymes, *Computational Biology and Chemistry*, 33 (2), 137-148.
- [3] Lü, W., Du, J., Wacker, T., Gerbig-Smentek, E., Andrade, S. L. A. and Einsle, O. (2011). pH-dependent gating in a FocA formate channel, *Science*, 332(6027), 352-354.
- [4] Matzke, J., Schwermann, B. and Bakker, E. P. (1997). Acidostable and acidophilic proteins: The example of the $[\alpha]$ -amylase from *Alicyclobacillus acidocaldarius*, *Comparative Biochemistry and Physiology Part A: Physiology*, 118(3), 475-479.
- [5] Schäfer, K., Magnusson, U., Scheffel, F., Schiefner, A., Sandgren, M. O. J., Diederichs, K., Welte, W., Hülsmann, A., Schneider, E. and Mowbray, S. L. (2004). X-ray structures of the maltose-maltodextrin-binding protein of the thermoacidophilic bacterium *Alicyclobacillus acidocaldarius* provide insight into acid stability of proteins, *Journal of Molecular Biology*, 335(1), 261-274.
- [6] Asoodeh, A., Chamani, J. and Lagzian, M. (2010). A novel thermostable, acidophilic α -amylase from a new thermophilic "*Bacillus* sp. *Ferdowsicus*" isolated from Ferdows hot mineral spring in Iran: Purification and biochemical characterization, *International Journal of Biological Macromolecules*, 46(3), 289-297.
- [7] Michaux, C., Pouyez, J., Mayard, A., Vandurm, P., Housen, I. and Wouters, J. (2010). Structural insights into the acidophilic pH adaptation of a novel endo-1,4-beta-xylanase from *Scytalidium acidophilum*, *Biochimie*, 92(10), 1407-1415.
- [8] Castelle, C., Ilbert, M., Infossi, P., Leroy, G. and Giudici-Ortoni, M.T. (2010). An unconventional copper protein required for cytochrome c oxidase respiratory function under extreme acidic conditions, *Journal of Biological Chemistry*, 285(28), 21519-21525.

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[9] Nouailler, M., Bruscella, P., Lojou, E., Lebrun, R., Bonnefoy, V. and Guerlesquin, F. (2006). Structural analysis of the HiPIP from the acidophilic bacteria: *Acidithiobacillus ferrooxidans*, *Extremophiles*, 10(3), 191-198.

[10] Abergel, C., Nitschke, W., Malarte, G., Bruschi, M., Claverie, J.M. and Giudici-Orticoni, M.T. (2003). The Structure of *Acidithiobacillus ferrooxidans* c4-cytochrome: A model for complex-induced electron transfer tuning, *Structure (London, England: 1993)*, 11(5), 547-555.

[11] Barrett, M. L., Harvey, I., Sundararajan, M., Surendran, R., Hall, J. F., Ellis, M. J., Hough, M. A., Strange, R. W., Hillier, I. H. and Hasnain, S. S. (2006). Atomic resolution crystal structures, EXAFS, and quantum chemical studies of rusticyanin and its two mutants provide insight into its unusual properties, *Biochemistry*, 45(9), 2927-2939.

[12] Duarte, F., Araya-Secchi, R., González, W., Perez-Acle, T., González-Nilo, D. and Holmes, D. S. (2009). Protein function in extremely acidic conditions: Molecular simulation studies of a predicted aquaporin and a voltage gated potassium channel in *Acidithiobacillus ferrooxidans*, *Advanced Materials Research*, 71-73, 211-214.

[13] Pieper, U., Webb, B. M., Barkan, D. T., Schneidman-Duhovny, D., Schlessinger, A., Braberg, H., Yang, Z., Meng, E. C., Pettersen, E. F., Huang, C. C., Datta, R. S., Sampathkumar, P., Madhusudhan, M. S., Sjölinder, K., Ferrin, T. E., Burley, S. K. and Sali, A. (2011). ModBase, a database of annotated comparative protein structure models, and associated resources, *Nucleic Acids Research*, 39(suppl 1), D465-D474.

[14] Cardozo, T., Totrov, M. and Abagyan, R. (1995). Homology modeling by the ICM method, *Proteins: Structure, Function, and Bioinformatics*, 23(3), 403-414.

[15] Li, K.B. (2003). ClustalW-MPI: ClustalW analysis using distributed and parallel computing, *Bioinformatics*, 19(12), 1585-1586.

[16] Laskowski, R. A., Rullmann, J. A. C., MacArthur, M. W., Kaptein, R. and Thornton, J. M. (1996). AQUA and PROCHECK-NMR: Programs for checking the quality of protein structures solved by NMR, *Journal of Biomolecular NMR*, 8(4), 477-486.

[17] Phillips, J. C., Braun, R., Wang, W., Gumbart, J., Tajkhorshid, E., Villa, E., Chipot, C., Skeel, R. D., Kalé, L. and Schulten, K. (2005). Scalable molecular dynamics with NAMD, *Journal of Computational Chemistry*, 26(16), 1781-1802.

[18] MacKerell, A. D., Banavali, N. and Foloppe, N. (2000). Development and current status of the CHARMM force field for nucleic acids, *Biopolymers*, 56(4), 257-265.

[19] Humphrey, W., Dalke, A. and Schulten, K. (1996). VMD: Visual molecular dynamics, *Journal of Molecular Graphics*, 14(1), 33-38.

[20] Laskowski, R. A. (2001). PDBsum: summaries and analyses of PDB structures, *Nucleic Acids Research*, 29(1), 221-222.

[21] Neshich, G., Mazoni, I., Oliveira, S. R. M., Yamagishi, M. E. B., Kuser-Falco, P., Borro, L. C., Morita, D. U., Souza, K. R. R., Almeida, G. V., Rodrigues, D. V., Jardine, J. G., Togawa, R. C., Mancini, A. L., Higa, R. H., Cruz, S. A. B., Vieira, F. D., Santos, E. H., Melo, R. C. and Santoro, M. M. (2006). The Star STING server: a

➤ Identification and functional analysis of a regulatory protein for the petII operon in *Acidithiobacillus ferrooxidans* ATCC23270

➤ Challenges for life at pH 1: Terrestrial evolution and extra-terrestrial life signatures

➤ Binding Agents of Chlorides Mixed with CaO, MgO and Water Glass for Dust and Soil Stabilization

➤ Research on control of pH in solvent extraction of zinc by D2EHPA (P204)

➤ Microbial community structure and redox potential in a copper sulphide bioleaching system with low pH, high ferric concentration and elevated temperature

➤ Expression and characterization of an *Acidithiobacillus ferrooxidans* ATCC23270 heat shock protein hsp90 (AtHtpG) functionally expressed in *Escherichia coli*

➤ Dynamics of pH Value and Metal Elements of Rainfall with in Mixed Forests in Japanese Pine and Cypress

➤ Atomic force microscopy and scanning electrochemical microscopy study on bioleaching of Cu_xS by acidophilic leaching organisms

➤ Summary of Fujian low A/S and high iron gibbsite bauxite

➤ Summary of Guangxi low A/S and high iron gibbsite bauxite

➤ Column bioleaching of apatite rich low grade Indian uranium ore

➤ Fungal bio-leaching of nickel from Indonesian low grade limonitic ore

➤ Effect of organic extractant, pH and temperature change, on bioleaching

➤ The effects of pH, anions, cations and ionic strength on tetrathionate oxidation by *Acidithiobacillus caldus*

➤ The effect of increasing temperature on the bioleaching of Yinshan low grade complex sulphide ores

multiplatform environment for protein structure analysis, *Genetics and Molecular Research*, 5(4), 717-722.

[22] Kyte, J. and Doolittle, R. F. (1982). A simple method for displaying the hydropathic character of a protein, *Journal of Molecular Biology*, 157(1), 105-132.

[23] Radzicka, A. and Wolfenden, R. (1988). Comparing the polarities of the amino acids: Side-chain distribution coefficients between the vapor phase, cyclohexane, 1-octanol, and neutral aqueous solution, *Biochemistry*, 27(5), 1664-1670.

[24] Zardoya, R. (2005). Phylogeny and evolution of the major intrinsic protein family, *Biol. Cell*, 97(6), 397-414.

[25] Heymann, J. B. and Engel, A. (2000). Structural clues in the sequences of the aquaporins, *Journal of Molecular Biology*, 295, 1039-1053.

[26] Kuo, M. M. C., Haynes, W. J., Loukin, S. H., Kung, C. and Saimi, Y. (2005). Prokaryotic K⁺ channels: From crystal structures to diversity, *FEMS Microbiology Reviews*, 29(5), 961-985.

[27] Jiang, Y., Pico, A., Cadene, M., Chait, B. T. and MacKinnon, R. (2001). Structure of the RCK domain from the E. coli K⁺ channel and demonstration of its presence in the human BK channel, *Neuron*, 29(3), 593-601.

[28] Savage, D. F., Egea, P. F., Robles-Colmenares, Y., Iii, J. D. O. C. and Stroud, R. M. (2003). Architecture and selectivity in aquaporins: 2.5 Å X-Ray structure of aquaporin Z, *PLoS Biol*, 1(3), e72.

[29] Uysal, S., Vázquez, V., Tereshko, V., Esaki, K., Fellouse, F. A., Sidhu, S. S., Koide, S., Perozo, E. and Kossiakoff, A. (2009). Crystal structure of full-length KcsA in its closed conformation, *Proceedings of the National Academy of Sciences*, 106(16), 6644-6649.

[30] Jang, H. J., Lee, C.-H., Lee, W. and Kim, Y. S. (2002). Two flexible loops in subtilisin-like thermophilic protease, thermicin, from *Thermoanaerobacter yonseiensis*, *Journal of Biochemistry and Molecular Biology*, 35(5), 498.

[31] Watanabe, K., Chishiro, K., Kitamura, K., and Suzuki, Y. (1991). Proline residues responsible for thermostability occur with high frequency in the loop regions of an extremely thermostable oligo-1,6-glucosidase from *Bacillus thermoglucosidasius* KP1006, *Journal of Biological Chemistry*, 266(36), 24287-24294.

[32] Watanabe, K., Kitamura, K. and Suzuki, Y. (1996). Analysis of the critical sites for protein thermostabilization by proline substitution in oligo-1,6-glucosidase from *Bacillus coagulans* ATCC 7050 and the evolutionary consideration of proline residues, *Appl. Environ. Microbiol.*, 62(6), 2066-2073.

[33] Takano, K., Higashi, R., Okada, J., Mukaiyama, A., Tadokoro, T., Koga, Y. and Kanaya, S. (2009). Proline effect on the thermostability and slow unfolding of a hyperthermophilic protein, *Journal of Biochemistry*, 145(1), 79-85.

- ➔ Leaching behavior of calcium from a low grade copper sulfide ore
- ➔ The effect of KNO₃ on substrate utilisation by *Sulfobacillus* sp. in mixed ferrous ion and tetrathionate growth medium
- ➔ Results and discussion of the pH experiments
- ➔ pH
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- ➔ Purification and enzymatic properties of arsenic resistance protein ArsH from heterogeneous expression in E.coli BL21
- ➔ A strategy to produce monoclonal antibodies against gp96 by prime-boost regimen using endogenous protein and E. coli heterologously-expressed fragment
- ➔ Citrate-stabilized CdSe/CdS quantum dots as fluorescence probe for protein determination
- ➔ Effect of aggressive pH media on peat treated by cement and sodium silicate grout
- ➔ Corrosion behaviour of die-cast AZ91D magnesium alloys in sodium sulphate solutions with different pH values
- ➔ Influence of landfill structures on stabilization of fully recycled leachate
- ➔ Preparation of magnetic iron/mesoporous silica composite spheres and their use in protein immobilization
- ➔ Dynamic Effects of Cerium on Syntheses of Soluble Protein and Taxol in Suspension Culture of *Taxus Chinensis* Var. *Mairei* Cells
- ➔ Separation of sulfide lead-zinc-silver ore under low alkalinity condition
- ➔ Potential—pH diagrams of Cr-H₂O system at elevated temperatures
- ➔ QUENCH IN STABILIZATION OF Cu-Zn-Al ALLOY
- ➔ Influence of pH value on chromate-free conversion coating for magnesium alloys
- ➔ SiO₂
- ➔ Antioxidant properties of wheat germ protein hydrolysates evaluated in vitro
- ➔ Preparation and H⁺ response mechanism of WWO₃ pH electrode by sol-gel method
- ➔ Enhancing excess sludge

aerobic digestion with low
intensity ultrasound



FORMATION AND SOLUBILITY
OF POTASSIUM
ALUMINOSILICATE



Dynamic simulation of universal
spacer in Dynesys dynamic
stabilization system for human
vertebra



Al₂O₃



pH



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