Document details

‹ Back to results | 1 of 1

Export Download Print E-mail Save to PDF Add to List More... ›

Full Text View at Publisher

Current Opinion in Green and Sustainable Chemistry
Volume 27, February 2021, Article number 100406

Facilitating enzymatic reactions by using ionic liquids: A mini review

(Review) (Open Access)

Elgharbawy, A.A.M.[a,b], Moniruzzaman, M.[c,d], Goto, M.[e,f]

[a]International Institute for Halal Research and Training (INHART), International Islamic University Malaysia (IIUM), Gombak, Selangor, 53100, Malaysia
[b]Nanoscience and Nanotechnology Research Group (NNRG), Kulliyyah of Engineering, IIUM, Malaysia
[c]Chemical Engineering Department, Universiti Teknologi PETRONAS, Seri Iskandar, 32610, Malaysia

View additional affiliations

Abstract

View references (55)

Over the past two decades, ionic liquids (ILs) have been widely used for enzymatic conversions of substrates — especially substrates that are insoluble in common organic solvents and water — resulting in high conversion rates, high selectivity, and improved enzyme stability, wherein the ILs are recoverable and recyclable. Compared with performance in first-generation ILs, researchers recently considerably improved the technological utility of enzymes in second- and third-generation ILs composed of enzyme-benign cations and anions. Use of upgraded ILs with enzymes offers further improved activity and stability compared with research studies in the past decade, rendering IL-assisted biocatalytic processes more environmentally and economically attractive. This short review briefly presents recent developments of enzymatic reactions in ILs. The review covers approaches for and modifications of enzymes and ILs within the past 2 years for improved enzymes performance in ILs. © 2020 Elsevier B.V.

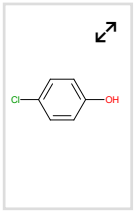
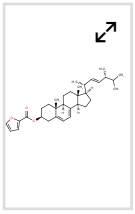
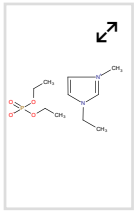
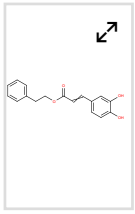
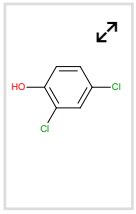
SciVal Topic Prominence

Topic: Ionic Liquids | Triacylglycerol Lipase | 1-butyl-3-methylimidazolium Chloride

Prominence percentile: 93.217

Chemistry database information

Substances View all substances (7)

ISSN: 24522236
Source Type: Journal
Original language: English
DOI: 10.1016/j.cogsc.2020.100406
Document Type: Review
Publisher: Elsevier B.V.

References (55)

View in search results format ›

All Export Print E-mail Save to PDF Create bibliography

1 Elgharbawy, A.A.M., Moniruzzaman, M., Goto, M.
Recent advances of enzymatic reactions in ionic liquids: Part II

(2020) *Biochemical Engineering Journal*, 154, art. no. 107426. Cited 12 times.
www.elsevier.com/locate/bej
doi: 10.1016/j.bej.2019.107426

View at Publisher

2 Schindl, A., Hagen, M.L., Muzammal, S., Gunasekera, H.A.D., Croft, A.K.
Proteins in ionic liquids: Reactions, applications, and futures (Open Access)

(2019) *Frontiers in Chemistry*, 7 (MAY), art. no. 347. Cited 26 times.
https://doi.org/10.3389/fchem.2019.00347
doi: 10.3389/fchem.2019.00347

View at Publisher

3 Nasirpour, N., Mohammadpourfard, M., Zeinali Heris, S.
Ionic liquids: Promising compounds for sustainable chemical processes and applications

(2020) *Chemical Engineering Research and Design*, 160, pp. 264-300. Cited 13 times.
http://www.elsevier.com/wps/find/journaldescription.cws_home/713871/description#description
doi: 10.1016/j.cherd.2020.06.006

View at Publisher

4 Zappi, D., Gabriele, S., Gontrani, L., Dini, D., Sadun, C., Marini, F., Antonelli, M.L.
Biologically friendly room temperature ionic liquids and nanomaterials for the development of innovative enzymatic biosensors: Part II (Open Access)

(2019) *Talanta*, 194, pp. 26-31. Cited 14 times.
https://www.journals.elsevier.com/talanta
doi: 10.1016/j.talanta.2018.10.001

View at Publisher

5 Singh, S.K., Savoy, A.W.
Ionic liquids synthesis and applications: An overview

(2020) *Journal of Molecular Liquids*, 297, art. no. 112038. Cited 80 times.
https://www.journals.elsevier.com/journal-of-molecular-liquids
doi: 10.1016/j.molliq.2019.112038

View at Publisher

6 Sivapragasam, M., Moniruzzaman, M., Goto, M.
An Overview on the Toxicological Properties of Ionic Liquids toward Microorganisms

(2020) *Biotechnology Journal*, 15 (4), art. no. 1900073. Cited 12 times.
http://onlinelibrary.wiley.com/journal/10.1002/(ISSN)1860-7314
doi: 10.1002/biot.201900073

View at Publisher

7 Umeda, K., Kobayashi, K., Minato, T., Yamada, H.
Atomic-Scale Three-Dimensional Local Solvation Structures of Ionic Liquids

(2020) *Journal of Physical Chemistry Letters*, 11 (4), pp. 1343-1348. Cited 6 times.
http://pubs.acs.org/journal/jpclcd
doi: 10.1021/acs.jpclett.9b03874

View at Publisher

8 Almeida, H.F.D., Neves, M.C., Trindade, T., Marrucho, I.M., Freire, M.G.

Supported ionic liquids as efficient materials to remove non-steroidal anti-inflammatory drugs from aqueous media (Open Access)

(2020) *Chemical Engineering Journal*, 381, art. no. 122616. Cited 10 times.
www.elsevier.com/inca/publications/store/6/0/1/2/7/3/index.htt
doi: 10.1016/j.cej.2019.122616

View at Publisher

9 Priyanka, V.P., Gardas, R.L.

Mono- and di- cationic ionic liquids based aqueous biphasic systems for the extraction of diclofenac sodium (Open Access)

(2020) *Separation and Purification Technology*, 234, art. no. 116048. Cited 14 times.
http://www.journals.elsevier.com/separation-and-purification-technology/
doi: 10.1016/j.seppur.2019.116048

View at Publisher

10 Moshikur, R.M., Chowdhury, M.R., Wakabayashi, R., Tahara, Y., Moniruzzaman, M., Goto, M.

Ionic liquids with methotrexate moieties as a potential anticancer prodrug: Synthesis, characterization and solubility evaluation

(2019) *Journal of Molecular Liquids*, 278, pp. 226-233. Cited 19 times.
doi: 10.1016/j.molliq.2019.01.063

View at Publisher

11 Bisht, M., Jha, I., Venkatesu, P.

Does choline-based amino acid ionic liquid behave as a biocompatible solvent for stem bromelain structure?

(2018) *Process Biochemistry*, 74, pp. 77-85. Cited 9 times.
www.elsevier.com/inca/publications/store/4/2/2/8/5/7
doi: 10.1016/j.procbio.2018.07.005

View at Publisher

12 Barbosa, M.S., Freire, C.C.C., Souza, R.L., Cabrera-Padilla, R.Y., Pereira, M.M., Freire, M.G., Lima, Á.S., (...), Soares, C.M.F.

Effects of phosphonium-based ionic liquids on the lipase activity evaluated by experimental results and molecular docking

(2019) *Biotechnology Progress*, 35 (4), art. no. e2816. Cited 7 times.
http://onlinelibrary.wiley.com/journal/10.1021/(ISSN)1520-6033
doi: 10.1002/btpr.2816

View at Publisher

13 Yang, W., Zhou, M., Yan, L., Ju, X., Li, L.

Diversity of Paenibacillus sp. LLZ1 cellulase and its improved enzyme activity and stability in the Ionic Liquid 1-Ethyl-3-methylimidazolium diethyl phosphate

(2019) *BioResources*, 14 (2), pp. 3132-3145. Cited 4 times.
http://www.ncsu.edu/bioresources/Back_Issues.htm
doi: 10.15376/biores.14.2.3132-3145

View at Publisher

14 da Silva, V.G., de Castro, R.J.S.

Biocatalytic action of proteases in ionic liquids: Improvements on their enzymatic activity, thermal stability and kinetic parameters

(2018) *International Journal of Biological Macromolecules*, 114, pp. 124-129. Cited 12 times.
www.elsevier.com/locate/ijbiomac
doi: 10.1016/j.ijbiomac.2018.03.084

View at Publisher

15 Gomes, F.O., Maia, L.B., Delerue-Matos, C., Moura, I., Moura, J.J.G., Morais, S.

Third-generation electrochemical biosensor based on nitric oxide reductase immobilized in a multiwalled carbon nanotubes/1-n-butyl-3-methylimidazolium tetrafluoroborate nanocomposite for nitric oxide detection (Open Access)

(2019) *Sensors and Actuators, B: Chemical*, 285, pp. 445-452. Cited 12 times.
https://www.journals.elsevier.com/sensors-and-actuators-b-chemical
doi: 10.1016/j.snb.2019.01.074

View at Publisher

16 Calderón, C., Contreras, R., Campodónico, R.

Surfactant-mediated enzymatic superactivity in water/ionic liquid mixtures, evaluated on a model hydrolytic reaction catalyzed by α-chymotrypsin

(2019) *Journal of Molecular Liquids*, 283, pp. 522-531. Cited 3 times.
doi: 10.1016/j.molliq.2019.03.106

View at Publisher

17 Saha, D., Mukherjee, A.

Effect of water and ionic liquids on biomolecules (Open Access)

(2018) *Biophysical Reviews*, 10 (3), pp. 795-808. Cited 18 times.
http://www.springer.com/life+sciences/biochemistry+%26+biophysics/journal/12551
doi: 10.1007/s12551-018-0399-2

View at Publisher

18 Mai, N.L., Koo, Y.-M.

Enzymatic reactions in ionic liquids

(2017) *Emerging Areas in Bioengineering*, pp. 35-65. Cited 4 times.
http://onlinelibrary.wiley.com/book/10.1002/9783527803293
ISBN: 978-352780328-6; 978-352734088-0
doi: 10.1002/9783527803293.ch3

View at Publisher

19 Nascimento, P.A.M., Pereira, J.F.B., de Carvalho Santos-Ebinuma, V.

Insights into the effect of imidazolium-based ionic liquids on chemical structure and hydrolytic activity of microbial lipase

(2019) *Bioprocess and Biosystems Engineering*, 42 (7), pp. 1235-1246. Cited 5 times.
https://rd.springer.com/journal/449
doi: 10.1007/s00449-019-02121-w

View at Publisher

20 da Silva, V.G., de Castro, R.J.S.

Biocatalytic action of proteases in ionic liquids: Improvements on their enzymatic activity, thermal stability and kinetic parameters

(2018) *International Journal of Biological Macromolecules*, 114, pp. 124-129. Cited 12 times.
www.elsevier.com/locate/ijbiomac
doi: 10.1016/j.ijbiomac.2018.03.084

View at Publisher

21 Ben Hmad, I., Gargouri, A.

Ionic liquid-tolerant cellulase system of Stachybotrys microspora exploited in the in situ saccharification of lignocellulosic biomass

(2020) *Journal of Molecular Liquids*, 310, art. no. 113167. Cited 4 times.
https://www.journals.elsevier.com/journal-of-molecular-liquids
doi: 10.1016/j.molliq.2020.113167

View at Publisher

22 Fernandez, F.J.H.
Keys for the use of ionic liquids as reaction media in enzyme-catalyzed processes
(2018) *J Bioprocess Biotech*, 8, pp. 9-11. Cited 2 times.

23 Zhang, Y., Zhen, B., Li, H., Feng, Y.
Basic ionic liquid as catalyst and surfactant: green synthesis of quinazolinone in aqueous media (Open Access)

(2018) *RSC Advances*, 8 (64), pp. 36769-36774. Cited 12 times.
http://pubs.rsc.org/en/journals/journal/ra
doi: 10.1039/C8RA06378H

View at Publisher

24 He, W.-S., Li, L.-L., Huang, Q.-J., Yin, J., Cao, X.-C.
Highly efficient synthesis of phytosterol linolenate in the presence of Bronsted acidic ionic liquid

(2018) *Food Chemistry*, 263, pp. 1-7. Cited 13 times.
www.elsevier.com/locate/foodchem
doi: 10.1016/j.foodchem.2018.04.107

View at Publisher

25 Lozano, P., Alvarez, E., Nieto, S., Villa, R., Bernal, J.M., Donaire, A.
Biocatalytic synthesis of panthenyl monoacyl esters in ionic liquids and deep eutectic solvents

(2019) *Green Chemistry*, 21 (12), pp. 3353-3361. Cited 7 times.
http://pubs.rsc.org/en/journals/journal/gc
doi: 10.1039/c9gc01076a

View at Publisher

26 Carvalho, N.B., Vidal, B.T., Barbosa, A.S., Pereira, M.M., Mattedi, S., Freitas, L.D.S., Lima, Á.S., (...), Soares, C.M.F.
Lipase immobilization on silica xerogel treated with protic ionic liquid and its application in biodiesel production from different oils (Open Access)

(2018) *International Journal of Molecular Sciences*, 19 (7), art. no. 1829. Cited 14 times.
http://www.mdpi.com/1422-0067/19/7/1829/pdf
doi: 10.3390/ijms19071829

View at Publisher

27 Wang, F., He, S., Zhu, C., Rabausch, U., Streit, W., Wang, J.
The combined use of a continuous-flow microchannel reactor and ionic liquid cosolvent for efficient biocatalysis of unpurified recombinant enzyme

(2018) *Journal of Chemical Technology and Biotechnology*, 93 (9), pp. 2671-2680. Cited 9 times.
http://onlinelibrary.wiley.com/journal/10.1002/(ISSN)1097-4660
doi: 10.1002/jctb.5621

View at Publisher

28 Zhang, Y., Di, X., Wang, W., Song, M., Yu, Q., Wang, Z., Yuan, Z., (...), Guo, Y.
Kinetic study of lipase-catalyzed esterification of furoic acid to methyl-2-furoate

(2020) *Biochemical Engineering Journal*, 161, art. no. 107587. Cited 3 times.
www.elsevier.com/locate/bej
doi: 10.1016/j.bej.2020.107587

View at Publisher

29 Fan, Y., Cai, D., Wang, X., Yang, L.
Ionic liquids: Efficient media for the lipase-catalyzed Michael addition (Open Access)

(2018) *Molecules*, 23 (9), art. no. 2154. Cited 3 times.
http://www.mdpi.com/1420-3049/23/9/2154/pdf
doi: 10.3390/molecules23092154

View at Publisher

30 Rajapriya, G., Morya, V.K., Mai, N.L., Koo, Y.-M.
Aspergillus niger whole-cell catalyzed synthesis of caffeic acid phenethyl ester in ionic liquids

(2018) *Enzyme and Microbial Technology*, 111, pp. 67-73. Cited 8 times.
www.elsevier.com/locate/enzmictec
doi: 10.1016/j.enzmictec.2017.10.005

View at Publisher

31 Sikora, A., Chałupka, J., Marszałł, M.P.
The use of ion liquids as a trojan horse strategy in enzyme-catalyzed biotransformation of (R,S)-atenolol (Open Access)

(2020) *Catalysts*, 10 (7), art. no. 787.
https://www.mdpi.com/2073-4344/10/7/787/pdf
doi: 10.3390/catal10070787

View at Publisher

32 Villalobos, M.C., Gonçalves, A.G., Noseda, M.D., Mitchell, D.A., Krieger, N.
A novel enzymatic method for the synthesis of methyl 6-O-acetyl-α-D-glucopyranoside using a fermented solid containing lipases produced by Burkholderia contaminans LTEB11

(2018) *Process Biochemistry*, 73, pp. 86-93. Cited 7 times.
www.elsevier.com/inca/publications/store/4/2/2/8/5/7
doi: 10.1016/j.procbio.2018.07.023

View at Publisher

33 Park, S., Doan, T.T.N., Koo, Y.-M., Oh, K.K., Lee, S.H.
Ionic liquids as cosolvents for the lipase-catalyzed kinetic resolution of ketoprofen

(2018) *Molecular Catalysis*, 459, pp. 113-118. Cited 9 times.
http://www.elsevier.com/locate/issn/24688231
doi: 10.1016/j.mcat.2018.09.001

View at Publisher

34 Amin, R., Khorshidi, A., Shojaei, A.F., Rezaei, S., Faramarzi, M.A.
Immobilization of laccase on modified Fe_3O_4@SiO_2@Kit-6 magnetite nanoparticles for enhanced delignification of olive pomace bio-waste

(2018) *International Journal of Biological Macromolecules*, 114, pp. 106-113. Cited 34 times.
www.elsevier.com/locate/ijbiomac
doi: 10.1016/j.ijbiomac.2018.03.086

View at Publisher

35 Tonova, K.
Long-term preservation of α-amylase activity in highly concentrated aqueous solutions of imidazolium ionic liquid (Open Access)

(2018) *Green Processing and Synthesis*, 7 (2), pp. 106-113. Cited 5 times.
http://www.degruyter.com/view/j/gps
doi: 10.1515/gps-2017-0016

View at Publisher

36 Li, J., Huang, W.-C., Gao, L., Sun, J., Liu, Z., Mao, X.

Efficient enzymatic hydrolysis of ionic liquid pretreated chitin and its dissolution mechanism

(2019) *Carbohydrate Polymers*, 211, pp. 329-335. Cited 15 times.
http://www.elsevier.com/wps/find/journaldescription.cws_home/405871/description#description
doi: 10.1016/j.carbpol.2019.02.027

View at Publisher

37 Elgharbawy, A.A., Alam, M.Z., Moniruzzaman, M., Kabbashi, N.A., Jamal, P.

Chemical and structural changes of pretreated empty fruit bunch (EFB) in ionic liquid-cellulase compatible system for fermentability to bioethanol (Open Access)

(2018) *3 Biotech*, 8 (5), art. no. 236. Cited 7 times.
http://www.springerlink.com/content/2190-572x/
doi: 10.1007/s13205-018-1253-8

View at Publisher

38 Fan, Y., Wang, X., Li, J., Zhang, L., Yang, L., Gao, P., Zhou, Z.

Kinetic study of the inhibition of ionic liquids on the trypsin activity

(2018) *Journal of Molecular Liquids*, 252, pp. 392-398. Cited 13 times.
doi: 10.1016/j.molliq.2018.01.014

View at Publisher

39 Janati-Fard, F., Housaindokht, M.R., Monhemi, H., Esmaeili, A.A., Nakhaei Pour, A.

The influence of two imidazolium-based ionic liquids on the structure and activity of glucose oxidase: Experimental and theoretical studies

(2018) *International Journal of Biological Macromolecules*, 114, pp. 656-665. Cited 6 times.
www.elsevier.com/locate/ijbiomac
doi: 10.1016/j.ijbiomac.2018.03.083

View at Publisher

40 Wang, B., Zhang, C., He, Q., Qin, H., Liang, G., Liu, W.

Efficient resolution of (R,S)-1-(1-naphthyl)ethylamine by Candida antarctica lipase B in ionic liquids

(2018) *Molecular Catalysis*, 448, pp. 116-121. Cited 8 times.
http://www.elsevier.com/locate/issn/24688231
doi: 10.1016/j.mcat.2018.01.026

View at Publisher

41 Scherer, G.C.R.S., Nyari, N.L.D., Hillesheim, E.L., Paulazzi, A.R., Da Silva, B.A., Zeni, J., Mignoni, M.L.

Pseudomonas fluorescens AK Lipase Immobilization on MCM-48-Type Mesoporous Support in the Presence of Ionic Liquid

(2018) *Industrial Biotechnology*, 14 (4), pp. 222-229. Cited 2 times.
www.liebertonline.com/ind
doi: 10.1089/ind.2018.0015

View at Publisher

42 Suo, H., Xu, L., Xu, C., Chen, H., Yu, D., Gao, Z., Huang, H., (...), Hu, Y.

Enhancement of catalytic performance of porcine pancreatic lipase immobilized on functional ionic liquid modified Fe_3O_4-Chitosan nanocomposites

(2018) *International Journal of Biological Macromolecules*, 119, pp. 624-632. Cited 27 times.
www.elsevier.com/locate/ijbiomac
doi: 10.1016/j.ijbiomac.2018.07.187

View at Publisher

43 Fan, Y., Wang, X., Zhang, L., Li, J., Yang, L., Gao, P., Zhou, Z.
Lipase-catalyzed synthesis of biodiesel in a hydroxyl-functionalized ionic liquid

(2018) *Chemical Engineering Research and Design*, 132, pp. 199-207. Cited 14 times.
http://www.elsevier.com/wps/find/journaldescription.cws_home/713871/description#description
doi: 10.1016/j.cherd.2018.01.020

View at Publisher

44 Barbosa, M.S., Santos, A.J., Carvalho, N.B., Figueiredo, R.T., Pereira, M.M., Lima, Á.S., Freire, M.G., (...), Soares, C.M.F.
Enhanced Activity of Immobilized Lipase by Phosphonium-Based Ionic Liquids Used in the Support Preparation and Immobilization Process

(2019) *ACS Sustainable Chemistry and Engineering*, 7 (18), pp. 15648-15659. Cited 12 times.
http://pubs.acs.org/journal/ascecg
doi: 10.1021/acssuschemeng.9b03741

View at Publisher

45 Qiu, X., Qin, J., Xu, M., Kang, L., Hu, Y.
Organic-inorganic nanocomposites fabricated via functional ionic liquid as the bridging agent for Laccase immobilization and its application in 2,4-dichlorophenol removal

(2019) *Colloids and Surfaces B: Biointerfaces*, 179, pp. 260-269. Cited 16 times.
www.elsevier.com/locate/colsurfb
doi: 10.1016/j.colsurfb.2019.04.002

View at Publisher

46 Zhao, H., Kanpadee, N., Jindarat, C.
Ether-functionalized ionic liquids for nonaqueous biocatalysis: Effect of different cation cores

(2019) *Process Biochemistry*, 81, pp. 104-112. Cited 5 times.
www.elsevier.com/inca/publications/store/4/2/2/8/5/7
doi: 10.1016/j.procbio.2019.03.018

View at Publisher

47 Qiu, X., Wang, Y., Xue, Y., Li, W., Hu, Y.
Laccase immobilized on magnetic nanoparticles modified by amino-functionalized ionic liquid via dialdehyde starch for phenolic compounds biodegradation

(2020) *Chemical Engineering Journal*, 391, art. no. 123564. Cited 20 times.
www.elsevier.com/inca/publications/store/6/0/1/2/7/3/index.htt
doi: 10.1016/j.cej.2019.123564

View at Publisher

48 Xie, W., Wang, H.
Immobilized polymeric sulfonated ionic liquid on core-shell structured Fe_3O_4/SiO_2 composites: A magnetically recyclable catalyst for simultaneous transesterification and esterifications of low-cost oils to biodiesel

(2020) *Renewable Energy*, 145, pp. 1709-1719. Cited 79 times.
http://www.journals.elsevier.com/renewable-and-sustainable-energy-reviews/
doi: 10.1016/j.renene.2019.07.092

View at Publisher

49 Suo, H., Gao, Z., Xu, L., Xu, C., Yu, D., Xiang, X., Huang, H., (...), Hu, Y.
Synthesis of functional ionic liquid modified magnetic chitosan nanoparticles for porcine pancreatic lipase immobilization

(2019) *Materials Science and Engineering C*, 96, pp. 356-364. Cited 23 times.
doi: 10.1016/j.msec.2018.11.041

View at Publisher

50 Suo, H., Xu, L., Xue, Y., Qiu, X., Huang, H., Hu, Y.

Ionic liquids-modified cellulose coated magnetic nanoparticles for enzyme immobilization: Improvement of catalytic performance

(2020) *Carbohydrate Polymers*, 234, art. no. 115914. Cited 17 times.
http://www.elsevier.com/wps/find/journaldescription.cws_home/405871/description#description
doi: 10.1016/j.carbpol.2020.115914

View at Publisher

51 Bui-Le, L., Clarke, C.J., Bröhl, A., Brogan, A.P.S., Arpino, J.A.J., Polizzi, K.M., Hallett, J.P.

Revealing the complexity of ionic liquid–protein interactions through a multi-technique investigation (Open Access)

(2020) *Communications Chemistry*, 3 (1), art. no. 55. Cited 9 times.
nature.com/commschem/
doi: 10.1038/s42004-020-0302-5

View at Publisher

52 Kadotani, S., Nokami, T., Itoh, T.

Enhanced activity and modified substrate-favoritism of Burkholderia cepacia lipase by the treatment with a pyridinium alkyl-PEG sulfate ionic liquid

(2019) *Tetrahedron*, 75 (4), pp. 441-447. Cited 7 times.
http://www.journals.elsevier.com/tetrahedron/
doi: 10.1016/j.tet.2018.12.028

View at Publisher

53 Grabner, B., Nazario, M.A., Gundersen, M.T., Loïs, S., Fantini, S., Bartsch, S., Woodley, J.M., (...), Gruber-Woelfler, H.

Room-temperature solid phase ionic liquid (RTSPIL) coated Ω-transaminases: Development and application in organic solvents

(2018) *Molecular Catalysis*, 452, pp. 11-19. Cited 6 times.
http://www.elsevier.com/locate/issn/24688231
doi: 10.1016/j.mcat.2018.03.012

View at Publisher

54 Zhao, H., Harter, G.A., Martin, C.J.

"water-like" Dual-Functionalized Ionic Liquids for Enzyme Activation (Open Access)

(2019) *ACS Omega*, 4 (12), pp. 15234-15239. Cited 3 times.
pubs.acs.org/journal/acsodf
doi: 10.1021/acsomega.9b02118

View at Publisher

55 Ghanta, K.P., Pal, T., Mondal, S., Bandyopadhyay, S.

Microscopic Understanding of the Effect of Ionic Liquid on Protein from Molecular Simulation Studies

(2020) *Journal of Physical Chemistry B*, 124 (19), pp. 3909-3921. Cited 4 times.
http://pubs.acs.org/journal/jpcbfk
doi: 10.1021/acs.jpcb.0c02001

View at Publisher

Goto, M.; Center for Future Chemistry, Kyushu University, Fukuoka, Japan; email:m-goto@mail.cstm.kyushuu-u.ac.jp