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Chemical Additives for Corrosion Control in Desalination Plants

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- Chapter
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Abstract

The addition of chemical additives has been considered as a standard operation in water treatment systems. This chapter discusses the chemical additives used for the control of corrosion in desalination systems. Specifically, corrosion inhibitors for various metallurgies, biocides, and oxygen scavengers are covered. The pros and cons of the additive chemicals have been highlighted. The need to utilize green corrosion inhibitors based on plants and ionic liquids materials have been emphasized. This class of materials are environmentally friendly, cheap, and readily available.

Keywords

- Desalination
- Corrosion
- Chemical additive
- Corrosion inhibitor

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References

1. F.R. Spellman, *The Science of Environmental Pollution*. 2nd edn, (CRC press, Taylor and Francis, 2009), ISBN 9781138626607

Google Scholar

- World Health Organization., <u>Guidelines for drinking-water quality</u>, p. 631, ISBN 978-92-4-154995-0, 2017
- World Health Organization., <u>Drinking</u> water (2019), <u>https://www.who.int/news-room/fact-sheets/detail/drinking-water</u>
- 4. Food and Agriculture Organization of the United Nations, Coping with Water Scarcity: An Action Framework for Agriculture and Food Security, FAO water reports 38, Rome, ISBN 978-92-5-107304-9, 2012

Google Scholar

 R.J. Forbes, A short history of the art of distillation: From the beginnings up to the death of Cellier Blumenthal, Ams Pr Inc, ISBN-13: 978– 0404184704, 1948

Google Scholar

 E. Jones, M. Qadir, M.T.H. vanVliet, V. Smakhtin, S. Kang, The state of desalination and brine production: A global outlook. Sci. Total Environ. 657, 1343–1356 (2019)

CAS Google Scholar

- T. Outteridge, Preventing desalination plant corrosion: The role of molybdenum. The International Molybdenum Association (IMOA), <u>http://www.sswnews.com/pdf/Preventing Desalination Plant Co</u> <u>rrosion.pdf</u>
- T. Hodgkiess, K.H. Al-Omari, N. Bontems, B. Lesiak, Acid cleaning of thermal desalination plant: Do we need to use corrosion inhibitors? Desalination 183, 209–216 (2005)

CAS Google Scholar

- 9. The Courier Mail, Corrosion Hits Tugun Desalination Plant, April 18 2009. <u>https://www.couriermail.com.au/news/special-features/corrosion-hits-desal-plant/news-story/0056a6868b238497868cc24cdb8127a9</u>
- 10.A.I. El-Twaty, S.A. Karshman, Experience with desalination plants in Libya. Desalination **73**, 385–396 (1989)

CAS Google Scholar

- 11.NACE, NACE study estimates global cost of corrosion at \$2.5 trillion annually, March 8, NACE International (2016), <u>https://inspectioneering.com/news/2016-03-08/5202/nacestudy-estimates-global-cost-of-corrosion-at-25-trillion-ann</u>
- 12.M. Schorr, B. Valdez, J. OcaMpo, A. So, A. Eliezer, Materials and corrosion control in desalination plants. Mater. Perform. **51**, 56–60 (2012)

CAS Google Scholar

13.A.U. Malik, S. Ahmad, I. Andijani, N. Asrar, Acid cleaning of some Desal units at Al-Jubail plant. Technical Report No. TR3804/APP95007 (1997), <u>https://www.scribd.com/document/258538217/Acid-Cleaningof-Some-Desal-Units</u> 14.M.G. Fontana, *Corrosion Engineering*. (Mc Graw Hill Intl., 1987), 3rd edn., p. 172

Google Scholar

15.H. Uhlig, R. Revie, Corrosion and Control. (Wiley, 1985), 3rd edn., p. 13

Google Scholar

16.Japan Titanium Society, (1994). Counter measures against deposit of scale oceanic lives – light gauge titanium tubes for seawater desalination plants – 3, Q&A practical application, p. 14

Google Scholar

17.A.U. Malik, I.N. Andijani, A. Nadeem Siddiqi, A. Shahreer, A.S. Al-Mobayaed, Studies on the role of sulfamic acid as a descalant in desalination plant. Proc. VI Middle East Corros. Conf., January 24–26 1994, pp. 65–78

Google Scholar

- 18.ARMOHIB® corrosion inhibitors, https://surfacechemistry.nouryon.com
- 19.IBIT[®] for acid cleaning, <u>https://www.asahi-</u> <u>chem.co.jp/english/products/ibit/cleaning.html</u>. Accessed 2 July 2019
- 20.Corrosion inhibitor for hydrochloric acidic cleaning, <u>http://www.thwater.net/06-Hydrochloric-Acid-Cleaning.htm</u>. Accessed 2 July 2019
- 21.Corrosion inhibitors, <u>https://www.indiamart.com/proddetail/corrosion-inhibitors-10793739288.html</u>
- 22.Rodine 213, HCl acid inhibitor, <u>http://www.chemequal.com/supplier/rodine-213</u>
- 23.S.D. Wadekar, V.N. Pandey, G.J. Hipparge, Environmentally friendly corrosion inhibitors for high temperature applications. US 0233872 A1, 2017

Google Scholar

24.Y. Feng, S. Chen, J. You, W. Guo, Investigation of alkylamine selfassembled films on iron electrodes by SEM, FT-IR, EIS and molecular simulations. Electrochim. Acta **53**, 1743–1753 (2007)

CAS Google Scholar

25.G. Schmitt, Application of inhibitors for acid media. Br. Corros. J. **19**, 166–176 (1984)

Google Scholar

26.R.H. Hausler, Corrosion inhibition and inhibitors, in *Corrosion Chemistry*, ed. by G.R. Brubaker, P.B.P. Phipps, ACS Symp. Ser., 89, (American Chemical Society, Washington, 1979), 263–320

Google Scholar

27.S. Zhang, N. Sun, X. He, X. Lu, X. Zhang, Physical properties of ionic liquids: database and evaluation. J. Phys. Chem. **35**, 1475–1517 (2006)

CAS Google Scholar

28.P. Kannan, J. Karthikeyan, P. Murugan, T.S. Rao, N. Rajendran, Corrosion inhibition effect of novel methyl benzimidazolium ionic liquid for carbon steel in HCl medium. J. Mol. Liq. **221**, 368–380 (2016)

CAS Google Scholar

29.T. Tüken, F. Demir, N. Kıcır, G. Sığırcık, M. Erbil, Inhibition effect of 1ethyl-3-methylimidazolium dicyanamide against steel corrosion. Corros. Sci. **59**, 110–118 (2012)

Google Scholar

30.Q.B. Zhang, Y.X. Hua, Corrosion inhibition of mild steel by alkylimidazolium ionic liquids in hydrochloric acid. Electrochim. Acta 54, 1881–1887 (2009)

CAS Google Scholar

31.G. Chen, M. Zhang, M. Pan, X. Hou, H. Su, J. Zhang, Extracts of *Punicagranatum* Linne husk as green and eco-friendly corrosion inhibitors for mild steel in oil fields. Res. Chem. Intermed. **39**, 3545–3552 (2013)

CAS Google Scholar

32.G. Ji, S. Anjum, S. Sundaram, R. Prakash, *Musa paradisica* peel extract as green corrosion inhibitor for mild steel in HCl solution. Corros. Sci. **90**, 107–117 (2015)

CAS Google Scholar

33.A.K. Singh, S. Mohapatra, B. Pani, Corrosion inhibition effect of Aloe Vera gel: gravimetric and electrochemical study. J. Ind. Eng. Chem. **33**, 288– 297 (2016)

CAS Google Scholar

34.L.L. Liao, S. Mo, H.Q. Luo, N.B. Li, Longan seed and peel as environmentally friendly corrosion inhibitor for mild steel in acid solution: Experimental and theoretical studies. J. Colloid Interface Sci. 499, 110–119 (2017)

CAS Google Scholar

35.L.L. Liao, S. Mo, H.Q. Luo, N.B. Li, Corrosion protection for mild steel by extract from the waste of lychee fruit in HCl solution: experimental and theoretical studies. J. Colloid Interface Sci. **520**, 41–49 (2018)

36.M. Tabyaoui, B. Tabyaoui, H. El Attari, F. Bentiss, The use of *Euphorbia falcata* extract as eco-friendly corrosion inhibitor of carbon steel in hydrochloric acid solution. Mater. Chem. Phys. **141**, 240–247 (2013)

Google Scholar

37.M. Chevalier, F. Robert, N. Amusant, M. Traisnel, C. Roos, M. Lebrini, Enhanced corrosion resistance of mild steel in 1M hydrochloric acid solution by alkaloids extract from Anibarosaeodora plant: Electrochemical, phytochemical and XPS studies. Electrochim. Acta **131**, 96–105 (2014)

CAS Google Scholar

38.N. M'hiri, D. Veys-Renaux, E. Rocca, I. Ioannou, N.M. Boudhrioua, M. Ghoul, Corrosion inhibition of carbon steel in acidic medium by orange peel extract and its main antioxidant compounds. Corros. Sci. **102**, 55–62 (2016)

Google Scholar

39.Q. Hu, Y. Qiu, G. Zhang, X. Guo, Capsella bursa-pastoris extract as an eco-friendly inhibitor on the corrosion of Q235 carbon steels in 1 mol·L⁻¹hydrochloric acid. Chin. J. Chem. Eng. **23**, 1408–1415 (2015)

CAS Google Scholar

40.M. Srivastava, P. Tiwari, S.K. Srivastava, A. Kumar, G. Ji, R. Prakash, Low cost aqueous extract of *Pisumsativum* peels for inhibition of mild steel corrosion. J. Mol. Liq. **254**, 357–368 (2018)

CAS Google Scholar

41.V. Rajeswari, D. Kesavan, M. Gopiraman, P. Viswanathamurthi, K. Poonkuzhali, T. Palvannan, Corrosion inhibition

of *Eleusineaegyptiaca* and *Croton rottleri* leaf extracts on cast iron surface in 1M HCl medium. Appl. Surf. Sci. **314**, 537–545 (2014)

CAS Google Scholar

42.N. El Hamdani, R. Fdil, M. Tourabi, C. Jama, F. Bentiss, Alkaloids extract of *Retamamonosperma (L.) Boiss* seeds used as novel eco-friendly inhibitor for carbon steel corrosion in 1M HCl solution: Electrochemical and surface studies. Appl. Surf. Sci. **357**, 1294–1305 (2015)

Google Scholar

43.K.K. Anupama, K. Ramya, K.M. Shainy, A. Joseph, Adsorption and electrochemical studies of *Pimentadioica* leaf extracts as corrosion inhibitor for mild steel in hydrochloric acid. Mater. Chem. Phys. **167**, 28– 41 (2015)

CAS Google Scholar

44.N.A. Odewunmi, S.A. Umoren, Z.M. Gasem, S.A. Ganiyu, Q. Muhammad, L-Citrulline: An active corrosion inhibitor component of watermelon rind extract for mild steel in HCl medium. J. Taiwan Inst. Chem. Eng. **51**, 177– 185 (2015)

CAS Google Scholar

45.M. Jokar, T. ShahrabiFarahani, B. Ramezanzadeh, Electrochemical and surface characterizations of *Morus alba pendula* leaves extract (MAPLE) as a green corrosion inhibitor for steel in 1M HCl. J. Taiwan Inst. Chem. Eng. **63**, 436–452 (2016)

CAS Google Scholar

46.P. Muthukrishnan, P. Prakash, B. Jeyaprabha, K. Shankar, Stigmasterol extracted from Ficushispida leaves as a green inhibitor for the mild steel corrosion in 1M HCl solution. Arab. J. Chem. (2015). <u>https://doi.org/10.1016/j.arabjc.2015.09.005</u>

- 47.E. Baran, A. Cakir, B. Yazici, Inhibitory effect of *Gentiana olivieri* extracts on the corrosion of mild steel in 0.5M HCI: electrochemical and phytochemical evaluation. Arab. J. Chem. (2016). <u>https://doi.org/10.1016/j.arabjc.2016.06.008</u>
- 48.H. Gerengi, I. Uygur, M. Solomon, M. Yildiz, H. Goksu, Evaluation of the inhibitive effect of *Diospyros kaki* (Persimmon) leaves extract on St37 steel corrosion in acid medium. Sustain. Chem. Pharm. **4**, 57–66 (2016)

49.G. Chen, X. Hou, Q. Gao, L. Zhang, J. Zhang, J. Zhao, Research on *Diospyros* Kaki L.f leaf extracts as green and eco-friendly corrosion and oil field microorganism inhibitors. Res. Chem. Intermed. **41**, 82–92 (2015)

Google Scholar

50.Y. El Ouadi, A. Bouyanzer, L. Majidi, J. Paolini, J.M. Desjobert, J. Costa, A. Chetouani, B. Hammouti, S. Jodeh, I. Warad, Y. Mabkhot, T.B. Hadda, Evaluation of *Pelargonium* extract and oil as eco-friendly corrosion inhibitor for steel in acidic chloride solutions and pharmacological properties. Res. Chem. Intermed. **41**, 7125–7149 (2015)

Google Scholar

51.C.O. Akalezi, E.E. Oguzie, Evaluation of anticorrosion properties of *Chrysophyllum albidum* leaves extract for mild steel protection in acidic media. Int. J. Ind. Chem. **7**, 81–92 (2016)

CAS Google Scholar

52.A.S. Fouda, A.S. Abousalem, G.Y. EL-Ewady, Mitigation of corrosion of carbon steel in acidic solutions using an aqueous extract of *Tiliacordata* as green corrosion inhibitor. Int. J. Ind. Chem. 8, 61–73 (2017)

53.K. Shalabi, A.A. Nazeer, Adsorption and inhibitive effect of *Schinus terebinthifolius* extract as a green corrosion inhibitor for carbon steel in acidic solution. Prot. Met. Phys. Chem. Surf. **51**, 908–917 (2015)

CAS Google Scholar

54.M. Larif, A. Elmidaoui, A. Zarrouk, H. Zarrok, R. Salghi, B. Hammouti, H. Oudda, F. Bentiss, An investigation of carbon steel corrosion inhibition in hydrochloric acid medium by an environmentally friendly green inhibitor. Res. Chem. Intermed. **39**, 2663–2677 (2013)

CAS Google Scholar

55.A. Khadraoui, A. Khelifa, H. Hamitouche, R. Mehdaoui, Inhibitive effect by extract of *Mentharotundifolia* leaves on the corrosion of steel in 1 M HCl solution. Res. Chem. Intermed. **40**, 961–972 (2014)

CAS Google Scholar

56.A.A. Nazeer, K. Shalabi, A.S. Fouda, Corrosion inhibition of carbon steel by Roselle extract in hydrochloric acid solution: electrochemical and surface study. Res. Chem. Intermed. **41**, 4833–4850 (2015)

Google Scholar

57.G. Ji, P. Dwivedi, S. Sundaram, R. Prakash, Aqueous extract of Argemone mexicana roots for effective protection of mild steel in an HCI environment. Res. Chem. Intermed. 42, 439–459 (2016)

CAS Google Scholar

58.C.O. Akalezi, C.K. Enenebaku, E.E. Oguzie, Inhibition of acid corrosion of mild steel by biomass extract from the *Petersianthus macrocarpus* plant.J. Mater. Environ. Sci. 4, 217–226 (2013)

59.M. Chraibi, K. Fikri Benbrahim, H. Elmsellem, A. Farah, I. Abdel-Rahman, B. El Mahi, Y. Filali Baba, Y. Kandri Rodi, F. Hlimi, Antibacterial activity and corrosion inhibition of mild steel in 1.0 M hydrochloric acid solution by *M. piperita* and *M. pulegium* essential oils. J. Mater. Environ. Sci. 8, 972–981 (2017)

CAS Google Scholar

60.M.A. Amin, K.F. Khaled, Copper corrosion inhibition in O₂-saturated H₂SO₄ solutions. Corros. Sci. **52**, 1194–1204 (2010)

CAS Google Scholar

61.B. Tan, S. Zhang, W. Li, X. Zuo, Y. Qiang, L. Xu, J. Hao, S. Chen, Experimental and theoretical studies on inhibition performance of Cu corrosion in 0.5 M H₂SO₄ by three disulfide derivatives. J. Ind. Eng. Chem. **77**, 449–460 (2019)

CAS Google Scholar

62.B.V. Appa Rao, K.C. Kumar, 5-(3-Aminophenyl) tetrazole – A new corrosion inhibitor for Cu–Ni (90/10) alloy in seawater and sulphide containing seawater. Arab. J. Chem. **10**, S2245–S2259 (2017)

CAS Google Scholar

63.K. Abderrahim, I. Selatnia, A. Sid, P. Mosset, 1, 2-bis (4chlorobenzylidene) azine as new and effective corrosion inhibitor for copper in 0.1 N HCI: A combined experimental and theoretical approach. Chem. Phys. Lett. **707**, 117–128 (2018)

64.B. Tan, S. Zhang, Y. Qiang, L. Feng, C. Liao, Y. Xu, S. Chen, Investigation of the inhibition effect of Montelukast Sodium on the copper corrosion in 0.5 mol/L H₂SO₄. J. Mol. Liq. **248**, 902–910 (2017)

CAS Google Scholar

65.K.F. Khaled, Adsorption and inhibitive properties of a new synthesized guanidine derivative on corrosion of copper in 0.5 M H₂SO₄. Appl. Surf. Sci **255**, 1811–1818 (2008)

CAS Google Scholar

66.D.K. Verma, E.E. Ebenso, M.A. Quraishi, C. Verma, Gravimetric, electrochemical surface and density functional theory study of acetohydroxamic and benzohydroxamic acids as corrosion inhibitors for copper in 1M HCl. Results Phys. **13**, 102194 (2019)

Google Scholar

67.Y. Tang, W. Yang, X. Yin, Y. Liu, R. Wan, J. Wang, Phenyl-substituted amino thiadiazoles as corrosion inhibitors for copper in 0.5 M H₂SO₄. Mater. Chem. Phys. **116**, 479–483 (2009)

CAS Google Scholar

68.R. Farahati, A. Ghaffarinejad, S.M. Mousavi-Khoshdel, J. Rezania, H. Behzadi, A. Shockravi, Synthesis and potential applications of some thiazoles as corrosion inhibitor of copper in 1 M HCI: Experimental and theoretical studies. Prog. Org. Coat. **132**, 417–428 (2019)

CAS Google Scholar

69.E.M.M. Sutter, A. Cornet, J. Pagetti, The inhibition of the corrosion of titanium in 10 N sulphuric acid by cupferron (n-nitrosophenyl hydroxylamine). Corros. Sci. **27**, 229–238 (1987)

70.M.A. Deyab, Corrosion inhibition of heat exchanger tubing material (titanium) in MSF desalination plants in acid cleaning solution using aromatic nitro compounds. Desalination **439**, 73–79 (2018)

CAS Google Scholar

71.J.A. Petit, G. Chatainier, F. Dabos, Inhibitors for the corrosion of reactive metals: Titanium and zirconium and their alloys in acid media. Corros. Sci. 21, 279–299 (1981)

CAS Google Scholar

72.A.U. Malik, S.A. Al-Fozan, M.A. Romiah, Relevance of corrosion research in the material selection for desalination plants. 2nd Science Symposium on Maintenance Planing and Operations, King Saud University, Riyadh, 24–26 April 1993

Google Scholar

73.Y.A. Alzafin, A.-H.I. Mourad, M. Abou Zour, O.A. Abuzeid, A study on the failure of pump casings made of ductile Ni-resist cast irons used in desalination plants. Eng. Fail. Anal. **14**, 1294–1300 (2007)

CAS Google Scholar

74.Y.A. Alzafin, A.-H.I. Mourad, M. Abou Zour, O.A. Abuzeid, Stress corrosion cracking of Ni-resist ductile iron used in manufacturing brine circulating pumps of desalination plants. Eng. Fail. Anal. **16**, 733–739 (2009)

75.A. Matin, Z. Khan, S.M.J. Zaidi, M.C. Boyce, Biofouling in reverse osmosis membranes for seawater desalination: Phenomena and prevention. Desalination 281, 1–16 (2011)

CAS Google Scholar

76.R. Jia, T. Unsal, D. Xu, Y. Lekbach, T. Gu, Microbiologically influenced corrosion and current mitigation strategies: A state of the art review. Int. Biodeter. Biodegr. **137**, 42–58 (2019)

CAS Google Scholar

77.F.A. Abd El Aleem, K.A. Al-Sugair, M.I. Alahmad, Biofouling problems in membrane processes for water desalination and reuse in Saudi Arabia. Int. Biodeter. Biodegr. 41, 19–23 (1998)

CAS Google Scholar

78.A.U. Malik, T.L. Prakash, I. Andijani, Failure evaluation in desalination plants some case studies. Desalination **105**, 283–295 (1996)

CAS Google Scholar

79.R. Jia, D. Yang, D. Xu, T. Gu, Anaerobic corrosion of 304 stainless steel caused by the *Pseudomonas aeruginosa* biofilm. Front. Microbiol. **8**, 2335 (2017)

Google Scholar

80.I.G. Chamritski, G.R. Burns, B.J. Webster, N.J. Laycock, Effect of ironoxidizing bacteria on pitting of stainless steel. Corrosion **60**, 658–669 (2004)

81.K.M. Usher, A.H. Kaksonen, I. Cole, D. Marney, Critical review: Microbially influenced corrosion of buried carbon steel pipes. Int. Biodeter. Biodegr. **93**, 84–106 (2014)

CAS Google Scholar

82.S. Lattemann, T. Höpner, Environmental impact and impact assessment of seawater desalination. Desalination **220**, 1–15 (2008)

CAS Google Scholar

83.M.A. Deyab, Efficiency of cationic surfactant as microbial corrosion inhibitor for carbon steel in oilfield saline water. J. Mol. Liq. **255**, 550–555 (2018)

CAS Google Scholar

84.M. Pakiet, I. Kowalczyk, R.L. Garcia, R. Moorcroft, T. Nichol, T. Smith, R. Akid, B. Brycki, Gemini surfactant as multifunctional corrosion and biocorrosion inhibitors for mild steel. Bioelectrochemistry **128**, 252–262 (2019)

CAS Google Scholar

85.M. Lavania, P.M. Sarma, A.K. Mandal, S. Cheema, B. Lal, Efficacy of natural biocide on control of microbial induced corrosion in oil pipelines mediated by *Desulfovibrio vulgaris* and *Desulfovibrio gigas*. J. Environ. Sci. 23, 1394–1402 (2011)

CAS Google Scholar

86.T. Nguyen, F.A. Roddick, L. Fan, Biofouling of water treatment membranes: A review of the underlying causes, monitoring techniques and control measures. Membranes 2, 804–840 (2012)

87.A.U. Malik, P.C. Mayan Kutty, N.A. Siddiqi, I.N. Andijani, T.S. Thankachan, Effect of deaeration and sodium sulfite addition to MSF make-up water on corrosion of evaporator and heat exchanger materials. J. King Saud Univ. 8, 21–36 (1996)

CAS Google Scholar

- 88.J.D. Zupanovich, Oxidation and Degradation Products of Common Oxygen Scavengers. The Analyst: *The Voice of the Water Treatment Industry*, Fall, 1–8 (2002), <u>https://www.awt.org/pub/0149322F-0C20-5CEC-AE62-1E826AF61A4C</u>
- 89.N.A. Nada, A. Zahrani, B. Ericsson, Experience on pre- and posttreatment from sea water desalination plants in Saudi Arabia. Desalination **66**, 303–318 (1987)

CAS Google Scholar

90.O. Kattan, K. Ebbers, A. Koolaard, H. Vos, G. Bargeman, Membrane contactors: An alternative for de-aeration of salt solutions? Sep. Purif. Technol. **205**, 231–240 (2018)

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