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Menthol and Fatty Acid-Based Hydrophobic Deep Eutectic Solvents as Media for Enzyme Activation

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Abstract

This research aims to provide insights into the biological efficacy of a newly formed hydrophobic deep eutectic solvent (DES). A DES based on menthol was successfully synthesized with fatty acids. The DESs' properties as enzyme activators were examined against a neat counterpart. The menthol:decanoic acid (1:1) combination showed improved thermal stability, strong catalytic activity, and reusability for up to four subsequent cycles under ideal conditions (pH 7.0, 40 °C for 2 h). The hydrophobic DES replaced hexane in ester synthesis, where RNL@DES5 showed better fatty acid conversion compared to neat RNL. This study demonstrated promising applications of hydrophobic DESs in non-aqueous organic reactions. © 2023 by the authors.

Author keywords

enzyme kinetics; fatty acid; hydrogen-bonding; hydrophobic agent; natural deep eutectic solvents

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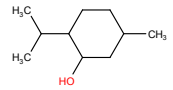

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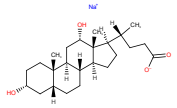

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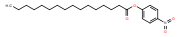

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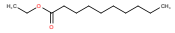

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References (61)

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All

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1 Khan, P.A., Johl, S.K., Johl, S.K.

Does adoption of ISO 56002-2019 and green innovation reporting enhance the firm sustainable development goal performance? An emerging paradigm

(2021) *Business Strategy and the Environment*, 30 (7), pp. 2922-2936. Cited 43 times.
http://onlinelibrary.wiley.com/journal/10.1002/(ISSN)1099-0836
doi: 10.1002/bse.2779

View at Publisher

2 Khan, P.A., Johl, S.K., Akhtar, S.

Vinculum of Sustainable Development Goal Practices and Firms' Financial Performance: A Moderation Role of Green Innovation

(2022) *Journal of Risk and Financial Management*, 15 (3), art. no. 96. Cited 21 times.
https://www.mdpi.com/1911-8074/15/3/96/pdf?version=1645538700
doi: 10.3390/jrfm15030096

View at Publisher

3 Abbott, A.P., Capper, G., Davies, D.L., Rasheed, R.K., Tambyrajah, V.

Novel solvent properties of choline chloride/urea mixtures

(2003) *Chemical Communications*, (1), pp. 70-71. Cited 3482 times.
http://pubs.rsc.org/en/journals/journal/cc
doi: 10.1039/b210714g

View at Publisher

4 Dai, Y., Witkamp, G.-J., Verpoorte, R., Choi, Y.H.

Tailoring properties of natural deep eutectic solvents with water to facilitate their applications (Open Access)

(2015) *Food Chemistry*, 187, pp. 14-19. Cited 670 times.
www.elsevier.com/locate/foodchem
doi: 10.1016/j.foodchem.2015.03.123

View at Publisher

5 Aroso, I.M., Paiva, A., Reis, R.L., Duarte, A.R.C.

Natural deep eutectic solvents from choline chloride and betaine – Physicochemical properties

(2017) *Journal of Molecular Liquids*, 241, pp. 654-661. Cited 173 times.
doi: 10.1016/j.molliq.2017.06.051

View at Publisher

6 Hayyan, A., Ali Hashim, M., Mjalli, F.S., Hayyan, M., AlNashef, I.M.

A novel phosphonium-based deep eutectic catalyst for biodiesel production from industrial low grade crude palm oil

(2013) *Chemical Engineering Science*, 92, pp. 81-88. Cited 126 times.
http://www.journals.elsevier.com/chemical-engineering-science/
doi: 10.1016/j.ces.2012.12.024

View at Publisher

7 Pena-Pereira, F., De La Calle, I.

Solvents and eutectic solvents

(2019) *Encyclopedia of Analytical Science*, pp. 184-190. Cited 3 times.
http://dx.doi.org/10.1016/B978-0-12-409547-2.14020-X
ISBN: 978-008101983-2; 978-008101984-9
doi: 10.1016/B978-0-12-409547-2.14020-X

View at Publisher

8 He, Y., Li, K., Bo, G., Wang, J., Xu, L., Yan, J., Yang, M., (...), Yan, Y.

Enhancing biodiesel production via liquid Yarrowia lipolytica lipase 2 in deep eutectic solvents (Open Access)

(2022) *Fuel*, 316, art. no. 123342. Cited 10 times.
http://www.journals.elsevier.com/fuel/
doi: 10.1016/j.fuel.2022.123342

View at Publisher

9 Lynam, J.G., Kumar, N., Wong, M.J.

Deep eutectic solvents' ability to solubilize lignin, cellulose, and hemicellulose; thermal stability; and density (Open Access)

(2017) *Bioresource Technology*, 238, pp. 684-689. Cited 238 times.
www.elsevier.com/locate/biortech
doi: 10.1016/j.biortech.2017.04.079

View at Publisher

10 Piemontese, L., Perna, F.M., Logrieco, A., Capriati, V., Solfrizzo, M.

Deep eutectic solvents as novel and effective extraction media for quantitative determination of Ochratoxin A in wheat and derived products (Open Access)

(2017) *Molecules*, 22 (1), art. no. 121. Cited 32 times.
http://www.mdpi.com/1420-3049/22/1/121/pdf
doi: 10.3390/molecules22010121

View at Publisher

11 Ribeiro, B.D., Florindo, C., Iff, L.C., Coelho, M.A.Z., Marrucho, I.M.

Menthol-based eutectic mixtures: Hydrophobic low viscosity solvents

(2015) *ACS Sustainable Chemistry and Engineering*, 3 (10), pp. 2469-2477. Cited 344 times.
http://pubs.acs.org/journal/ascecg
doi: 10.1021/acssuschemeng.5b00532

View at Publisher

12 Ahmad, I., Pertiwi, A.S., Kembaren, Y.H., Rahman, A., Mun'im, A.

Application of natural deep eutectic solvent-based ultrasonic assisted extraction of total polyphenolic and caffeine content from coffe beans (Coffea Beans L.) for instant food products

(2018) *Journal of Applied Pharmaceutical Science*, 8 (8), pp. 138-143. Cited 19 times.
http://www.japsonline.com/admin/php/uploads/2708_pdf.pdf
doi: 10.7324/JAPS.2018.8819

View at Publisher

13 Dai, Y., Witkamp, G.-J., Verpoorte, R., Choi, Y.H.

Natural deep eutectic solvents as a new extraction media for phenolic metabolites in carthamus tinctorius L.

(2013) *Analytical Chemistry*, 85 (13), pp. 6272-6278. Cited 474 times.
doi: 10.1021/ac400432p

View at Publisher

14 Saravana, P.S., Ho, T.C., Chae, S.-J., Cho, Y.-J., Park, J.-S., Lee, H.-J., Chun, B.-S.

Deep eutectic solvent-based extraction and fabrication of chitin films from crustacean waste (Open Access)

(2018) *Carbohydrate Polymers*, 195, pp. 622-630. Cited 86 times.
http://www.elsevier.com/wps/find/journaldescription.cws_home/405871/description#description
doi: 10.1016/j.carbpol.2018.05.018

View at Publisher

15 Baby, J.N., Sriram, B., Wang, S.-F., George, M.

Effect of Various Deep Eutectic Solvents on the Sustainable Synthesis of $MgFe_2O_4$ Nanoparticles for Simultaneous Electrochemical Determination of Nitrofurantoin and 4-Nitrophenol

(2020) *ACS Sustainable Chemistry and Engineering*, 8 (3), pp. 1479-1486. Cited 101 times.
http://pubs.acs.org/journal/ascecg
doi: 10.1021/acssuschemeng.9b05755

View at Publisher

16 Krishnan, S.K., Chipatecua Godoy, Y.

Deep Eutectic Solvent-Assisted Synthesis of Au Nanostars Supported on Graphene Oxide as an Efficient Substrate for SERS-Based Molecular Sensing

(2020) *ACS Omega*, 5 (3), pp. 1384-1393. Cited 22 times.
pubs.acs.org/journal/acsodf
doi: 10.1021/acsomega.9b02759

View at Publisher

17 Putra, S.S.S., Basirun, W.J., Elgharbawy, A.A.M., Hayyan, A., Hayyan, M., Mohammed, M.A.

Nanocellulose and natural deep eutectic solvent as potential biocatalyst system toward enzyme immobilization

(2022) *Molecular Catalysis*, 528, art. no. 112422. Cited 6 times.
http://www.elsevier.com/locate/issn/24688231
doi: 10.1016/j.mcat.2022.112422

View at Publisher

18 Shehata, M., Unlu, A., Sezerman, U., Timucin, E.

Lipase and Water in a Deep Eutectic Solvent: Molecular Dynamics and Experimental Studies of the Effects of Water-In-Deep Eutectic Solvents on Lipase Stability

(2020) *Journal of Physical Chemistry B*, 124 (40), pp. 8801-8810. Cited 22 times.
http://pubs.acs.org/journal/jpcbfk
doi: 10.1021/acs.jpcb.0c07041

View at Publisher

19 Cao, J., Wu, R., Zhu, F., Dong, Q., Su, E.

How to improve the efficiency of biocatalysis in non-aqueous pure deep eutectic solvents: A case study on the lipase-catalyzed transesterification reaction (Open Access)

(2022) *Biochemical Engineering Journal*, 179, art. no. 108336. Cited 8 times.
www.elsevier.com/locate/bej
doi: 10.1016/j.bej.2022.108336

View at Publisher

20 Hayyan, A., Hadj-Kali, M.K., Salleh, M.Z.M., Hashim, M.A., Rubaidi, S.R., Hayyan, M., Zulkifli, M.Y., (...), Basirun, W.J.

Characterization of tetraethylene glycol-based deep eutectic solvents and their potential application for dissolving unsaturated fatty acids

(2020) *Journal of Molecular Liquids*, 312, art. no. 113284. Cited 13 times.
https://www.journals.elsevier.com/journal-of-molecular-liquids
doi: 10.1016/j.molliq.2020.113284

View at Publisher

21 Florindo, C., Romero, L., Rintoul, I., Branco, L.C., Marrucho, I.M.

From Phase Change Materials to Green Solvents: Hydrophobic Low Viscous Fatty Acid-Based Deep Eutectic Solvents

(2018) *ACS Sustainable Chemistry and Engineering*, 6 (3), pp. 3888-3895. Cited 207 times.
http://pubs.acs.org/journal/ascecg
doi: 10.1021/acssuschemeng.7b04235

View at Publisher

22 Rashid, S.N., Hayyan, A., Hayyan, M., Hashim, M.A., Elgharbawy, A.A.M., Sani, F.S., Basirun, W.J., (...), Rageh, M.

Ternary glycerol-based deep eutectic solvents: Physicochemical properties and enzymatic activity

(2021) *Chemical Engineering Research and Design*, 169, pp. 77-85. Cited 7 times.
http://www.elsevier.com/wps/find/journaldescription.cws_home/713871/description#description
doi: 10.1016/j.cherd.2021.02.032

View at Publisher

23 Chin Ting, H., Warsi Khan, H., Vijaya Bhaskar Reddy, A., Goto, M., Moniruzzaman, M.

Extraction of salicylic acid from wastewater using ionic liquid-based green emulsion liquid membrane: COSMO-RS prediction and experimental verification (Open Access)

(2022) *Journal of Molecular Liquids*, 347, art. no. 118280. Cited 15 times.
https://www.journals.elsevier.com/journal-of-molecular-liquids
doi: 10.1016/j.molliq.2021.118280

View at Publisher

24 Khan, H.W., Reddy, A.V.B., Bustam, M.A., Goto, M., Moniruzzaman, M.

Development and optimization of ionic liquid-based emulsion liquid membrane process for efficient recovery of lactic acid from aqueous streams

(2021) *Biochemical Engineering Journal*, 176, art. no. 108216. Cited 14 times.
www.elsevier.com/locate/bej
doi: 10.1016/j.bej.2021.108216

View at Publisher

25 Silva, J.M., Pereira, C.V., Mano, F., Silva, E., Castro, V.I.B., Sá-Nogueira, I., Reis, R.L., (...), Duarte, A.R.C.

Therapeutic Role of Deep Eutectic Solvents Based on Menthol and Saturated Fatty Acids on Wound Healing

(2019) *ACS Applied Bio Materials*, 2 (10), pp. 4346-4355. Cited 77 times.
pubs.acs.org/journal/aabmcb
doi: 10.1021/acsabm.9b00598

View at Publisher

26 Simakova, I.L., Vajglová, Z., Mäki-Arvela, P., Eränen, K., Hupa, L., Peurla, M., Mäkilä, E.M., (...), Murzin, D.Y.

Citral-to-Menthol Transformations in a Continuous Reactor over Ni/Mesoporous Aluminosilicate Extrudates Containing a Sepiolite Clay Binder

(2022) *Organic Process Research and Development*, 26 (2), pp. 387-403. Cited 8 times.
http://pubs.acs.org/journal/oprdfk
doi: 10.1021/acs.oprd.1c00435

View at Publisher

27 Sharma, A., Tyagi, V.V., Chen, C.R., Buddhi, D.

Review on thermal energy storage with phase change materials and applications (Open Access)

(2009) *Renewable and Sustainable Energy Reviews*, 13 (2), pp. 318-345. Cited 4130 times.
doi: 10.1016/j.rser.2007.10.005

View at Publisher

28 Hayyan, A., Mjalli, F.S., Alnashef, I.M., Al-Wahaibi, Y.M., Al-Wahaibi, T., Hashim, M.A.

Glucose-based deep eutectic solvents: Physical properties

(2013) *Journal of Molecular Liquids*, 178, pp. 137-141. Cited 249 times.
doi: 10.1016/j.molliq.2012.11.025

View at Publisher

29 McGaughy, K., Reza, M.T.

Liquid-liquid extraction of furfural from water by hydrophobic deep eutectic solvents: Improvement of density function theory modeling with experimental validations

(2020) *ACS Omega*, 5 (35), pp. 22305-22313. Cited 19 times.
pubs.acs.org/journal/acsodf
doi: 10.1021/acsomega.0c02665

View at Publisher

30 Longeras, O., Gautier, A., Ballerat-Busserolles, K., Andanson, J.-M.

Deep Eutectic Solvent with Thermo-Switchable Hydrophobicity (Open Access)

(2020) *ACS Sustainable Chemistry and Engineering*, 8 (33), pp. 12516-12520. Cited 37 times.
http://pubs.acs.org/journal/ascecg
doi: 10.1021/acssuschemeng.0c03478

View at Publisher

31 Schmitz, D., Shubert, V.A., Betz, T., Schnell, M.

Exploring the conformational landscape of menthol, menthone, and isomenthone: A microwave study

(2015) *Frontiers in Chemistry*, 3 (MAR), art. no. 15. Cited 31 times.
http://journal.frontiersin.org/article/10.3389/fchem.2015.00015/full
doi: 10.3389/fchem.2015.00015

View at Publisher

32 Hümmer, M., Kara, S., Liese, A., Huth, I., Schrader, J., Holtmann, D.

Synthesis of (-)-menthol fatty acid esters in and from (-)-menthol and fatty acids – novel concept for lipase catalyzed esterification based on eutectic solvents

(2018) *Molecular Catalysis*, Part A 458, pp. 67-72. Cited 52 times.
http://www.elsevier.com/locate/issn/24688231
doi: 10.1016/j.mcat.2018.08.003

View at Publisher

33 Hollenbach, R., Ochsenreither, K., Syldatk, C.

Enzymatic synthesis of glucose monodecanoate in a hydrophobic deep eutectic solvent

(2020) *International Journal of Molecular Sciences*, 21 (12), art. no. 4342, pp. 1-11. Cited 23 times.
https://www.mdpi.com/1422-0067/21/12/4342/pdf
doi: 10.3390/ijms21124342

View at Publisher

34 Cao, J., Wu, R., Dong, Q., Zhao, L., Cao, F., Su, E.

Effective Release of Intracellular Enzymes by Permeating the Cell Membrane with Hydrophobic Deep Eutectic Solvents

(2020) *ChemBioChem*, 21 (5), pp. 672-680. Cited 15 times.
http://onlinelibrary.wiley.com/journal/10.1002/(ISSN)1439-7633
doi: 10.1002/cbic.201900502

View at Publisher

35 López-Fernández, J., Benaiges, M.D., Valero, F.

Rhizopus oryzae lipase, a promising industrial enzyme: Biochemical characteristics, production and biocatalytic applications

(2020) *Catalysts*, 10 (11), art. no. 1277, pp. 1-50. Cited 33 times.
https://www.mdpi.com/2073-4344/10/11/1277/pdf
doi: 10.3390/catal10111277

View at Publisher

36 Elgharbawy, A.A., Hayyan, A., Hayyan, M., Rashid, S.N., Nor, M.R.M., Zulkifli, M.Y., Alias, Y., (...), Mirghani, M.E.S.

Shedding light on lipase stability in natural deep eutectic solvents

(2018) *Chemical and Biochemical Engineering Quarterly*, 32 (3), pp. 359-370. Cited 31 times.
https//hrcak.srce.hr/cabeq
doi: 10.15255/CABEQ.2018.1335

View at Publisher

37 Khan, H.W., Elgharbawy, A.A.M., Bustam, M.A., Goto, M., Moniruzzaman, M.

Vegetable Oil-Ionic Liquid-Based Emulsion Liquid Membrane for the Removal of Lactic Acid from Aqueous Streams: Emulsion Size, Membrane Breakage, and Stability Study

(2022) *ACS Omega*, 7 (36), pp. 32176-32183. Cited 4 times.
pubs.acs.org/journal/acsodf
doi: 10.1021/acsomega.2c03425

View at Publisher

38 Zhao, H.

What do we learn from enzyme behaviors in organic solvents? – Structural functionalization of ionic liquids for enzyme activation and stabilization (Open Access)

(2020) *Biotechnology Advances*, 45, art. no. 107638. Cited 27 times.
www.elsevier.com/inca/publications/store/5/2/5/4/5/5/index.htt
doi: 10.1016/j.biotechadv.2020.107638

View at Publisher

39 Pätzold, M., Weimer, A., Liese, A., Holtmann, D.

Optimization of solvent-free enzymatic esterification in eutectic substrate reaction mixture

(2019) *Biotechnology Reports*, 22, art. no. e00333. Cited 20 times.
http://www.journals.elsevier.com/biotechnology-reports/
doi: 10.1016/j.btre.2019.e00333

View at Publisher

40 Toledo, M.L., Pereira, M.M., Freire, M.G., Silva, J.P.A., Coutinho, J.A.P., Tavares, A.P.M.

Laccase Activation in Deep Eutectic Solvents

(2019) *ACS Sustainable Chemistry and Engineering*, 7 (13), pp. 11806-11814. Cited 68 times.
http://pubs.acs.org/journal/ascecg
doi: 10.1021/acssuschemeng.9b02179

View at Publisher

41 Lorsch, J.R.

Practical steady-state enzyme kinetics

(2014) *Methods in Enzymology*, 536, pp. 3-15. Cited 25 times.
ISBN: 978-012420070-8
doi: 10.1016/B978-0-12-420070-8.00001-5

View at Publisher

42 Fabrizio, A., Corminboeuf, C.

How do London Dispersion Interactions Impact the Photochemical Processes of Molecular Switches? (Open Access)

(2018) *Journal of Physical Chemistry Letters*, 9 (3), pp. 464-470. Cited 20 times.
http://pubs.acs.org/journal/jpclcd
doi: 10.1021/acs.jpclett.7b03316

View at Publisher

43 Strauss, M.A., Wegner, H.A.

Exploring London Dispersion and Solvent Interactions at Alkyl–Alkyl Interfaces Using Azobenzene Switches

(2019) *Angewandte Chemie - International Edition*, 58 (51), pp. 18552-18556. Cited 24 times.
http://onlinelibrary.wiley.com/journal/10.1002/(ISSN)1521-3773
doi: 10.1002/anie.201910734

View at Publisher

44 Sonesson, A.W., Elofsson, U.M., Brismar, H., Callisen, T.H.
Adsorption and mobility of a lipase at a hydrophobic surface in the presence of surfactants

(2006) *Langmuir*, 22 (13), pp. 5810-5817. Cited 42 times.
doi: 10.1021/la0531244

View at Publisher

45 Mozhaev, V.V.
Engineering stability of enzymes in systems with organic solvents

(1998) *Progress in Biotechnology*, 15 (C), pp. 355-363. Cited 17 times.
http://www.sciencedirect.com/science/bookseries/09210423
doi: 10.1016/S0921-0423(98)80053-1

View at Publisher

46 Egorova, K.S., Gordeev, E.G., Ananikov, V.P.
Biological Activity of Ionic Liquids and Their Application in Pharmaceutics and Medicine

(2017) *Chemical Reviews*, 117 (10), pp. 7132-7189. Cited 1017 times.
http://pubs.acs.org/journal/chreay
doi: 10.1021/acs.chemrev.6b00562

View at Publisher

47 Di, X., Zhang, Y., Fu, J., Yu, Q., Wang, Z., Yuan, Z.
Ionic Liquid-Strengthened Immobilized Rhizomucor miehei Lipase for Catalytic Esterification of Itaconic Acid in Aqueous Media (Open Access)

(2020) *ACS Sustainable Chemistry and Engineering*, 8 (4), pp. 1805-1812. Cited 15 times.
http://pubs.acs.org/journal/ascecg
doi: 10.1021/acssuschemeng.9b05731

View at Publisher

48 Bingham, R.J., Ballone, P.
Computational study of room-temperature ionic liquids interacting with a POPC phospholipid bilayer (Open Access)

(2012) *Journal of Physical Chemistry B*, 116 (36), pp. 11205-11216. Cited 67 times.
http://pubs.acs.org/journal/jpcbfk
doi: 10.1021/jp306126q

View at Publisher

49 Makoś, P., Słupek, E., Gębicki, J.
Hydrophobic deep eutectic solvents in microextraction techniques–A review (Open Access)

(2020) *Microchemical Journal*, 152, art. no. 104384. Cited 207 times.
www.elsevier.com/inca/publications/store/6/2/0/3/9/1
doi: 10.1016/j.microc.2019.104384

View at Publisher

50 Ge, D., Wang, Y., Jiang, Q., Dai, E.

A Deep Eutectic Solvent as an Extraction Solvent to Separate and Preconcentrate Parabens in Water Samples Using in situ Liquid-Liquid Microextraction (Open Access)

(2019) *Journal of the Brazilian Chemical Society*, 30 (6), pp. 1203-1210. Cited 40 times.
http://jbcs.sbq.org.br/imagebank/pdf/2018-0549AR.pdf
doi: 10.21577/0103-5053.20190014

View at Publisher

51 Florindo, C., Lima, F., Branco, L.C., Marrucho, I.M.

Hydrophobic Deep Eutectic Solvents: A Circular Approach to Purify Water Contaminated with Ciprofloxacin (Open Access)

(2019) *ACS Sustainable Chemistry and Engineering*, 7 (17), pp. 14739-14746. Cited 60 times.
http://pubs.acs.org/journal/ascecg
doi: 10.1021/acssuschemeng.9b02658

View at Publisher

52 Cao, J., Wu, R., Zhu, F., Dong, Q., Su, E.

Enzymes in nearly anhydrous deep eutectic solvents: Insight into the biocompatibility and thermal stability (Open Access)

(2022) *Enzyme and Microbial Technology*, 157, art. no. 110022. Cited 5 times.
www.elsevier.com/locate/enzmictec
doi: 10.1016/j.enzmictec.2022.110022

View at Publisher

53 Guajardo, N., Ahumada, K., Domínguez de María, P.

Immobilized lipase-CLEA aggregates encapsulated in lentikats® as robust biocatalysts for continuous processes in deep eutectic solvents (Open Access)

(2020) *Journal of Biotechnology*, 310, pp. 97-102. Cited 34 times.
www.elsevier.com/locate/jbiotec
doi: 10.1016/j.jbiotec.2020.02.003

View at Publisher

54 Tang, W., Dai, Y., Row, K.H.

Evaluation of fatty acid/alcohol-based hydrophobic deep eutectic solvents as media for extracting antibiotics from environmental water (Open Access)

(2018) *Analytical and Bioanalytical Chemistry*, 410 (28), pp. 7325-7336. Cited 101 times.
link.springer.de/link/service/journals/00216/index.htm
doi: 10.1007/s00216-018-1346-6

View at Publisher

55 Elgharbawy, A.A., Riyadi, F.A., Alam, M.Z., Moniruzzaman, M.

Ionic liquids as a potential solvent for lipase-catalysed reactions: A review (Open Access)

(2018) *Journal of Molecular Liquids*, 251, pp. 150-166. Cited 103 times.
doi: 10.1016/j.molliq.2017.12.050

View at Publisher

56 Li, Y., Sun, Z., Ge, X., Zhang, J.

Effects of lignin and surfactant on adsorption and hydrolysis of cellulases on cellulose (Open Access)

(2016) *Biotechnology for Biofuels*, 9 (1), art. no. 20. Cited 121 times.
http://www.biotechnologyforbiofuels.com/
doi: 10.1186/s13068-016-0434-0

View at Publisher

57 Noori, M.S., Karimi, K.

Detailed study of efficient ethanol production from elmwood by alkali pretreatment (Open Access)

(2016) *Biochemical Engineering Journal*, Part A 105, pp. 197-204. Cited 45 times.
www.elsevier.com/locate/bej
doi: 10.1016/j.bej.2015.09.019

View at Publisher

58 Kim, S.H., Park, S., Yu, H., Kim, J.H., Kim, H.J., Yang, Y.-H., Kim, Y.H., (...), Lee, S.H.

Effect of deep eutectic solvent mixtures on lipase activity and stability (Open Access)

(2016) *Journal of Molecular Catalysis B: Enzymatic*, 128, pp. 65-72. Cited 86 times.
www.elsevier.com/locate/molcatb
doi: 10.1016/j.molcatb.2016.03.012

View at Publisher

59 Hou, C., Zhu, H., Wu, D., Li, Y., Hou, K., Jiang, Y., Li, Y.

Immobilized lipase on macroporous polystyrene modified by PAMAM-dendrimer and their enzymatic hydrolysis (Open Access)

(2014) *Process Biochemistry*, 49 (2), pp. 244-249. Cited 29 times.
doi: 10.1016/j.procbio.2013.10.019

View at Publisher

60 Elgharbawy, A.A.M., Syed Putra, S.S., Hayyan, M., Hayyan, A., Basirun, W.J., Mirghani, M.E.S., Majrashi, A.A., (...), Taskin Tok, T.

Polyamidoamine dendrimers: Favorable polymeric nanomaterials for lipase activation (Open Access)

(2020) *Materials Today Communications*, 25, art. no. 101492. Cited 8 times.
http://www.journals.elsevier.com/materials-today-communications/
doi: 10.1016/j.mtcomm.2020.101492

View at Publisher

61 Bassi, J.J., Todero, L.M., Lage, F.A.P., Khedy, G.I., Ducas, J.D., Custódio, A.P., Pinto, M.A., (...), Mendes, A.A.

Interfacial activation of lipases on hydrophobic support and application in the synthesis of a lubricant ester (Open Access)

(2016) *International Journal of Biological Macromolecules*, 92, pp. 900-909. Cited 53 times.
www.elsevier.com/locate/ijbiomac
doi: 10.1016/j.ijbiomac.2016.07.097

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