ABSTRACT AND REFERENCES

TECHNOLOGY ORGANIC AND INORGANIC SUBSTANCES

DOI: 10.15587/1729-4061.2020.200126

AN EXPERIMENTAL STUDY OF Al_2O_3 NANOPARTICLES INFLUENCE ON CALORIC PROPERTIES OF PROPYLENE GLYCOL BASED COOLANTS (p. 6–12)

Igor Motovoy
Odessa National Academy of Food Technologies, Odessa, Ukraine
ORCID: http://orcid.org/0000-0002–1409-4453

Sergiy Artemenko
Odessa National Academy of Food Technologies, Odessa, Ukraine
ORCID: http://orcid.org/0000-0002–1398–1472

Olga Khliyeva
Odessa National Academy of Food Technologies, Odessa, Ukraine
ORCID: http://orcid.org/0000-0002-3592-4989

Vitaly Zhelezny
Odessa National Academy of Food Technologies, Odessa, Ukraine
ORCID: http://orcid.org/0000-0002-0987–1561

Yury Semenyuk
Odessa National Academy of Food Technologies, Odessa, Ukraine
ORCID: http://orcid.org/0000-0002-3489-0262

Aleksey Paskal
Odessa National Academy of Food Technologies, Odessa, Ukraine
ORCID: http://orcid.org/0000-0001-6569-6115

Nanofluids are promising heat carriers, which contribute to the overall efficiency of energy systems. The main obstacle to the practical application of nanocoolants based on aqueous propylene glycol solutions is the lack of accurate data on their thermophysical properties. In the paper, experimental study (adiabatic calorimetry method) of the heat capacity and parameters of solid phase – liquid phase transitions of propylene glycol and coolant based on aqueous propylene glycol solution is carried out. Experimental study of the heat capacity of the liquid phase of the coolant based on an aqueous solution of propylene glycol with additives of Al_2O_3 nanoparticles (up to 2.01 wt. %) in the temperature range of 235...338 K and propylene glycol with additives of Al_2O_3 nanoparticles (1.03 wt. %) in the temperature range of 268...335 K is performed.

The comparison of the temperature dependence of the effective heat capacity of coolants with changes in their internal structure is made. It is shown that adding water to propylene glycol increases the temperature and heat of the solid phase – liquid phase transition (the heat of the propylene glycol phase transition is 37.85 $J \cdot g^{-1}$, propylene glycol/water coolant (54/46 wt. %) – 77.97 $J \cdot g^{-1}$). It is shown that additives of Al_2O_3 nanoparticles both in propylene glycol and in the coolant based on an aqueous propylene glycol solution contribute to the reduction of the heat capacity of the liquid. The heat capacity decreases approximately in proportion to the increase in the concentration of nanoparticles. The effect of heat capacity reduction is greater at high temperatures (3.9 % at 265 K and 5.0 % at 325 K for the nanocoolant with an Al_2O_3 nanoparticle concentration of 2.01 wt. %).

The results obtained will improve the design quality of heat exchange equipment using nanocoolants. The results are useful for developing methods for predicting the specific heat of nanofluids.

Keywords: coolant, propylene glycol, nanoparticles, caloric properties, heat capacity, phase transition, melting point, adiabatic calorimeter.

References

1. Gupta, M., Singh, V., Kumar, R., Said, Z. (2017). A review on thermophysical properties of nanofluids and heat transfer applications. Renewable and Sustainable Energy Reviews, 74, 638–670. doi: https://doi.org/10.1016/j.rser.2017.02.073
2. Sekrani, G., Poncet, S. (2018). Ethylene- and Propylene-Glycol Based Nanofluids: A Litterature Review on Their Thermophysical Properties and Thermal Performances. Applied Sciences, 8 (11), 2311. doi: https://doi.org/10.3390/app8112311
3. Pérez-Tavernier, J., Vallejo, J. P., Cabaleiro, D., Fernández-Seara, J., Lugo, L. (2019). Heat transfer performance of a nano-enhanced propylene glycol: water mixture. International Journal of Thermal Sciences, 139, 413–423. doi: https://doi.org/10.1016/j.ijthermalsci.2019.02.012
4. Manikandan, S., Rajan, K. S. (2016). Sand-propylene glycol-water nanofluids for improved solar energy collection. Energy, 113, 917–929. doi: https://doi.org/10.1016/j.energy.2016.07.120
5. Khliyeva, O., Ryabikin, S., Lukianov, N., Zhelezny, V. (2017). Experimental study of heat exchange and hydrodynamics at the laminar flow of nanocoolant based on propylene glycol and Al2O3 nanoparticles. Eastern-European Journal of Enterprise Technologies, 1 (8 (85)), 4–12. doi: https://doi.org/10.15587/1729-4061.2017.91780
6. Nikulin, A., Moita, A. S., Moreira, A. L. N., Murshed, S. M. S., Huminic, A., Grosu, Y. et. al. (2019). Effect of Al2O3 nanoparticles on laminar, transient and turbulent flow of isopropyl alcohol. International Journal of Heat and Mass Transfer, 130, 1032–1044. doi: https://doi.org/10.1016/j.ijheatmasstransfer.2018.10.114
7. Riazi, H., Murphy, T., Webber, G. B., Atkin, R., Tehrani, S. S. M., Taylor, R. A. (2016). Specific heat control of nanofluids: A critical review. International Journal of Thermal Sciences, 107, 25–38. doi: https://doi.org/10.1016/j.ijthermalsci.2016.03.024
8. Akilu, S., Baheta, A. T., Kadirgama, K., Padmanabhan, E., Sharma, K. V. (2019). Viscosity, electrical and thermal conductivities of ethylene and propylene glycol-based β-SiC nanofluids. Journal of Molecular Liquids, 284, 780–792. doi: https://doi.org/10.1016/j.molliq.2019.03.159
9. Zhelezny, V., Khliyeva, O., Motovoy, I., Lukianov, N. (2019). An experimental investigation and modelling of the thermal and caloric properties of nanofluids isopropyl alcohol – Al_2O_3 nanoparticles. Thermochimica Acta, 678, 178296. doi: https://doi.org/10.1016/j.tca.2019.05.011
10. Satti, J. R., Das, D. K., Ray, D. (2016). Specific heat measurements of five different propylene glycol based nanofluids and development of a new correlation. International Journal of Heat and Mass Transfer, 94, 343–353. doi: https://doi.org/10.1016/j.ijheatmasstransfer.2015.11.065
11. Chandran, M. N., Manikandan, S., Suganthi, K. S., Rajan, K. S. (2017). Novel hybrid nanofluid with tunable specific heat and thermal conductivity: Characterization and performance assessment for energy related applications. Energy, 140, 27–39. doi: https://doi.org/10.1016/j.energy.2017.08.056
12. Sahoo, R., Ghosh, P., Sarkar, J. (2017). Performance comparison of various coolants for louvered fin tube automotive radiator. Thermal Science, 21 (6 Part B), 2871–2881. doi: https://doi.org/10.2298/tsci150219213s
13. Dyment, O. N., Kazanskiy, K. S., Miroshnikov, A. M. (1976). Glikoli i drugie proizvodnye okisey etilena i propilena. Moscow: Himiya.
14. Khliyeva, O. Y., Nikulina, A. S., Polyuganich, M. P., Ryabikin, S. S., Zhelezny, V. P. (2016). Viscosity of ternary solutions composed of propylene glycol, ethanol and water. Refrigeration Engineering

and Technology, 52 (3), 29–35. doi: https://doi.org/10.15673/ret.v52i3.120
15. Zhelezny, V., Motovoy, I., Khliyeva, O., Lukianov, N. (2019). An influence of Al_2O_3 nanoparticles on the caloric properties and parameters of the phase transition of isopropyl alcohol in solid phase. Thermochimica Acta, 671, 170–180. doi: https://doi.org/10.1016/j.tca.2018.11.020
16. Taylor, B. N., Kuyatt, C. E. (1994). Guidelines for evaluating and expressing the uncertainty of NIST measurement results. NIST Technical Note 1297. doi: https://doi.org/10.6028/nist.tn.1297
17. VDI Heat Atlas (2010). Springer, 1586. doi: https://doi.org/10.1007/978-3-540-77877-6

DOI: 10.15587/1729-4061.2020.200559

SELECTION OF THE FORMATION MODE OF A ZINC MESH ELECTRODE FOR AN ELECTROCHROMIC DEVICE WITH THE POSSIBILITY OF ENERGY RECOVERY (p. 13–20)

Valerii Kotok
Ukrainian State University of Chemical Technology, Dnipro, Ukraine
Vyatka State University, Kirov, Russian Federation
ORCID: http://orcid.org/0000-0001-8879-7189

Vadym Kovalenko
Ukrainian State University of Chemical Technology, Dnipro, Ukraine
Vyatka State University, Kirov, Russian Federation
ORCID: http://orcid.org/0000-0002-8012-6732

Zinc mesh electrode was proposed for creating a prototype of an electrochromic device capable of recuperating energy spent on coloration. The search for a suitable formation regime of the mesh electrode with required capacity was realized using several approaches: use of multiwire substrates, deposition of zinc from different electrolytes, change in the composition of pasted electrodes. Deposition of zinc from a simple sulfate electrolyte yielded good deposits, however, their capacity wasn't sufficient. The use of the alkaline zincate electrolyte yielded deposits with developed surface and higher capacity, but the deposits had dark color, poor adhesion and were falling off the substrate. The pasted electrode with a paste of zinc oxide, graphite and polyvinyl butyral demonstrated the highest capacity of – 0.83 mA·h. The proposed method for forming the zinc mesh electrode was used to develop a prototype of electrochromic devices capable of recuperating electrical energy.

The assembled prototype with the described electrodes demonstrated stable characteristics at a coloration degree of 50 %. The prototype was also capable of working as an energy storage unit and was used to power an LED.

Keywords: electrochromic device, nickel hydroxide, polyvinyl butyral, zinc, zincate, zinc electrode, recuperation, chemical power source, discharge, charge.

References

1. Global energy statistical yearbook 2019. Available at: https://yearbook.enerdata.net/total-energy/world-consumption-statistics.html
2. Energy. Available at: https://ourworldindata.org/energy
3. Vlasov, A. I., Shakhnov, V. A., Filin, S. S., Krivoshein, A. I. (2019). Sustainable energy systems in the digital economy: concept of smart machines. Entrepreneurship and Sustainability Issues, 6 (4), 1975–1986. doi: https://doi.org/10.9770/jesi.2019.6.4(30)
4. Smart home gadgets for smarter energy consumption. Available at: https://www.whatissmartgrid.org/featured-article/5-smart-home-gadgets-for-smarter-energy-consumption
5. Smart windows: electrochromic windows for building optimization. Available at: https://www.sageglass.com/sites/default/files/masdar_technology_journal_issue_5_september_2018_smart_windows.pdf
6. Lampert, C. M. (2004). Chromogenic smart materials. Materials Today, 7 (3), 28–35. doi: https://doi.org/10.1016/s1369-7021(04)00123-3
7. Ma, D., Wang, J. (2016). Inorganic electrochromic materials based on tungsten oxide and nickel oxide nanostructures. Science China Chemistry, 60 (1), 54–62. doi: https://doi.org/10.1007/s11426-016-0307-x
8. Xiong, S., Yin, S., Wang, Y., Kong, Z., Lan, J., Zhang, R. et. al. (2017). Organic/inorganic electrochromic nanocomposites with various interfacial interactions: A review. Materials Science and Engineering: B, 221, 41–53. doi: https://doi.org/10.1016/j.mseb.2017.03.017
9. Kotok, V. A., Kovalenko, V. L., Kovalenko, P. V., Solovov, V. A., Deabate, S., Mehdi, A. et. al. (2017). Advanced electrochromic $Ni(OH)_2$/PVA films formed by electrochemical template synthesis. ARPN Journal of Engineering and Applied Sciences, 12 (13), 3962–3977.
10. Kotok, V. A., Malyshev, V. V., Solovov, V. A., Kovalenko, V. L. (2017). Soft Electrochemical Etching of FTO-Coated Glass for Use in $Ni(OH)_2$-Based Electrochromic Devices. ECS Journal of Solid State Science and Technology, 6 (12), P772–P777. doi: https://doi.org/10.1149/2.0071712jss
11. Kotok, V., Kovalenko, V. (2019). A study of an electrochromic device based on Ni(OH)2/PVA film with the mesh-like silver counter electrode. Eastern-European Journal of Enterprise Technologies, 5 (6 (101)), 49–55. doi: https://doi.org/10.15587/1729-4061.2019.181396
12. Kotok, V., Kovalenko, V. (2019). Material selection for the mesh electrode of electrochromic device based on Ni(OH)2. Eastern-European Journal of Enterprise Technologies, 4 (6 (100)), 54–60. doi: https://doi.org/10.15587/1729-4061.2019.176439
13. Guo, Q., Zhao, X., Li, Z., Wang, D., Nie, G. (2020). A novel solid-state electrochromic supercapacitor with high energy storage capacity and cycle stability based on poly(5-formylindole)/WO_3 honeycombed porous nanocomposites. Chemical Engineering Journal, 384, 123370. doi: https://doi.org/10.1016/j.cej.2019.123370
14. Österholm, A. M., Shen, D. E., Dyer, A. L., Reynolds, J. R. (2013). Optimization of PEDOT Films in Ionic Liquid Supercapacitors: Demonstration As a Power Source for Polymer Electrochromic Devices. ACS Applied Materials & Interfaces, 5 (24), 13432–13440. doi: https://doi.org/10.1021/am4043454
15. Esmail, A., Hashem, H., Soltan, S., Hammam, M., Ramadan, A. (2016). Thickness dependence of electro-optical properties of WO_3 films as an electrochromic functional material for energy-efficient applications. Physica Status Solidi (a), 214 (1), 1600478. doi: https://doi.org/10.1002/pssa.201600478
16. Atak, G., Coşkun, Ö. D. (2019). Effects of anodic layer thickness on overall performance of all-solid-state electrochromic device. Solid State Ionics, 341, 115045. doi: https://doi.org/10.1016/j.ssi.2019.115045
17. Bahmet'eva, L. M., Pushkin, D. V., Serezhkina, L. B. (2005). Okislitel'no-vosstanovitel'nye reaktsii. Samara: Izd-vo 'Univers-grupp', 59.
18. Skelton, J., Serenyi, R. (1997). Improved silver/zinc secondary cells for underwater applications. Journal of Power Sources, 65 (1-2), 39–45. doi: https://doi.org/10.1016/s0378-7753(96)02611-0
19. Chang, C.-C., Lee, Y.-C., Liao, H.-J., Kao, Y.-T., An, J.-Y., Wang, D.-Y. (2018). Flexible Hybrid Zn–Ag/Air Battery with Long Cycle Life. ACS Sustainable Chemistry & Engineering, 7 (2), 2860–2866. doi: https://doi.org/10.1021/acssuschemeng.8b06328
20. Zeng, X., Yang, Z., Fan, M., Cui, F., Meng, J., Chen, H., Chen, L. (2020). Shape-controlled growth of three-dimensional flower-like ZnO@Ag composite and its outstanding electrochemical performance

for Ni-Zn secondary batteries. Journal of Colloid and Interface Science, 562, 518–528. doi: https://doi.org/10.1016/j.jcis.2019.11.083
21. McBreen, J. (1994). Nickel/zinc batteries. Journal of Power Sources, 51 (1-2), 37–44. doi: https://doi.org/10.1016/0378-7753(94)01954-1
22. Kotok, V., Kovalenko, V. (2017). The electrochemical cathodic template synthesis of nickel hydroxide thin films for electrochromic devices: role of temperature. Eastern-European Journal of Enterprise Technologies, 2 (11 (86)), 28–34. doi: https://doi.org/10.15587/1729-4061.2017.97371
23. Song, Q., Chiu, C. H., Chan, S. L. I. (2006). Nanocrystalline Nickel Hydroxide in Pasted Nickel Electrodes for Rechargeable Nickel Batteries. 2006 International Conference on Nanoscience and Nanotechnology. doi: https://doi.org/10.1109/iconn.2006.340567
24. Zhang, C., Wang, J.-M., Zhang, Z., Zhang, J.-Q., Cao, C.-N. (2001). Effects of calcium additive on performance of pasted zinc electrode. Zhongguo Youse Jinshu Xuebao/Chinese Journal of Nonferrous Metals, 11 (5), 780–784.
25. Zhang, C., Wang, J. M., Zhang, L., Zhang, J. Q., Cao, C. N. (2001). Study of the performance of secondary alkaline pasted zinc electrodes. Journal of Applied Electrochemistry, 31 (9), 1049–1054. doi: https://doi.org/10.1023/A:1017923924121
26. Kotok, V., Kovalenko, V. (2018). Definition of the aging process parameters for nickel hydroxide in the alkaline medium. Eastern-European Journal of Enterprise Technologies, 2 (12 (92)), 54–60. doi: https://doi.org/10.15587/1729-4061.2018.127764
27. Kotok, V., Kovalenko, V., Vlasov, S. (2018). Investigation of Ni-Al hydroxide with silver addition as an active substance of alkaline batteries. Eastern-European Journal of Enterprise Technologies, 3 (6 (93)), 6–11. doi: https://doi.org/10.15587/1729-4061.2018.133465
28. Kovalenko, V., Kotok, V. (2017). Definition of effectiveness of β-$Ni(OH)_2$ application in the alkaline secondary cells and hybrid supercapacitors. Eastern-European Journal of Enterprise Technologies, 5 (6 (89)), 17–22. doi: https://doi.org/10.15587/1729-4061.2017.110390
29. Hosny, A. Y., O'Keefe, T. J., James, W. J. (1989). Hull cell technique for evaluating zinc sulfate electrolytes. Minerals Engineering, 2 (3), 415–423. doi: https://doi.org/10.1016/0892-6875(89)90010-1
30. Cheng, H., Xiao, H.-F., Chen, Q., Li, X.-M., Qin, W.-M., Chen, B.-S. et. al. (2018). Significantly enhanced dehalogenation selectivity in near-neutral zinc sulfate electrolytes by diffusion dialysis. Journal of Membrane Science, 563, 142–148. doi: https://doi.org/10.1016/j.memsci.2018.05.053
31. Kotok, V., Kovalenko, V. (2017). The properties investigation of the faradaic supercapacitor electrode formed on foamed nickel substrate with polyvinyl alcohol using. Eastern-European Journal of Enterprise Technologies, 4 (12 (88)), 31–37. doi: https://doi.org/10.15587/1729-4061.2017.108839
32. Stender, V. V. (1961). Prikladnaya elektrohimiya. Kharkiv: Iz-vo HGU im. Gor'kogo, 541.

DOI: 10.15587/1729-4061.2020.200994

ESTABLISHING THE REGULARITIES IN FORMING THE PROPERTIES OF CERAMIC WALL MATERIALS CONTAINING WASTE FROM GAS EXTRACTION (DRILLING SLUDGE) (p. 21–27)

Nadegda Rykusova
National Technical University
«Kharkiv Polytechnical Institute», Kharkiv, Ukraine
ORCID: http://orcid.org/0000-0003-0963-1805

Oleksii Shestopalov
National Technical University
«Kharkiv Polytechnical Institute», Kharkiv, Ukraine
ORCID: http://orcid.org/0000-0001-6268-8638

Liudmyla Shchukina
National Technical University
«Kharkiv Polytechnical Institute», Kharkiv, Ukraine
ORCID: http://orcid.org/0000-0002-5817-4279

Larysa Yashchenko
National Technical University
«Kharkiv Polytechnical Institute», Kharkiv, Ukraine
ORCID: http://orcid.org/0000-0003-4939-1244

Iraida Stanovska
Odessa National Polytechnic University, Odessa, Ukraine
ORCID: http://orcid.org/0000-0003-0601-7658

Arsen Muradian
Odessa National Maritime University, Odessa, Ukraine
ORCID: http://orcid.org/0000-0002-6488-6627

Valentyna Ocheretna
Odessa National Maritime University, Odessa, Ukraine
ORCID: http://orcid.org/0000-0003-4077-6711

This paper addresses the prospects of recycling waste from oil and gas extraction in order to manufacture building materials. The principal possibility has been established to apply the examined samples of drilling sludge as the basic raw material and a mineral additive in the compositions of masses to produce wall ceramics with the required consumer properties.

The main technological parameters for obtaining wall ceramics using the samples of gas extraction waste have been investigated. The formulations for ceramic masses have been developed applying fusible medium-sintered loam and drilling sludge in the amount of 20–80 % by weight. The properties of the obtained ceramic samples containing clay and high-carbonate drilling sludges have been analyzed. It has been found that increasing the amount of drilling sludge in the samples by 20 % to 80 % leads to a decrease in the density, strength, and an increase in the water absorption of the samples, which affects the quality of ceramics and the possibility of its practical use. We have established the regularities of change in the properties of the wall materials samples depending on the amount of the examined drilling sludge.

The optimal number of drilling sludge samples for the manufacture of wall ceramics with the norm-compliant properties has been determined. It has been found that it is possible to use clay drilling sludge (20–80 %) in the composition with fusible loam in order to obtain frost-resistant ceramic materials whose water absorption is at the level of 12 %, of grade M 125–M 175. Adding high carbonate sludge to fusible loam in the amount of 20 % makes it possible to receive frost-resistant ceramic materials of grade M 75, in the amount of 40 % – of grade M 100.

Keywords: drilling sludge, ceramic materials, ceramics, density, water absorption, frost-resistant wall ceramics, loam, mineral additive.

References

1. Razmgir, S. M., Afsari, M., Amani, M. (2011). Drilling Waste Management: A Case Study of the Drilling Waste Management and Environmental Control in one of the Iranian Offshore Fields. SPE Middle East Unconventional Gas Conference and Exhibition. doi: https://doi.org/10.2118/142487-ms
2. Rykusova, N. (2017). Impact of drilling operations and waste of drilling of oil and gas wells upon natural environment. Bulletin of NTU «KhPI». Series: Mechanical-technological systems and complexes, 20, 98–102. Available at: http://mtsc.khpi.edu.ua/article/view/109628/104610
3. Ablieieva, I. Yu. (2016). Ekonomichne obgruntuvannia tekhnolohiyi sumisnoi utylizatsiyi burovoho shlamu ta fosfohipsu. Sovremennye

tendentsii v nauke i obrazovanii: Sbornik nauchnyh statey. Warszawa, 71–73. Available at: http://xn--e1aajfpcds8ay4h.com.ua/files/file/scientific_conference_49/zbornik_49_6_Krak%C3%B3w_30.01.2016.pdf

4. Oreshkin, D. V., Chebotaev, A. N., Perfilov, V. A. (2015). Disposal of Drilling Sludge in the Production of Building Materials. Procedia Engineering, 111, 607–611. doi: https://doi.org/10.1016/j.proeng.2015.07.053
5. Bernardo, G., Marroccoli, M., Nobili, M., Telesca, A., Valenti, G. L. (2007). The use of oil well-derived drilling waste and electric arc furnace slag as alternative raw materials in clinker production. Resources, Conservation and Recycling, 52 (1), 95–102. doi: https://doi.org/10.1016/j.resconrec.2007.02.004
6. El-Mahllawy, M. S., Osman, T. A. (2010). Influence of Oil Well Drilling Waste on the Engineering Characteristics of Clay Bricks. Journal of American Science, 6 (7), 48–54. Available at: https://www.researchgate.net/publication/266041235_Influence_of_Oil_Well_Drilling_Waste_on_the_Engineering_Characteristics_of_Clay_Bricks
7. Mostavi, E., Asadi, S., Ugochukwu, E. (2015). Feasibility Study of the Potential Use of Drill Cuttings in Concrete. Procedia Engineering, 118, 1015–1023. doi: https://doi.org/10.1016/j.proeng.2015.08.543
8. Zhang, A., Li, M., Lv, P., Zhu, X., Zhao, L., Zhang, X. (2016). Disposal and Reuse of Drilling Solid Waste from a Massive Gas Field. Procedia Environmental Sciences, 31, 577–581. doi: https://doi.org/10.1016/j.proenv.2016.02.089
9. Tuncan, A., Tuncan, M., Koyuncu, H. (2000). Use of petroleum-contaminated drilling wastes as sub-base material for road construction. Waste Management & Research, 18 (5), 489–505. doi: https://doi.org/10.1177/0734242x0001800511
10. Huang, Z., Xu, Z., Quan, Y., Jia, H., Li, J., Li, Q. et. al. (2018). A review of treatment methods for oil-based drill cuttings. IOP Conference Series: Earth and Environmental Science, 170, 022074. doi: https://doi.org/10.1088/1755-1315/170/2/022074
11. Paladino, G., Arrigoni, J. P., Satti, P., Morelli, I., Mora, V., Laos, F. (2016). Bioremediation of heavily hydrocarbon-contaminated drilling wastes by composting. International Journal of Environmental Science and Technology, 13 (9), 2227–2238. doi: https://doi.org/10.1007/s13762-016-1057-5
12. Jamrozik, A., Ziaja, J., Gonet, A. (2011). Analysis of Applicability of Modified Drilling Waste for Filling out Annular Space in Horizontal Directional Drilling. Polish J. of Environ. Stud., 20 (3), 671–675. Available at: http://www.pjoes.com/Analysis-of-Applicability-of-Modified-Drilling-r-nWaste-for-Filling-out-Annular-Space,88605,0,2.html
13. Rykusova, N., Shestopalov, O., Lebedev, V., Tykhomyrova, T., Bakharieva, G. (2019). Identification of properties of recycled high-density polyethylene composites when filled with waste mud solids. Eastern-European Journal of Enterprise Technologies, 2 (10 (98)), 55–60. doi: https://doi.org/10.15587/1729-4061.2019.163656
14. Shestopalov, O., Briankin, O., Lebedev, V., Troshin, O., Muradian, A., Ocheretna, V., Yaremenko, N. (2019). Identifying the properties of epoxy composites filled with the solid phase of wastes from metal enterprises. Eastern-European Journal of Enterprise Technologies, 6 (10 (102)), 25–31. doi: https://doi.org/10.15587/1729-4061.2019.186050
15. Robinson, J., Kingman, S., Snape, C. E., Bradley, M., Bradshaw, S., Thomas, D. J. M., Page, P. W. (2009). Microwave Treatment of Oil-Contaminated Drill Cuttings at Pilot Scale. SPE Drilling & Completion, 24 (03), 430–435. doi: https://doi.org/10.2118/111637-pa
16. Mohammed, B., Cheeseman, C. R. (2011). Use of Oil Drill Cuttings as an Alternative Raw Material in Sandcrete Blocks. Waste and Biomass Valorization, 2 (4), 373–380. doi: https://doi.org/10.1007/s12649-011-9089-z
17. Rykusova, N., Shestopalov, O., Shchukina, L., Briankin, O., Galushka, Y. (2020). Study of the properties of drill cuttings at their use as technogenic raw materials for the production of building ceramics. ScienceRise, 1 (66), 10–22. doi: https://doi.org/10.21303/sr.v0i1.1158

DOI: 10.15587/1729-4061.2020.199849

DEVISING A CORROSION INHIBITOR FOR STEEL ST37-2 IN A WATER-OIL MIXTURE (p. 28–33)

Nikolai Gomelya
National Technical University of Ukraine «Igor Sikorsky Kyiv Polytechnic Institute», Kyiv, Ukraine
ORCID: http://orcid.org/0000-0003-1165-7545

Inna Trus
National Technical University of Ukraine «Igor Sikorsky Kyiv Polytechnic Institute», Kyiv, Ukraine
ORCID: http://orcid.org/0000-0001-6368-6933

Olena Stepova
National University «Yuri Kondratyuk Poltava Polytechnic», Poltava, Ukraine
ORCID: http://orcid.org/0000-0002-6346-5484

Oleksandr Kyryliuk
National Academy of the Security Service of Ukraine, Kyiv, Ukraine
ORCID: http://orcid.org/0000-0001-9248-0758

Olena Ivanenko
National Technical University of Ukraine «Igor Sikorsky Kyiv Polytechnic Institute», Kyiv, Ukraine
ORCID: http://orcid.org/0000-0001-6838-5400

Anna Khomenko
National University «Yuri Kondratyuk Poltava Polytechnic», Poltava, Ukraine
ORCID: https://orcid.org/0000-0003-3046-6867

Corrosion elimination implies the application of corrosion-resistant alloys, which is associated with high costs and is not a reliable enough technique, as well as corrosion inhibitors, which need to be constantly improved to improve their efficiency and bring down the cost. As corrosion is characterized by the destruction of a material as a result of interaction with the environment, one of the expedient methods for its minimization is the use of inhibitors. Therefore, it is a relevant task for environmental protection and economic development of the country to devise effective means to protect metals against corrosion. The reported inhibitor AC-2 (the solution of a mixture of 2-alkylimidazolines in methanol) rather effectively protects steel against corrosion in water-oil mixtures at the high concentrations of mineral salts in water. The efficacy of the inhibitor is almost unaffected by the ratio of the volumes of oil and concentrated aqueous solutions of sodium chloride. When using the inhibitor at a concentration of 50 mg/dm^3, the degree of protection of steel against corrosion exceeded 90 %. This is due to the fact that the protection of steel against corrosion occurs through the adsorption of the imidazoline components at the metal surface and the adsorption of organic oil components on the hydrophobic alkyl groups of 2-alkylimidazolines. In this case, the hydrophobization of the metal surface proceeds in the presence of minor quantities of oil. It has been shown that in the mixture that contained 200 cm^3 of a 3 % sodium chloride solution and 800 cm^3 of oil at the concentration of acetic acid, respectively, 0.5 and 3.0 g/dm^3 at a temperature of 80 °C at a dose of the inhibitor of 15–50 mg/dm^3 the efficiency reached 72–92 %. This makes it possible to resolve the issue of the rational use of natural resources and ensures the transition to the application of environmentally safe and energy-efficient technologies.

Keywords: corrosion inhibitor, 2-alkylimidazoline, water-oil mixture, steel corrosion rate, degree of corrosion protection.

References

1. Vasyliev, G., Brovchenko, A., Herasymenko, Y. (2013). Comparative Assessment of Corrosion Behaviour of Mild Steels 3, 20 and 08KP in Tap Water. Chemistry & Chemical Technology, 7 (4), 477–482. doi: https://doi.org/10.23939/chcht07.04.477
2. Gomelya, N. D., Trus, I. N., Nosacheva, Y. V. (2014). Water purification of sulfates by liming when adding reagents containing aluminum. Journal of Water Chemistry and Technology, 36 (2), 70–74. doi: https://doi.org/10.3103/s1063455x14020040
3. Trus, I. M., Fleisher, H. Y., Tokarchuk, V. V., Gomelya, M. D., Vorobyova, V. I. (2017). Utilization of the residues obtained during the process of purification of mineral mine water as a component of binding materials. Voprosy Khimii i Khimicheskoi Tekhnologii, 6, 104–109.
4. Rajasekar, A. (2016). Biodegradation of Petroleum Hydrocarbon and Its Influence on Corrosion with Special Reference to Petroleum Industry. Environmental Footprints and Eco-Design of Products and Processes, 307–336. doi: https://doi.org/10.1007/978-981-10-0201-4_9
5. Khalaf, M. M., Tantawy, A. H., Soliman, K. A., Abd El-Lateef, H. M. (2020). Cationic gemini-surfactants based on waste cooking oil as new «green» inhibitors for N80-steel corrosion in sulphuric acid: A combined empirical and theoretical approaches. Journal of Molecular Structure, 1203, 127442. doi: https://doi.org/10.1016/j.molstruc.2019.127442
6. Vasyliev, G., Vorobiova, V. (2019). Rape grist extract (Brassica napus) as a green corrosion inhibitor for water systems. Materials Today: Proceedings, 6, 178–186. doi: https://doi.org/10.1016/j.matpr.2018.10.092
7. Vasyl'ev, H. S., Herasymenko, Y. S. (2017). Corrosion Meters of New Generation Based on the Improved Method of Polarization Resistance. Materials Science, 52 (5), 722–731. doi: https://doi.org/10.1007/s11003-017-0015-9
8. Tantawy, A. H., Abo-Riya, M. A., Abdallah, S. M., El-Dougdoug, W. (2018). Novel cationic surfactants based on waste frying oil for cleaning water surface from petroleum films: Synthesis, antimicrobial and surface properties. Journal of Molecular Liquids, 253, 36–44. doi: https://doi.org/10.1016/j.molliq.2018.01.009
9. Shabliy, T., Nosachova, J., Radovenchik, Y., Vember, V. (2017). Study of effectiveness of heavy metals ions as the inhibitors of steel corrosion. Eastern-European Journal of Enterprise Technologies, 4 (12 (88)), 10–17. doi: https://doi.org/10.15587/1729-4061.2017.106974
10. Vorobyova, V. I., Skiba, M. I., Trus, I. M. (2019). Apricot pomaces extract (Prunus Armeniaca L.) as a highly efficient sustainable corrosion inhibitor for mild steel in sodium chloride solution. International Journal of Corrosion and Scale Inhibition, 8 (4), 1060–1084. doi: https://doi.org/10.17675/2305-6894-2019-8-4-15
11. Vorobyova, V., Chygyrynets', O., Skiba, M., Trus, I., Frolenkova, S. (2018). Grape Pomace Extract as Green Vapor Phase Corrosion Inhibitor. Chemistry & Chemical Technology, 12 (3), 410–418. doi: https://doi.org/10.23939/chcht12.03.410
12. Liang, M., Miao, J. (2013). Corrosion inhibition behavion of an iimidazoline inhibitor for P110 steel. Corrosion and Protection, 4 (5), 395–398.
13. Zhang, Q. H., Hou, B. S., Xu, N., Liu, H. F., Zhang, G. A. (2019). Two novel thiadiazole derivatives as highly efficient inhibitors for the corrosion of mild steel in the CO2-saturated oilfield produced water. Journal of the Taiwan Institute of Chemical Engineers, 96, 588–598. doi: https://doi.org/10.1016/j.jtice.2018.11.022
14. Al-Shihry, S. S., Sayed, A. R., Abd El-lateef, H. M. (2020). Design and assessment of a novel poly(urethane-semicarbazides) containing thiadiazoles on the backbone of the polymers as inhibitors for steel pipelines corrosion in CO_2-saturated oilfield water. Journal of Molecular Structure, 1201, 127223. doi: https://doi.org/10.1016/j.molstruc.2019.127223
15. Cen, H., Chen, Z., Guo, X. (2019). N, S co-doped carbon dots as effective corrosion inhibitor for carbon steel in CO2-saturated 3.5% NaCl solution. Journal of the Taiwan Institute of Chemical Engineers, 99, 224–238. doi: https://doi.org/10.1016/j.jtice.2019.02.036
16. Singh, A., Ansari, K. R., Lin, Y., Quraishi, M. A., Lgaz, H., Chung, I.-M. (2019). Corrosion inhibition performance of imidazolidine derivatives for J55 pipeline steel in acidic oilfield formation water: Electrochemical, surface and theoretical studies. Journal of the Taiwan Institute of Chemical Engineers, 95, 341–356. doi: https://doi.org/10.1016/j.jtice.2018.07.030
17. Lei, X., Wang, H., Feng, Y., Zhang, J., Sun, X., Lai, S. et. al. (2015). Synthesis, evaluation and thermodynamics of a 1H-benzo-imidazole phenanthroline derivative as a novel inhibitor for mild steel against acidic corrosion. RSC Advances, 5 (120), 99084–99094. doi: https://doi.org/10.1039/c5ra15002g
18. Gomelya, N., Trus, I., Stepova, O., Kyryliuk, O., Hlushko, O. (2020). Synthesis of high-effective steel corrosion inhibitors in water-oil mixtures. Eastern-European Journal of Enterprise Technologies, 1 (6 (103)), 6–11. doi: https://doi.org/10.15587/1729-4061.2020.194315

DOI: 10.15587/1729-4061.2020.197875

DEVELOPMENT OF ENVIRONMENTAL FRIENDLY CORROSION INHIBITOR FROM THE EXTRACT OF ARECA FLOWER FOR MILD STEEL IN ACIDIC MEDIA (p. 34–45)

Norman Subekti
Universitas Indonesia, Jawa Barat, Indonesia
ORCID: http://orcid.org/0000-0003-3673-8042

Johny W. Soedarsono
Universitas Indonesia, Jawa Barat, Indonesia
ORCID: http://orcid.org/0000-0001-6051-2866

Rini Riastuti
Universitas Indonesia, Jawa Barat, Indonesia
ORCID: http://orcid.org/0000-0003-3431-0413

Folo Daniel Sianipar
Universitas Indonesia, Jawa Barat, Indonesia
ORCID: http://orcid.org/0000-0003-2173-7565

One of the industries that play a role in supporting the development of the country is the oil and gas industry. In addition, this industry has an influence on the country's economy, so it must be operated as efficiently as possible so as not to produce substantial costs and not have a significant impact on the country's economy. The oil and gas industry is equipped with good supporting equipment that plays an important role in the success of the production process. The most important equipment for the continuity of production is the pipe. Generally, this pipe is made of mild steel and the material commonly used for pipes in the oil and gas industry is API 5L. Corrosion is one of the challenges found in pipes in the oil and gas industry. This is due to aggressive ions such as Cl^- and also the fluid contained in the pipe. The aggressive ions that exist can cause corrosion in the form of pitting corrosion. Corrosion that occurs in pipes in the oil and gas industry must be addressed as efficiently as possible with effective results. Inhibitors are one solution that can provide effective results in reducing corrosion rates. Corrosion rate can be reduced by 99 % or more if the concentration of the inhibitor is appropriately added. Generally, inhibitors that are often used are inorganic inhibitors, where these inhibitors contain chemical compounds that are

harmful to the environment and health. So, currently there are many developed environmentally friendly inhibitors, namely inhibitors produced from plants and fruits. Environmentally friendly inhibitors do not have an impact on environmental pollution because the material from these inhibitors has organic properties. Until now, there have been many studies on environmentally friendly inhibitors carried out on API 5L steel. However, there have been no studies on inhibitors obtained from Areca Flower extract as environmentally friendly inhibitors. Thus, this study was conducted in order to determine the effect of adding environmentally friendly inhibitors on the corrosion behavior of API 5L steel pipes in aggressive environments, namely HCl media. Areca flower extract has been investigated as a green corrosion inhibitor on API 5L Grade B in 1 M HCl acidic solution using Linear polarization and Electrochemical Impedance Spectroscopy (EIS). Additions of 4 ml, 8 ml, 12 ml, 16 ml, and 20 ml of corrosion inhibitors increase the efficiency of the inhibitors. Optimum inhibition efficiency occurs with the addition at a concentration of 20 ml is 96.6 % on Electrochemical Impedance Spectroscopy (EIS) testing. Polyphenolic and flavonoid compounds contained in the areca flower inhibit corrosion by physical adsorption, to form a monolayer which can inhibit corrosion. Adsorption occurs spontaneously in accordance with Langmuir isothermal adsorption. The polarization showed that the areca flower extract acts through mixed-type inhibition. The value of the free energy of −7.026 kJ/mol of adsorption indicated that the adsorption of inhibitor molecules was typical of physical adsorption.

Keywords: Green Inhibitors, Areca Flower, EIS, potentiodynamic polarization, weight loss.

References

1. Mohamed, H., Abd El-Lateef, H. M., Abbasov, V. M., Aliyeva, L. I., Ismayilov, T. A. (2012). Corrosion Protection of Steel Pipelines Against CO_2 Corrosion-A Review. Chemistry Journal, 02 (02), 52–63.
2. Tems, R. D., Al-Zahrani, A. M. (2006). Cost of Corrosion in Gas Sweetening and Fractionation Plants. NACE International.
3. Ludiana, Y., Sri, H. (2012). Effect of Tea Leaf Extract (Camelia sinensis) Inhibition Against Carbon Steel Corrosion Rate Schedule 40 Grade B ERW. Unpad Physics Journal, 1 (1).
4. Rustandi, A., Soedarsono, J. W., Suharno, B. (2011). The Use of Mixture of Piper Betle and Green Tea as a Green Corrosion Inhibitor for API X-52 Steel in Aerated 3.5 % NaCl Solution at Various Rotation Rates. Advanced Materials Research, 383-390, 5418–5425. doi: https://doi.org/10.4028/www.scientific.net/amr.383-390.5418
5. Pramana, R. I., Kusumastuti, R., Soedarsono, J. W., Rustandi, A. (2013). Corrosion Inhibition of Low Carbon Steel by Pluchea Indica Less. in 3.5% NaCL Solution. Advanced Materials Research, 785-786, 20–24. doi: https://doi.org/10.4028/www.scientific.net/amr.785-786.20
6. Ayende, Rustandi, A., Soedarsono, J. W., Priadi, D., Sulistijono, Suprapta, D. N. et. al. (2014). Effects of Purple Sweet Potato Extract Addition in Ascorbic Acid Inhibitor to Corrosion Rate of API 5L Steel in 3.5 % NaCl Environment. Applied Mechanics and Materials, 709, 384–389. doi: https://doi.org/10.4028/www.scientific.net/amm.709.384
7. Kusumastuti, R., Pramana, R. I., Soedarsono, J. W. (2017). The use of morinda citrifolia as a green corrosion inhibitor for low carbon steel in 3.5% NaCl solution. AIP Conference Proceedings. doi: https://doi.org/10.1063/1.4978085
8. Alaneme, K. K., Olusegun, S. J., Alo, A. W. (2016). Corrosion inhibitory properties of elephant grass (Pennisetum purpureum) extract: Effect on mild steel corrosion in 1M HCl solution. Alexandria Engineering Journal, 55 (2), 1069–1076. doi: https://doi.org/10.1016/j.aej.2016.03.012
9. Ji, G., Anjum, S., Sundaram, S., Prakash, R. (2015). Musa paradisica peel extract as green corrosion inhibitor for mild steel in HCl solution. Corrosion Science, 90, 107–117. doi: https://doi.org/10.1016/j.corsci.2014.10.002
10. Singh, A., Singh, V. K., Quraishi, M. A. (2010). Aqueous Extract of Kalmegh (Andrographis paniculata) Leaves as Green Inhibitor for Mild Steel in Hydrochloric Acid Solution. International Journal of Corrosion, 2010, 1–10. doi: https://doi.org/10.1155/2010/275983
11. Ashassi-Sorkhabi, H., Mirzaee, S., Rostamikia, T., Bagheri, R. (2015). Pomegranate (Punica granatum) Peel Extract as a Green Corrosion Inhibitor for Mild Steel in Hydrochloric Acid Solution. International Journal of Corrosion, 2015, 1–6. doi: https://doi.org/10.1155/2015/197587
12. Priyotomo, G., Nuraini, L. (2016). Preliminary studies of the potential of starfruit leaf as a corrosion inhibitor in carbon steel in hydrochloric acid solution. Research Center for Metallurgy & Materials, LIPI. Jurnal.
13. Jaiswal, P., Kumar, P., Singh, V. K., Singh, D. K. (2011). Areca catechu L.: A Valuable Herbal Medicine Against Different Health Problems. Research Journal of Medicinal Plant, 5 (2), 145–152. doi: https://doi.org/10.3923/rjmp.2011.145.152
14. Giri, S., Idle, J. R., Chen, C., Zabriskie, T. M., Krausz, K. W., Gonzalez, F. J. (2006). A Metabolomic Approach to the Metabolism of the Areca Nut Alkaloids Arecoline and Arecaidine in the Mouse. Chemical Research in Toxicology, 19 (6), 818–827. doi: https://doi.org/10.1021/tx0600402
15. Kassim, M. J., Wei, T. K. (2012). Plants Polyphenols: An Alternative Source for Green Corrosion Inhibitor. The Proceedings of 2nd Annual International Conference Syiah Kuala University.
16. Regha, A. (2010). Flavonoids: Structure, antioxidant properties and their role in biological systems. Journal Belian, 9, 196–202.
17. Sastri, V. S. (2011). Green Corrosion Inhibitor: Theory and Practice. John Wiley & Sons. doi: https://doi.org/10.1002/9781118015438
18. Adejo, S., Gbertyo, J. A., Ahile, J. U. (2013). Inhibitive properties and adsorption consideration of ethanol extract of Manihot Esceletum leaves for corrosion inhibition of alumunium in 2 M H_2SO_4. International Journal of Modern Chemistry, 4 (3), 137–146.
19. Ahmad, Z. (2006). Principles of Corrosion Engineering and Corrosion Control. Elsevier. doi: https://doi.org/10.1016/b978-0-7506-5924-6.x5000-4
20. Acharya, M., Chouhan, J. S., Dixit, A., Gupta, D. K. (2013), Green Inhibitors for Prevention of Metal and Alloys Corrosion: An Overview. Chemistry and Materials Research, 3 (6), 16–24.
21. Aribo, S., Olusegun, S. J., Ibhadiyi, L. J., Oyetunji, A., Folorunso, D. O. (2017). Green inhibitors for corrosion protection in acidizing oilfield environment. Journal of the Association of Arab Universities for Basic and Applied Sciences, 24 (1), 34–38. doi: https://doi.org/10.1016/j.jaubas.2016.08.001
22. Rocha, J. C. da, Gomes, J. A. da C. P., D'Elia, E. (2014). Aqueous extracts of mango and orange peel as green inhibitors for carbon steel in hydrochloric acid solution. Materials Research, 17 (6), 1581–1587. doi: https://doi.org/10.1590/1516-1439.285014
23. Abboud, Y., Chagraoui, A., Tanane, O., El Bouari, A., Hannache, H. (2013). Punica granatum leave extract as green corrosion inhibitor for mild steel in Hydrochloric acid. MATEC Web of Conferences, 5, 04029. doi: https://doi.org/10.1051/matecconf/20130504029
24. Yaro, A. S., Talib, K. F. (2014). Corrosion Inhibition of Mild Steel by Curcuma Extract in Petroleum Refinery Wastewater. Iraqi Journal of Chemical and Petroleum Engineering, 15 (3), 9–18.
25. Soltani, N., Khayatkashani, M. (2015). Gundelia tournefortii as a Green Corrosion Inhibitor for Mild Steel in HCl and H2SO4 Solutions. International Journal of Electrochemical Science, 10, 46–62.
26. Arlan, A. S., Subekti, N., Soedarsono, J. W., Rustandi, A. (2018). Corrosion Inhibition by a Caesalpinia Sappan L Modified Imidazoline

for Carbon Steel API 5L Grade X60 in HCl 1M Environment. Materials Science Forum, 929, 158–170. doi: https://doi.org/10.4028/www.scientific.net/msf.929.158
27. Deepaa, C. V., Vasudha, V. G., Sathiyapriya, T. (2011). Caesalpinia Pulcherrima as Corrosion Inhibitor for Mild Steel in Acid Medium. Asian Journal of Research in Chemistry, 4 (5), 722–725.
28. Safitri, R. (2002). Characteristics of Antioxidant Properties in vitro Some Compounds contained in Secang Plants (Caesalpinia sappan L.).
29. Rina, O. (2012). The Effectiveness of Secang (Caesalpinia Sappan L.) Wood Extract as a Meat Preservative. Journal Penelitian Pertanian Terapan, 12 (3), 181–186.
30. Zanin, J. L. B., de Carvalho, B. A., Salles Martineli, P., dos Santos, M. H., Lago, J. H. G., Sartorelli, P. et. al. (2012). The Genus Caesalpinia L. (Caesalpiniaceae): Phytochemical and Pharmacological Characteristics. Molecules, 17 (7), 7887–7902. doi: https://doi.org/10.3390/molecules17077887
31. Nagai, M., Nagumo, S., Eguchi, I., Lee, S., Suzuki, T. (1984). Sappanchalcone from Caesalpinia sappan L., the Proposed Biosynthetic Precursor of Brazilin. Yakugaku Zasshi, 104 (9), 935–938. doi: https://doi.org/10.1248/yakushi1947.104.9_935
32. Fouda, A. S. et. al. (2014). Chalcone Derivatives as Corrosion Inhibitors for Carbon Steel in 1 M HCl Solutions. International Journal of Electrochemical Science, 9, 7038–7058.
33. Ahmed, S. I., Hayat, M. Q., Tahir, M., Mansoor, Q., Ismail, M., Keck, K., Bates, R. B. (2016). Pharmacologically active flavonoids from the anticancer, antioxidant and antimicrobial extracts of Cassia angustifolia Vahl. BMC Complementary and Alternative Medicine, 16 (1). doi: https://doi.org/10.1186/s12906-016-1443-z
34. Hättenschwiler, S., Vitousek, P. M. (2000). The role of polyphenols in terrestrial ecosystem nutrient cycling. Trends in Ecology & Evolution, 15 (6), 238–243. doi: https://doi.org/10.1016/s0169-5347(00)01861-9
35. Prabakaran, M., Kim, S.-H., Hemapriya, V., Chung, I.-M. (2016). Evaluation of polyphenol composition and anti-corrosion properties of Cryptostegia grandiflora plant extract on mild steel in acidic medium. Journal of Industrial and Engineering Chemistry, 37, 47–56. doi: https://doi.org/10.1016/j.jiec.2016.03.006
36. Kayadoe, V., Turalely, R. (2016). Nipah leaf extract as SS-304 steel corrosion inhibitor in H_2SO_4 solution, 99–105.
37. De Souza, F. S., Spinelli, A. (2009). Caffeic acid as a green corrosion inhibitor for mild steel. Corrosion Science, 51 (3), 642–649. doi: https://doi.org/10.1016/j.corsci.2008.12.013
38. López, D. A., Pérez, T., Simison, S. N. (2003). The influence of microstructure and chemical composition of carbon and low alloy steels in CO_2 corrosion. A state-of-the-art appraisal. Materials & Design, 24 (8), 561–575. doi: https://doi.org/10.1016/s0261-3069(03)00158-4
39. Noor, E. A., Al-Moubaraki, A. H. (2008). Corrosion Behavior of Mild Steel in Hydrochloric Acid Solutions. International Journal of Electrochemical Science, 3, 806–818.
40. Introduction to Fourier Transform Infrared Spectroscopy (2001). Thermo Nicolet.
41. Mejeha, I. M., Uroh, A. A., Okeoma, K. B., Alozie, G. A. (2010). The inhibitive effect of Solanum melongena L. leaf extract on the corrosion of aluminium in tetraoxosulphate (VI) acid. African Journal of Pure and Applied Chemistry, 4 (8), 158–165.
42. Rajendran, S., Agasta, M., Devi, R. B., Devi, B. S., Raja, K., Jeyasundari, J. (2009). Corrosion inhibition by an aqueous extract of henna leaves (Lawsonia Inermis L). Zastita Materijala, 50, 77–84.
43. Steenkamp, P. A. (2005). Chemical Analysis of Medicinal and Poisonous Plants of Forensic Importance in South Africa. University of Johannesburg.
44. Raghavendra, N., Ishwara Bhat, J. (2019). Inhibition of Al corrosion in 0.5 M HCl solution by Areca flower extract. Journal of King Saud University – Engineering Sciences, 31 (3), 202–208. doi: https://doi.org/10.1016/j.jksues.2017.06.003
45. Muthukrishnan, P., Prakash, P., Jeyaprabha, B., Shankar, K. (2019). Stigmasterol extracted from Ficus hispida leaves as a green inhibitor for the mild steel corrosion in 1 M HCl solution. Arabian Journal of Chemistry, 12 (8), 3345–3356. doi: https://doi.org/10.1016/j.arabjc.2015.09.005
46. Kissi, M., Bouklah, M., Hammouti, B., Benkaddour, M. (2006). Establishment of equivalent circuits from electrochemical impedance spectroscopy study of corrosion inhibition of steel by pyrazine in sulphuric acidic solution. Applied Surface Science, 252 (12), 4190–4197. doi: https://doi.org/10.1016/j.apsusc.2005.06.035
47. Khaled, K. F. (2008). Application of electrochemical frequency modulation for monitoring corrosion and corrosion inhibition of iron by some indole derivatives in molar hydrochloric acid. Materials Chemistry and Physics, 112 (1), 290–300. doi: https://doi.org/10.1016/j.matchemphys.2008.05.056
48. Singh, A., Ebenso, E. E., Quraishi, M. A. (2012). Corrosion Inhibition of Carbon Steel in HCl Solution by Some Plant Extracts. International Journal of Corrosion, 2012, 1–20. doi: https://doi.org/10.1155/2012/897430
49. Benali, O., Selles, C., Salghi, R. (2012). Inhibition of acid corrosion of mild steel by Anacyclus pyrethrum L. extracts. Research on Chemical Intermediates, 40 (1), 259–268. doi: https://doi.org/10.1007/s11164-012-0960-8
50. Jebakumar Immanuel Edison, T., Sethuraman, M. G. (2013). Electrochemical Investigation on Adsorption of Fluconazole at Mild Steel/HCl Acid Interface as Corrosion Inhibitor. ISRN Electrochemistry, 2013, 1–8. doi: https://doi.org/10.1155/2013/256086
51. Behpour, M., Ghoreishi, S. M., Khayatkashani, M., Soltani, N. (2012). Green approach to corrosion inhibition of mild steel in two acidic solutions by the extract of Punica granatum peel and main constituents. Materials Chemistry and Physics, 131 (3), 621–633. doi: https://doi.org/10.1016/j.matchemphys.2011.10.027
52. Adamson, A. W. (1990). Physical Chemistry of Surfaces. John Wiley & Sons, 777.
53. Satapathy, A. K., Gunasekaran, G., Sahoo, S. C., Amit, K., Rodrigues, P. V. (2009). Corrosion inhibition by Justicia gendarussa plant extract in hydrochloric acid solution. Corrosion Science, 51 (12), 2848–2856. doi: https://doi.org/10.1016/j.corsci.2009.08.016

DOI: 10.15587/1729-4061.2020.198308

ADDITION OF BIO-ADDITIVE AS A CATALYST OF BURNING VEGETABLE OIL INFLUENCED BY 4 POLE MAGNETIC FIELD (p. 46–55)

Gatot Soebiyakto
Brawijaya University, Malang, Indonesia
Universitas Widyagama, Malang, Jawa Timur, Indonesia
ORCID: http://orcid.org/0000-0002-6046-9666

I. N. G. Wardana
Brawijaya University, Malang, Indonesia
ORCID: http://orcid.org/0000-0003-3146-9517

Nurkholis Hamidi
Brawijaya University, Malang, Indonesia
ORCID: http://orcid.org/0000-0003-2910-2353

Lilis Yuliati
Brawijaya University, Malang, Indonesia

The application of the combustion process influenced by magnetic circle 4 poles sequentially (N-S-N-S) against premixed combustion of vegetable-aromatic oil at an equivalence ratio approaching stoichiometry is studied. The reactant reaction causes the heat

transfer to be characterized by the increase in temperature and has the main strength that combines the metal atoms due to the interesting pull (N-S) and (S-N) causing the electrons to move freely due to energy electron. Electron interaction induces the separation of atoms from the reactants, followed by atomisation and fuel transfer into a droplet and then collisions into a smaller droplet, smoother and isolated forming cellular-cellular APIs. The results of the study reported that the magnetic field makes a premixed combustion reaction more intense as the magnetic field makes the spin of the electron and the proton hydrogen become more energetic. More energetic electrons and protons are more actively changing the structure of carbon bonds in saturated and unsaturated fatty acids, both long and short chains. Long-chain saturated fatty acids and polar forms are more active than short and straight because they have a stronger polarity and a more free electron movement. Magnetic field administration makes fire more reactive, faster in the vines, because paramagnetic O_2 is emitted more across the fire from the South Pole (S) to the North (N) while the heat carried by H_2O that is diamagnetic is emitted more across the fire from the North Pole (N) to the South (S). This event occurs in the shift of magnetic coil U and S. Consequently, in the area of switching, there is the formation of cellular-cellular fire and the growth of radius equivalence.

Keywords: vegetable oil, magnetic field, air-fuel comparison, triglycerides, geometry optimization, magnetic line direction, bio-additives.

References

1. Wardana, I. N. G. (2010). Combustion characteristics of jatropha oil droplet at various oil temperatures. Fuel, 89 (3), 659–664. doi: https://doi.org/10.1016/j.fuel.2009.07.002
2. Morin, C., Chauveau, C., Gökalp, I. (2000). Droplet vaporisation characteristics of vegetable oil derived biofuels at high temperatures. Experimental Thermal and Fluid Science, 21 (1-3), 41–50. doi: https://doi.org/10.1016/s0894-1777(99)00052-7
3. Jin, W., Wang, J., Yu, S., Nie, Y., Xie, Y., Huang, Z. (2015). Cellular instabilities of non-adiabatic laminar flat methane/hydrogen oxy-fuel flames highly diluted with CO2. Fuel, 143, 38–46. doi: https://doi.org/10.1016/j.fuel.2014.11.036
4. Saroso, H., Wardana, I., Soenoko, R., Hamidi, N. (2013). Burning characteristics of coconut oil vapor-air mixtures at premixed combustion. Advanced Studies in Theoretical Physics, 7, 941–956. doi: https://doi.org/10.12988/astp.2013.3884
5. Galle, J., Defruyt, S., Van de Maele, C., Rodriguez, R. P., Denon, Q., Verliefde, A., Verhelst, S. (2013). Experimental investigation concerning the influence of fuel type and properties on the injection and atomization of liquid biofuels in an optical combustion chamber. Biomass and Bioenergy, 57, 215–228. doi: https://doi.org/10.1016/j.biombioe.2013.07.004
6. Basco, A., Cammarota, F., Di Benedetto, A., Di Sarli, V., Salzano, E., Russo, G. (2012). Experimental and numerical analysis of laminar burning velocity of binary and ternary hydrocarbon/H_2 mixtures. Chemical Engineering Transactions, 26, 381–386. doi: http://doi.org/10.3303/CET1226064
7. Rakopoulos, D. C. (2013). Combustion and emissions of cottonseed oil and its bio-diesel in blends with either n-butanol or diethyl ether in HSDI diesel engine. Fuel, 105, 603–613. doi: https://doi.org/10.1016/j.fuel.2012.08.023
8. Suarta, I. M., Wardana, I. N. G., Hamidi, N., Wijayanti, W. (2016). The Role of Molecule Clustering by Hydrogen Bond in Hydrous Ethanol on Laminar Burning Velocity. Journal of Combustion, 2016, 1–9. doi: https://doi.org/10.1155/2016/5127682
9. Suarta, I. M., Wardana, I. N. G., Hamidi, N., Wijayanti, W. (2016). The Role of Hydrogen Bonding on Laminar Burning Velocity of Hydrous and Anhydrous Ethanol Fuel with Small Addition of n-Heptane. Journal of Combustion, 2016, 1–8. doi: https://doi.org/10.1155/2016/9093428
10. Jocher, A., Pitsch, H., Gomez, T., Bonnety, J., Legros, G. (2015). Impact of magnetic fields on the stability of non-premixed flames. Proceedings of the European Combustion Meeting 2015.
11. Yu, J. F., Yu, R., Fan, X. Q., Christensen, M., Konnov, A. A., Bai, X. S. (2013). Onset of cellular flame instability in adiabatic $CH_4/O_2/CO_2$ and CH_4/air laminar premixed flames stabilized on a flat-flame burner. Combustion and Flame, 160 (7), 1276–1286. doi: https://doi.org/10.1016/j.combustflame.2013.02.011
12. Ratna Kishore, V., Ravi, M. R., Ray, A. (2011). Adiabatic burning velocity and cellular flame characteristics of H_2-CO-CO_2-air mixtures. Combustion and Flame, 158 (11), 2149–2164. doi: https://doi.org/10.1016/j.combustflame.2011.03.018
13. Wada, Y., Kuwana, K. (2013). A numerical method to predict flame fractal dimension during gas explosion. Journal of Loss Prevention in the Process Industries, 26 (2), 392–395. doi: https://doi.org/10.1016/j.jlp.2011.11.006
14. Kaewpradap, A., Pimtawong, T., Tongtrong, P., Jugjai, S., Kadowaki, S. (2014). Study of the characteristics of cellular premixed flames on ceramic porous board for CH4/C2H6/co2 mixtures. Proc. 2014 Int. Conf. Util. Exhib. Green Energy Sustain. Dev. ICUE 2014.
15. Wu, F., Jomaas, G., Law, C. K. (2013). An experimental investigation on self-acceleration of cellular spherical flames. Proceedings of the Combustion Institute, 34 (1), 937–945. doi: https://doi.org/10.1016/j.proci.2012.05.068
16. Hinton, N., Stone, R. (2014). Laminar burning velocity measurements of methane and carbon dioxide mixtures (biogas) over wide ranging temperatures and pressures. Fuel, 116, 743–750. doi: https://doi.org/10.1016/j.fuel.2013.08.069
17. Xie, Y., Wang, J., Zhang, M., Gong, J., Jin, W., Huang, Z. (2013). Experimental and Numerical Study on Laminar Flame Characteristics of Methane Oxy-fuel Mixtures Highly Diluted with CO_2. Energy & Fuels, 27 (10), 6231–6237. doi: https://doi.org/10.1021/ef401220h
18. Kim, W. K., Mogi, T., Dobashi, R. (2014). Effect of propagation behaviour of expanding spherical flames on the blast wave generated during unconfined gas explosions. Fuel, 128, 396–403. doi: https://doi.org/10.1016/j.fuel.2014.02.062
19. Kurdyumov, V. N., Sánchez-Sanz, M. (2013). Influence of radiation losses on the stability of premixed flames on a porous-plug burner. Proceedings of the Combustion Institute, 34 (1), 989–996. doi: https://doi.org/10.1016/j.proci.2012.06.039
20. Kadarohman, A., Khoerunisa, F., Astuti, R. M. (2010). A potential study on clove oil, eugenol and eugenyl acetate as diesel fuel bio-additives and their performance on one cylinder engine. Transport, 25 (1), 66–76. doi: https://doi.org/10.1016/j.fuel.2012.03.037
21. Rahman, S. M. A., Van, T. C., Hossain, F. M., Jafari, M., Dowell, A., Islam, M. A. et. al. (2019). Fuel properties and emission characteristics of essential oil blends in a compression ignition engine. Fuel, 238, 440–453. doi: https://doi.org/10.1016/j.fuel.2018.10.136
22. Negm, N. A., Rabie, A. M., Mohammed, E. A. (2018). Molecular interaction of heterogeneous catalyst in catalytic cracking process of vegetable oils: chromatographic and biofuel performance investigation. Applied Catalysis B: Environmental, 239, 36–45. doi: https://doi.org/10.1016/j.apcatb.2018.07.070
23. Marlina, E., Wijayanti, W., Yuliati, L., Wardana, I. N. G. (2020). The role of pole and molecular geometry of fatty acids in vegetable oils droplet on ignition and boiling characteristics. Renewable Energy, 145, 596–603. doi: https://doi.org/10.1016/j.renene.2019.06.064
24. Nanlohy, H. Y., Wardana, I. N. G., Hamidi, N., Yuliati, L., Ueda, T. (2018). The effect of Rh3+ catalyst on the combustion characteristics of crude vegetable oil droplets. Fuel, 220, 220–232. doi: https://doi.org/10.1016/j.fuel.2018.02.001

DOI: 10.15587/1729-4061.2020.201689

DEVELOPMENT AND RESEARCH OF A LABEL CASEINE ADHESIVE FOR PACKAGING THE INDUSTRIAL AND HOUSEHOLD PRODUCTS (p. 56–66)

Anna Cherkashina
National Technical University «Kharkiv Polytechnic Institute», Kharkiv, Ukraine
ORCID: http://orcid.org/0000-0002-5239-6364

Alexii Rassokha
National Technical University «Kharkiv Polytechnic Institute», Kharkiv, Ukraine
ORCID: http://orcid.org/0000-0001-7944-7187

Igor Ryshchenko
National Technical University «Kharkiv Polytechnic Institute», Kharkiv, Ukraine
ORCID: http://orcid.org/0000-0001-9859-4510

Olga Komarova
National Technical University «Kharkiv Polytechnic Institute», Kharkiv, Ukraine
ORCID: http://orcid.org/0000-0001-7957-600x

A new composition of the environmentally friendly water-based casein adhesive glue with the increased adhesion to the substrate (glass, polyethylene terephthalate, etc.) and the improved water resistance has been developed and explored. The glue is easily washed away when labeling products that are packaged in reusable containers, but, at the same time, possesses high adhesion to different surfaces. The optimal formulation for the developed glue adhesive composition based on casein has been determined with the help of the investigated properties. The effect of the amount of a modifying additive on the dynamic viscosity at different deformation rates, the stickiness of the adhesive composition, and the hydrogen ions index (pH) has been studied.

Such technological properties of the glue adhesive composition were investigated as viscosity – 170 Pa·s; pH – 7.21; the mass share of dry residue – 38.2 %; stickiness – 58.17 a. u.; working temperature – +20...+25 °C.

The optimal technological parameters for using the glue have been defined: optimal viscosity, from 130 Pa·s to 170 Pa·s; temperature, 25 °C, and 35 °C, respectively. The adhesive strength between a paper label and glass is 4 points, polyethylene terephthalate – 3 points. The operation properties were assessed based on the resistance of the glue adhesive composition against changes in temperature and environmental conditions, humidity, and mechanical impact.

The requirements for the glue adhesive have been stated that are to be taken into consideration in its operation: resistance against the condensed and icy water and the ability of the label to be removed from the surface of the container in a washing machine at a temperature of 70–80 °C.

The glue adhesive composition was examined by a SAB Miller method to assess its quality during an ice water resistance test. A copy paper method was used to assess the label gluing quality. The requirements for the glue adhesive have been defined, which should be taken into consideration in its operation (the resistance against the condensed and icy water and the removal of a label in a washing machine at a temperature of 70–80 °C with the addition of NaOH or surface-active substances).

Keywords: glue adhesive composition, casein, modifying additive, stickiness, adhesive strength, water resistance, properties.

References

1. Dymar, O. V., Chaevskiy, S. I. (2007). Proizvodstvo kazeina: osnovy teorii i praktiki. Minsk: RUP «Institut myaso-molochnoy promyshlennosti», 70.
2. Lagrange, V., Whitsett, D., Burris, C. (2015). Global Market for Dairy Proteins. Journal of Food Science, 80 (S1), A16–A22. doi: https://doi.org/10.1111/1750-3841.12801
3. Sarode, A. R., Sawale, P. D., Khedkar, C. D., Kalyankar, S. D., Pawshe, R. D. (2016). Casein and Caseinate: Methods of Manufacture. Encyclopedia of Food and Health, 676–682. doi: https://doi.org/10.1016/b978-0-12-384947-2.00122-7
4. Ann Augustin, M., Oliver, C. M., Hemar, Y. (2011). Casein, Caseinates, and Milk Protein Concentrates. Dairy Ingredients for Food Processing, 161–178. doi: https://doi.org/10.1002/9780470959169.ch7
5. Freydin, A. S. (1985). Polimernye vodnye klei. Moscow: Himiya, 143.
6. Parker, E. A., Martsinko, D. Dzh. (2015). Pat. No. 2558365C2 RU. Emulsions and adhesives containing proteins, producing and using them. 2011140481/04; declareted: 08.03.2010; published: 10.08.2015, Bul. No. 22.
7. Guo, M., Wang, G. (2016). Whey protein polymerisation and its applications in environmentally safe adhesives. International Journal of Dairy Technology, 69 (4), 481–488. doi: https://doi.org/10.1111/1471-0307.12303
8. Zhao, Z., Gao, Z., Wang, W., Guo, M. (2011). Formulation designs and characterisations of whey-protein based API adhesives. Pigment & Resin Technology, 40 (6), 410–417. doi: https://doi.org/10.1108/03699421111180563
9. Chop, A. S., Cherkashina, G. M., Rassoha, O. M. (2018). Akrilova kleyova kompozitsiya z postiynoyu lipkistyu. The 8th International conference – Science and society. Hamilton, 373–384.
10. Cherkashina, G. M., Rasoshka, O. M., Titarenko, V. M. (2018). Development and research of environmental and energy safety climbing for the outlet industry. Intehrovani tekhnolohiyi ta enerhozberezhennia, 4, 11–18.
11. Rassokha, A., Cherkashina, A. (2016). Designing low viscosity furan-epoxy polymers of the materials for construction industry. Eastern-European Journal of Enterprise Technologies, 3 (6 (81)), 38–44. doi: https://doi.org/10.15587/1729-4061.2016.71266
12. Nascimento, L. G. L., Casanova, F., Silva, N. F. N., Teixeira, A. V. N. de C., Carvalho, A. F. de. (2020). Casein-based hydrogels: A mini-review. Food Chemistry, 314, 126063. doi: https://doi.org/10.1016/j.foodchem.2019.126063
13. Schulte, J., Stöckermann, M., Gebhardt, R. (2020). Influence of pH on the stability and structure of single casein microparticles. Food Hydrocolloids, 105, 105741. doi: https://doi.org/10.1016/j.foodhyd.2020.105741
14. Li, N., Zhong, Q. (2020). Casein core-polysaccharide shell nanocomplexes stable at pH 4.5 enabled by chelating and complexation properties of dextran sulfate. Food Hydrocolloids, 103, 105723. doi: https://doi.org/10.1016/j.foodhyd.2020.105723
15. Meena, G. S., Singh, A. K., Panjagari, N. R., Arora, S. (2017). Milk protein concentrates: opportunities and challenges. Journal of Food Science and Technology, 54 (10), 3010–3024. doi: https://doi.org/10.1007/s13197-017-2796-0
16. Gao, Z., Wang, W., Zhao, Z., Guo, M. (2010). Novel whey protein-based aqueous polymer-isocyanate adhesive for glulam. Journal of Applied Polymer Science, 120 (1), 220–225. doi: https://doi.org/10.1002/app.33025
17. Wang, W., Zhao, Z., Gao, Z., Guo, M. (2012). Water-resistant whey protein based wood adhesive modified by post-treated phenol-formaldehyde oligomers (PFO). BioResources, 7 (2), 1972–1983. doi: https://doi.org/10.15376/biores.7.2.1972-1983
18. Wang, G., Zhang, T., Ahmad, S., Cheng, J., Guo, M. (2013). Physico-chemical and adhesive properties, microstructure and storage

stability of whey protein-based paper glue. International Journal of Adhesion and Adhesives, 41, 198–205. doi: https://doi.org/10.1016/j.ijadhadh.2012.11.010

19. Gao, Z., Yu, G., Bao, Y., Guo, M. (2011). Whey-protein based environmentally friendly wood adhesives. Pigment & Resin Technology, 40 (1), 42–48. doi: https://doi.org/10.1108/03699421111095937
20. Wang, W., Zhao, Z., Gao, Z., Guo, M. (2011). Whey protein-based water resistant and environmentally safe adhesives for plywood. BioResources, 6 (3), 3339–3351.
21. Valishina, Z. T., Matuhin, E. L., Yarullin, R. N. (1997). Pat. No. 2133763 RU. Kley vodorastvorimiy dlya pishchevoy promyshlennosti. declareted: 13.01.1997; published: 27.07.1999.
22. Meiqi, J. (2017). Pat. No. CN 107722878 A. Ecological beer labeling glue and method for its manufacture. declareted: 31.10.2017; published: 23.02.2018.
23. Guo, M., Wang, G. (2016). Milk Protein Polymer and Its Application in Environmentally Safe Adhesives. Polymers, 8 (9), 324. doi: https://doi.org/10.3390/polym8090324
24. Younes, E. (2017). Structural Properties of Casein Micelles in Milk, the effect of salt, temperature, and pH. International Journal of Biotechnology and Bioengineering, 3 (6), 202–215. doi: https://doi.org/10.25141/2475-3432-2017-6.0202
25. Xiao-Zhou, S., Hong-Ru, W., Mian, H. (2014). Characterization of the Casein/Keratin Self-Assembly Nanomicelles. Journal of Nanomaterials, 2014, 1–7. doi: https://doi.org/10.1155/2014/183815
26. Pat. No. CN 100381532 C. Dry powder casein gum, its production process and its use method (2004). declareted: 13.07.2004; published: 16.04.2008.
27. Pat. No. CN 1560170 A. Preparation process of adhesive for high-speed machanical labeling (2004). declareted: 19.02.2004; published: 05.01.2005.
28. CN 102618192 A. Nano-modified water-based environmentally-friendly labeling adhesive with strong water resistance and alkali cleaning and preparation method. declareted: 26.03.2004; published: 01.08.2012.
29. Luo, J., Luo, J., Yuan, C., Zhang, W., Li, J., Gao, Q., Chen, H. (2015). An eco-friendly wood adhesive from soy protein and lignin: performance properties. RSC Advances, 5 (122), 100849–100855. doi: https://doi.org/10.1039/c5ra19232c
30. Yang, M., Jin, Q., Zhang, G. (2015). Pat. No. CN 104531059 A. Natural Environment-Friendly Modified Casein Glue and Preparation Process Thereof. declareted: 24.12.2014; published: 22.04.2015.
31. Pat. No. CN 1587336 A. Dry powder casein glue and its producing process. declareted: 13.07.2004; published: 02.03.2005.
32. CN 1314773 C. Method for preparing water-resistant high-speed labeling adhesive by compounding casein and montmorillonite intercalation. declareted: 07.04.2005; published: 09.05.2007.
33. Valishina, Z. T., Jarullin, R. N., Golubev, A. E. (2000). Pat. No. 2219214 C2 RU. Modified glue composition. No. 2000111830/04; declareted: 15.05.2000; published: 20.12.2003.
34. Valishina, Z. T., Jarullin, R. N., Gazizov, F. F. (1999). Pat. No. 2172757 C2 RU. Adheive composition. No. 99119426/04; declareted: 03.09.1999; published: 27.08.2001.
35. Kumylko, S. V., Zadorozhnyi, L. Ya., Avramenko, V. L., Blyzniuk, O. V., Kumylko, S. V., Dimov, B. P., Protsenko, O. P. (1998). Pat. No. 22742 UA. Vodnyi kazeinovyi klei. published: 07.04.1998.
36. Pidhorna, L. P., Cherkashyna, H. M., Lebediev, V. V. (2012). Teoriya ta metody doslidzhennia i vyprobuvannia plastmas, kleiv i hermetykiv. Kharkiv: NTU «KhPI», 268.